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Making Measurement Simple: The Metric System

Curriculum Unit 89.06.02
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I. Introduction

1.1 Intent of unit

The purpose of this unit is to advance the cause of teaching the metric system. With the understanding of the the metric system will come the increased understanding science and technology since these fields already operate in the metric system. Most of us in teaching today did not grow up learning the metric system. For many of us our first contact has come with the introduction of metrics into our curriculums and textbooks. Thus, there is probably some resistance among those of us who teach just as there is among the general population. Hopefully, this discussion will overcome much of this resistance. I intend to discuss how and why metrics came about, briefly I will also give some reasons why and some guidelines to keep in mind as we go about teaching it. Lastly, there will be three specific lesson plans and also bibliographies for teachers and for students.

1.2 Who uses metrics

Science and technology involve, to a great extent, measuring. The scientific community world wide long ago realized the necessity for standardization of units of measure. It was largely for this reason that the metric system was developed. Today, every major nation in the world and the vast majority of all nations, have officially adopted the metric system. The United States is the only major exception. We continue to use the customary, or English, system which goes back to about the 1200's.

1.3 What is "metrics"

The metric system is a group of units used to make any kind of measurement, such as length, temperature, or weight. No other system equals it in simplicity. The scientists who created it designed it to fit their needs. The system is logical and exact. But a non scientist needs to know only a few metric units to make everyday measurements.

1.4 Why switch

The metric system may seem difficult to those of us who have not grown up using it but that is mainly because of unfamiliarity with the units. The rest of the world has made the switch without any major problems and we can too. This is because metrics is simple. In fact, it is far more simple than our present system. There are two reasons for the simplicity of the metric system. First, it follows the decimal number system—that is metric units increase or decrease in size by multiples of 10. For example, one centimeter has 10 parts called millimeters and 100 centimeters make one meter. Under the customary system there is no single relationship between the units. For example, feet and inches go by i2 but yards and feet go by 3. The second reason for simplicity is that there are only 7 basic units that make up all measurements. The customary system has more than 20 basic units just for its common measurements. Customary units used for special purposed add many more basic units to that system.

II. Historical Background

2.1 Earliest measures

Experts theorize that the earliest units of length were derived from parts of the body. Units of capacity probably also had the same beginning. The problems with this are obvious. Different size people result in different size measurements. Man realized early that a standard system of weights and measures was necessary. Officials, either government or religious, became the setters and keepers of the standardization for different societies. Still the diversities continued. Both the Greek and Roman civilizations made attempts at standardization and yet neither were entirely successful with dual systems resulting in both empires. None of the systems that developed were entirely logical. Some weights were derived from natural sources such as grain, others from the weight of water in a particular cube. Another weakness of logic in some areas was the tendency to mix two or more systems of numbers in one system of weights and measures. Then, as now, there were four systems of numbers at use in different places and for various purposes; the decimal system of units subdivided by tenths, the duo-decimal system in which twelve and its factors are dividers, the binary system of halves, quarters etc. and the sexagesimal system of division by 60, as in time and angles. The decimal system supposedly came from the Chinese and Egyptians, the duo-decimal from the Romans, the binary from the Hindus and the sexagesimal from the Sumarians and Babylonians.

2.2 How and why metrics came about

Confusion in the European system of weights and measures was well established by the time the Roman Empire collapsed. The Dark Ages probably caused the regression from any semblance of standardization that existed. By the Middle Ages the number of local units of weights and measures had become almost limitless. The crude systems of the Middle Ages continued throughout the world without much question until the 16th or 17th century when scientists started demanding something better. Traders and travelers could convert from one system to another but the work of scientists was becoming international and science could not progress without an exact and uniform system of weights and measures. At the end of the 18th century, scientists created the metric system. While there was sentiment in both England and America for standardization, it was the political climate of France that allowed it to happen. The basic concept of the metric system was not new in the 1790's. Scientists such as France's Mouton, England's Tallyrand, and America's Franklin had developed theories based on the decimal system. The main holdup seemed to be agreement on a fundamental unit. In the end, the lineal system was to be one ten millionth of the meridian distance between the pole and the equator as determined by survey. In 1795 in France an act was passed legalizing the metric system. The names, it was agreed, would be polysyllabic in which Greek prefixes would be affixed to denote multiples of it and Roman prefixes to denote subdivisions.

Myriameter — 10,000 meters

Kilometer	— 1,000	meters
Hectometer	— 100	meters
Dekameter	— 10	meters
Meter	— 1	meter
Decimeter	— 0.1	meter
Centimeter	— 0.01	meter

Millimeter — 0.001 meter

Similar prefixes were applied to units of weight and capacity.

