METRICATION: ITS IMPLEMENTATION IN NEWFOUNDLAND SCHOOLS

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NEWFOUNDLAND SCHOOLS

by

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ABSTRACT

This internship report describes the implications of and a plan for implementation of the metric system into the Newfoundland School System. The report provides a detailed description of the history of the metric system, its evolvement in recent times as the predominant measurement system in the universe, and the recent developments which have provided the initial activity in the adoption of the metric system in Canada.

The implications of the adoption of the metric system are discussed with a comprehensive review of the literature on the topic. Mathematics educators have recently become interested in this development since many of them feel that the change to the metric system of measurement in society will allow educators to 'clean house' and modify significantly the approach to the teaching of measurement. An approach to the development of the "Think Metric" concept is presented, since the literature indicates that only through the teaching of the metric system as a distinct system and by relating various metric units to real world experiences can an appreciation for what each unit really is be developed.

The main portion of the report describes the activities of the intern in the development and implementation process. The sequential plan which was developed and carried out is described in detail. Modifications and feedback received at various stages are also noted in order to highlight the developmental nature of the study.

An evaluation of the in-service education program for teachers and the objectives of the process are also included. The degree to which the program met the stated objectives regarding follow-up activities is also discussed. Since the process of implementation is an on-going affair it was not possible to give a final report nor to comment concerning the long term effectiveness or result of the implementation process. This more long-range procedure is outside the scope of this internship but is recommended as an excellent follow-up study.

Many of the support materials which were utilized by the researcher in the program have been duplicated and are contained in the Appendices.

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I. INTRODUCTION

With the introduction of the White Paper on Metric Conversion in Canada, January 1970, the Federal Government began the process of the eventual adoption of the metric system in this country. The White Paper indicated official government policy in this area and in essence suggested that Canada's adoption of metric units as the standard measurement system was "inevitable and in the national interest" (Government of Canada, p. 5).

As a result of this development significant progress toward the attainment of this goal has taken place over the last couple of years. All sectors of the economy and all areas of society have felt, to various degrees, the initial effects of this changeover.

The field of education is in no way separated from such developments. Metric Conversion in society will have specific implications for education in general and teaching in particular.

The purpose of this internship was to outline a detailed plan for implementing the Metric System in Newfoundland schools. It attempted to present a comprehensive picture of the areas of concern and delineate specific recommendations for the accomplishment of this goal on a province-wide basis. In effect, it considered a plan of action where a detailed in-service education program for teachers was conducted in co-ordination with the systematic development and integration of the Metric System into various areas of the curriculum.

II. STATEMENT OF THE PROBLEM

The problem of implementing the Metric System into the Newfoundland School System cannot be reviewed in isolation. Education must move in this direction, since the rest of society has begun evolving and will continue to progress toward the total adoption of the metric system. Newfoundland must necessarily tie in with developments in the rest of the country. In essence, then, the researcher is suggesting that the change to the Metric System of measurement is a national problem.

The problem