There were two important points of simplicity. Its basic units of weight and capacity were directly related to the fundamental linear unit; the liter was a cubic decimeter and the gram, the weight of a cubic centimeter of water. And, all of its secondary units were multiples or divisions by ten of the basic units. All that it is needed to know is the size of a meter, the relationship between meters and units of capacity and mass, and the meaning of the prefixes. The memorizing of the mass of arbitrary and unrelated units such as miles, feet, and acres was unnecessary. The original basis for the meter, the ten millionth of a meridian, proved to be both inaccurate and continuously changing, but that is unimportant. What is important is that most any length would do as long as it was basic to all aspects of the system and was divided and multiplied decimally.

2.3 Progress once developed

Although it was official, the real acceptance was gradual. The acceptance of the system in other European countries has taken even longer. A conference in France in 1870 attended by 15 nations including the United States, led to the signing in 1875 of the “Metric Convention”, a treaty under which an International Bureau of Weights and Measures was established. The bureau resides in suburban Paris and is still the world center of metrology. The fault of any physical material standard, or a linear measure is that its length remains fixed only under certain controlled conditions. Thus, a meter is now defined as 1,650,763.73 wavelengths of the orange-red radiation of Krypton 86, and this is only the semi-scientific definition. During the twentieth century most of the other nations of the world have officially adopted the metric system. The United States is the only remaining major nation not officially converted to the metric system. It must be said that there is no country in the world in which the pure metric system is used for all transactions in weights and measures. The most common variation is the continued use of old names for metric units. Another departure from the true metric system is the application of the binary number system to metric units. For example, the equivalent of a pint of milk is called a half-liter. In most metric countries nonmetric units continue to be used in some industries, sometimes side by side with metric units, sometimes independent of them. In general this is true in industries that have a close association with the United States. Japan’s bicycle industry still does much business on an inch basis. In countries that have been on the metric system for any length of time, the nonmetric instances are minor. Most people live by the metric system, and the young people know no other. The exceptions may comfort people who fear that quarts and pounds will disappear from supermarket shelves or roadsigns will change from miles to kilometers overnight.

Since the establishment of the International Conference on Weights and Measures, some changes have been made in the metric system, most of them of interest primarily to scientists and engineers. The Standard of the second has been redefined and prefixes have been added for both multiples and subdivisions to extend the scale of measurement. The prefix “tera” before meter or gram means one trillion, “giga” one billion, and “mega” one million. “Micro” means one millionth, “nano” one billionth, and “pico” one trillionth. At its 1960 meeting, the International Convention, which meets every six years, interpreted the metric system in the System International d'Unites, for which the abbreviation is S.I. in all languages. For all purposes other than scientific and advanced technical work this is merely a change in name. Actually, it is a purification and extension of the metric system to make it truly universal.

Through the years, several systems had developed which were all metric but differed in detail in various parts of the world. The S. I. also formalized the extension of the metric system to seven base units. The basic units of the complete S. I. system are:

Quantity Measured *Name of Unit* *Symbol*

Length	— Meter	(m)
Mass	— Kilogram	(kg)
Time	— Second	(s)
Electric Current	— Ampere	(A)
Temperature	— Kelvin	(K)
Luminous Intensity	— Candela	(cd)

Amount of Substance — Mole (mol)

In addition to base units the S. I. system includes a number of derived units for measurement of such things as force energy and power. The unit of force is the "newton" (N) which is defined as the amount of force that, acting for one second on one kilogram of matter, will increase its speed by one meter per second. Named for the English formulator of the law of mechanics, it is,appropriately, just about the gravitational force acting on an average falling apple.

Energy has many forms, but all energy is basically the product of force and distance and is convertible form one form to another. Thus, the S. I. system uses one unit for all kinds of energy; the "joule" (J) which is the amount of energy needed to push a distance of one meter against a force of one newton.

When Watt perfected the steam engine it replaced the horse so people wanted to know its capabilities in terms of the horse. So engines were rated in horsepower. When the electric motor was invented, its power was named after Watt. No matter what form power takes, it is a rate of generation or dissipation of energy, so the only unit of power in the S. I. system is called the Watt (W) which represents one joule of energy per second. One horsepower is roughly equivalent to 746 Watts.

2.4 Conclusion

These derived units, as well as the ampere, the kelvin, the candela, and the mole are of use to scientists and engineers, but not of much concern to most people. Measures of length, weight, and capacity are the commonly used ones. The most commonly used metric units of length in everyday life are millimeter (mm) for small dimensions, the centimeter Ccm) for daily practical use, the meter (m) for expressing dimensions of larger objects and short distances, and the kilometer (km) for longer distances. The most convenient unit of volume for everyday use is the liter (1), although it is part of the S. I. system only in that it is recognized as a name for the cubic decimeter.

There is no international standard liter. One liter is slightly larger than the U.S. quart. Precise measurements of volume in science are expressed in cubic centimeters (cm^3) or cubic millimeters (mm^3).

The most common unit of mass or weight is the kilogram (kg) which equals about 2.2 pounds. Grams (g) and metric tons (t) are also used.

To the general public, most of the history and all but the more basic units of the metric system are unnecessary. Some background and at least a basic awareness of all the components of the metric system are useful for those of us who will teach it.

What does all this mean to teachers of math? First of all, like it or not, this country will eventually join the rest of the world in using the metric system. Thus, we would be doing our students a disservice by not equipping them with the tools necessary to compete in the world. And even though they would learn the metric system without us, by teaching them in a manner in which they can see the usefulness of it, we can go a long way in eliminating the unfavorable way that our students compare in math with students in the rest of the world.

Besides, it’s easier. Not only does the aforementioned simplicity make it easier to teach, but also, the areas of the present curriculum which could be eliminated or at least deemphasized would also simplify our jobs. For example, the customary measures as they are now taught could be relegated to the status of simple mention as a historical footnote, or better, eliminated completely. Also, with the system of fractions and the operations using them, reduction to the introduction of the most basic such as halves, thirds, and quarters with a few simple calculations would be sufficient. Who among us hasn’t sighed at the frustration of trying to impart the concept of “inverse” when teaching the division of fractions. Time spent on these areas would be greatly reduced allowing more time for concentration on more useful areas.

Certainly, there would also be drawbacks. The major one, of course, is monetary. The expense of converting all packaging, signs, much machinery, etc. would be astronomical. Along with the cost would be the inconvenience. Most of the population has not grown up learning metrics and therefore might find conversion annoying at best. An argument could certainly be made for just allowing the “creeping conversion” now going on to simply continue. At some future time conversion would be complete with far less disruption and cost.

I am of the opinion that compromise is probably the best route to go. Immediate, legislated conversion would not be practical. Yet, by concentrated education of our youth in the metric system, the next generation would hasten and complete the conversion as they assumed roles of responsibility. That brings us back to our unit.

III. *Expected Grade Competencies*

In order to consider a concentrated effort to teach the metric system, we should know what students should be learning and when various experiences should take place. The National Council of Teachers of Mathematics recommends an activity approach to the learning of measurement and the use of estimation as a means of learning to think metric. A report, approved and released by the NCTM Board of Directors acting on the recommendation of Instructional Affairs Committee listed the following competencies as suggestions for a basic guide for planning instructional programs.:

3.1 Grade three

Third-Grade Competencies (age 9)

By the end of the third grade, students should be able to . . .

1. Identify the centimeter and the meter as units of linear measure; identify the kilogram as a unit of weight (mass) measure; and identify the liter as a unit of volume (liquid) measure.

2. Distinguish between models of the meter and the centimeter.
3. Use a centimeter ruler (without millimeter markings) to measure line segments and linear objects to the nearest centimeter, and to draw a line segment having a given measure in centimeters to the nearest centimeter.
4. Identify the unit name associated with each of the symbols cm, m, kg, 1, (but not necessarily reverse the process).
5. Find the weight (mass) of an object to the nearest kilogram.
6. Distinguish a liter model from another capacity model at least 50 percent larger or smaller; and use a liter container to measure the volume of a liquid or granular substance.
7. Read a temperature (positive, zero, and negative) from a Celsius scale thermometer to the nearest degree; and identify a zero Celsius temperature as “freezing” and a negative Celsius temperature as “below freezing”.

3.2 Sixth grade

Sixth-Grade Competencies (age 12)

At the end of the sixth grade, students should be able to . . .

1. Select a unit model for each of the units meter, decimeter, centimeter, liter, and kilogram; and measure lengths to the nearest of millimeters.

2. Use a meterstick (or other rule) with millimeter markings to measure line segments and linear objects to the nearest tenth of a centimeter, tenth of a decimeter, and tenth of a meter; use the kilometer to describe experience-related travel distances; and apply the following equivalences:

10 cm = 1 cm, 100 cm = 1 m, 10 dm = 1 m, and 1000 m = 1 km.

3. Make a direct reading of the weight (mass) measure of an object to the nearest tenth of a kilogram from a scale; read the measure of a liquid or granular substance in a graduated container to the nearest ten milliliters.
4. State application for each metric unit which they have basic familiarity, from areas such as commerce, industry, science, and the arts.
5. Identify the unit name associated with each of the symbols mm, cm, dm, m, km, g, kg, ml, 1, and degrees Celsius, and, in most cases, reverse the process.
6. State that the linear dimensions of the standard model of a square centimeter and a cubic centimeter are 1 cm by 1 cm and 1 cm by 1 cm by 1 cm, respectively; make a similar statement for the dimensions of the standard models of a square and cubic meter.
7. Recognize and apply the following relationships: 1 meter is a little more than a yard, 1 kilometer is a little more than 1/2 mile, 1 kilogram is a little more than 2 pounds, 2.5 cm is about 1 inch, and 1 liter is a little more than 1 quart. This is the extent of conversions between the two systems recommended for the interim changeover period.
8. Relate zero degree Celsius and 100 degrees Celsius to the freezing and boiling temperatures of water; identify 27 degrees Celcius as “normal” body temperature; and identify temperatures in the human “comfort zone” (about 22 to 25 degrees Celcius).
9. Estimate distances up to 5 meters in whole meters and lengths up to 10 centimeters in whole centimeters.
10. Estimate volumes up to 5 liters in whole liters and estimate 250 millimeters (approximately 1 cup).
11. Compute sums and differences of measures expressed in decimal form such as:

1.36 m 4.200 1

+ 2.49 m Đ1.600 1

3.85 m 2.600 1

3.3 Ninth grade

Ninth-Grade Competencies (age 15)

By the end of the ninth grade, students should be able to . . .

1. Arrange in a greater-to less sequence the prefixes kilo, hecto, deca, (unit), deci, centi- and milli and relate them to the multiplication constants 1000, 100, 10 (1), 0.1, 0.01, 0.001; and read lengths directly from a meterstick or metric tape as decimal measures, for example, 37.5 for 375 mm length, or 2.55 m for 255 cm length.

2. Select the appropriate type of unit for a given measurement situation, such as linear unit for length, volume unit for volume, weight (mass) unit for weight (mass), and select a convenient size unit for similar situations.
3. Convert from one unit to a larger (or smaller) unit of the same type. For example, 136 cm = 1.36 and 25 m = 0.25 km.

4. Relate square centimeter, cubic centimeter, square meter, cubic meter, square millimeter, and cubic millimeter to their respective symbols (cm 2, cm, c, m , mm, and mm).
5. Identify the liter as a special name for 1 cubic decimeter (and also for 1000 cubic centimeters); identify 1 cubic centimeter and 1 milliliter as equivalent; and re-name 1000 kilograms as 1 ton (lt) and vice versa.
6. Estimate distances up to 100 meters in multiples of 10 meters; and estimate distances up to 100 centimeters in multiples of 10 centimeters.
7. Use referents for varying amounts of weight (mass), such as paper clip (about 1 g) a liter of milk (about 1 kg), or personal weight (mass) (perhaps) 50 kg); and give a meaningful referent for 1 kilometer.
8. Convert a combination measurement expression to a decimal multiple of one of the two units used such as: 1 m 34 cm = 1.3m (or 134 cm) and 1 liter 300 ml = 1.3000 liter (or 1300 ml).
9. Convert from smaller to larger (or larger to smaller) square and cubic units, such as: 3000 cm = 0.3 m^2 or 7500 mm = 7.5 cm^3 .

IV. *Implementation*

4.1 Attitudes

Certain factors should be kept in mind as any instructional program begins. First, remember that even though the customary system has received less emphasis in recent years, the metric system represents a change and people tend to resist change. Our students may not show much resistance to the metric system because of some familiarity with it, but their parents with little or no knowledge of it, might. It must be taught in a way that doesn't necessarily create an "either, or" situation or "you better learn this way or else!"

4.2 Learning by doing

As is apparent in many other situations, learning metrics should be an activity, or hands on situation. Students, especially younger ones, do not learn by listening to a teacher or doing monotonous paper work. Actual measuring in length, area, mass, volume, and temperature provide much more meaningful experience. Along with helping to learn metrics, this hands on approach will also provide practice in measuring skills. Another useful skill that can go along with measuring is the use of estimation. Students should be encouraged to estimate the measurement they are contemplating in metrics before the actual act. This skill is extremely useful in all aspects of life and can also be used to reinforce the idea of what is logical or reasonable. It will also help in getting them to think in the metric system.

4.3 Motivating students

It is important to remember that concepts being taught and activities used be appropriate to the students mental development and knowledge of the metric system. This is where coordination and planning come in. Assuming a teacher knows the approximate range of mental development of his or her students, one must be aware of how much previous instruction in metrics the students have had and also how effective instruction has been. Obviously, as in every aspect of education, there are no clear, simple answers, thus many factors must be taken into account when planning the curriculum. Like everyone else, students will learn what they can see a need or use for. Therefore, as a particular unit or concept is being learned, some practical uses or application from outside the classroom should demonstrate a reason for learning it. This could involve bringing objects or speakers in or possible field trips. Get the community involved as much as possible. Parents may be able to share some meaningful, related experience. People from business and industry can relate what the metric system means to them. Government officials can talk to the extent of their involvement and their feelings about conversion to metrics Use anything to achieve and maintain interest.

One thing that should probably be avoided is teaching conversion from one system to another. This would encourage thinking in both systems. Conversion tables and some simple ability in the process will probably be necessary but beyond that it would only serve to confuse and complicate instruction in the metric system.

Lastly, evaluation should be an important part of the curriculum. Continuous change and improvement will be necessary to provide a better working system. As we learn what works and what doesn’t we can accommodate this into our curriculum. It would also be useful to have students evaluate the curriculum so that we may see, from their perspective, what they feel is effective and what isn’t.

4.4 Integrating instruction

Just as elements of math involve many aspects of everyday life, so must instruction in the metric system involve many disciplines in education. Social Studies, English, Unified Arts and even Physical Education should be involved, as well as Math and Science. Among the possible topics relating to metrics in Social Studies might be a time line on the development of the metric system listing the important dates. Maps with metric scales could be made. Investigations into the current status of the metric system could be used as report assignments. The list of possibilities is limited only by the imagination but each could promote interest in the metric system.

In English, the idea of prefixes and base words could become a unit. One could assign interviews or letters to persons in science, business, or government relating to the metric system.

In Industrial Arts, comparisons of the advantages and disadvantages of the American system to the metric system, or how elements of the metric system are already in place are possible topics. There could be an investigation into the decision by General Motors to go metric and its ramifications.

The area of homemaking will be greatly affected by the change to the metric system. Many possibilities exist here. Will all measuring utensils and recipes change? Will sizes of clothes necessitate changes of machines and measuring?

Even in the area of physical education, the fact that the rest of the world competes on fields and in events which are measured in metric means that many traditional concepts will have to change. Will Jose Conseco’s towering home run be only 120 meters instead of 400 feet. Will Kareem Jabar be a whopping 220 centimeters instead of a mere 7 feet 2 inches?

4.5 Conclusion

All the different areas of education must participate if our children are to grow up understanding the educational system. It must also begin with the youngest and continue on through all the grades. There must be a well thought out sequence possibly like the one previously mentioned. Most important, teachers in all areas must have a knowledge of and a commitment to the metric system and society must will it to be.

Lesson Plan #1

Objective
To introduce the metric system

To show conversion of units by powers of ten

Procedure

1. Briefly explain what the metric system is and how it came about.
2. Show how meters, centimeters, and millimeters can be converted using powers of 10. Use a metric ruler and a meter stick for illustration.
3. Have students measure various items such as pencils, books, desks, and other students and decide which unit is most appropriate.
4. Homework might be to find and measure at least two items appropriate to each unit of measure; meters, centimeters, and millimeters.

Lesson Plan #2

Objective
To think in metrics

To measure in metrics

To convert from one unit of measure to another

Plan

Make a metric scale drawing

Procedure

1. Make a meter stick. This could be done in class with various materials. It could also be an assignment for an industrial arts class.
2. Students would be instructed to measure their house or some area of it. (They might practice by measuring the classroom or hallway.)

3. The following class assignment would be to make a scale drawing to some appropriate scale such as 1 m to 1 cm or 1 m to 5 cm. Additional assignments might include other scale drawings or maps using estimated metric distances.

Another assignment might be the construction of a measuring wheel. The dimensions might be calculated in class while the actual construction could take place at home or in industrial arts.

Lesson Plan #3

Objective
To understand the size of an atom

To multiply and divide by powers of ten To practice estimation

Materials needed
Film “Powers of Ten” (available from the central A.V. office)

Procedure

1. Review the fact that the metric base unit of length is the meter and show the meter stick so there a concrete display of size.
2. Discuss the concept of atoms so that students are aware that everything is made up of atoms. This might lead to discussions of the states of matter or similar things.
3. Show the film “Powers of Ten” and discuss.
4. Discuss the fact that, in metrics, different units result from multiplying or dividing by powers of ten. Thus a meter divided by ten equals a decimeter which divided by ten equals a centimeter and so on. So, if a meter divided into a thousand parts equals a millimeter, then a millimeter divided into 10 million parts is roughly the size of an atom; or mathematically an atom equals

_____1m____ or ___1mm__ 10,000,000,000 10,000,000

If the concept of negative powers of ten has been introduced, then it can be shown as 10 m or 10 mm. Remind students that when numbers are expressed as powers of ten and multiplied or divided, the exponents are simply added or subtracted.

5. Moving on to a concrete representation of the relative sizes, suppose that a grain of sand is i mm long. Then in the length of 1 grain of sand there would be 10,000,000 atoms or 10^{7}. But, because the grain of sand also has width and height, it would be 10^{7} wide and 10^{7} high. Knowing that volume equals length times width times height (v=lwh) then 10^{7} 10^{7} 10^{7} $=10^{21}$ or 1,000,000,000,000,000,000,000 atoms in a grain of sand. This should give students the idea of just how miniscule an atom is. Another way to say it would be to figure a trip to the sun. If the sun is roughly 100,000,000 km away, how far would a journey equal to the length of 1 atom be? (100,000,000 km = 10^{8} km = 10^{11} m divided by 10^{10} which is the number of atoms in a meter gives us 10^{1} or 10 meters in our journey to the sun.)

A possible assignment might be to have students think of other situations which might lend themselves to estimation, powers of ten and the atom.

Bibliography

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Consumers Association of Canada, “Metrics and Measurements” and “S.I. is Simple” from Canadian Consumer Jan. and Nov. 1972

The World Book Encyclopedia, “Metrics” 1977

The Mafex Teacher’s Press “The Painless Metric System” from Metric Idea Exchange, Area Cooperative Educational Services, Nov. 1978

National Bureau of Standards Technical News Bulletin, “The Metric Changeover” Vol. 57, No. 5

Teacher Bibliography

For Reading

Donovan, Frank *Prepare Now For A Metric Future* , Web and Talley, N.Y. 1970 (good for history, advantages, and disadvantages of metrics)

Kemp, Albert F. and Richards, Thomas J. *The Metric System Made Simple* Laidlaw Brothers, 1973 (good for brief explanations and examples)

Consumer's Association of Canada, "Metrics and Measurements" and "S. I. Is Simple" from Canadian Consumer, Jan. and Nov. 1972 (shows how Canada handled conversion)

Holden, Alan *The Nature of Solids* Columbia University Press, 1972 (deep, but shows scientific application)

National Bureau of Standards Technical News Bulletin, "The Metric Changeover" Vol. 57 No. 5 Pgs. 103-106 (discusses America's progress toward change)

For Source Material

The World Book Encyclopedia 1977 (good time line of history and conversion tables for customary and metric)

Szabo, Dr. Michael and Trueblood, Dr. Cecil R. *A K-12 Curriculum Activities Handbook for Teachers* The Norhteastern Metric Educational Consortium, 1977 (sample activities for all grade levels in all disciplines)

Evans, Richard, Wixon, Edwin, and Hanson,Susan *Make Your Own Metric Measuring Aids* Area Cooperative Educational Services (ACES) (excellent for all levels)

These last two plus a number of "Metric Idea Exchange" pamphlets which contain topical articles on the metric system are available from the ACES office at 800 Dixwell Ave. in New Haven. There are also numerous publishers and supply catalogs offering metric materials such as Education Supplements, 163 Westport Ave., Norwalk, Conn. 06851, and Enrich, 760 Kifer Rd., Sunnyvale, CA. 94086. I haven't reviewed these materials.

Also, SNET Co. published a nice little metric conversion booklet but I'm not sure it's still available.

Student Bibliography

These sources offer free materials. *Amazing Story of Measurement* (comic book)

Available from Cooper Group

P.O. Box 728

Apex, N.C. 27502

Metric Packet

National Bureau of Standards Metric Information Office

Washington, D.C. 20234

The United States Metric System

Federal Reserve Bank of Minneapolis

Minneapolis, Mn. 55480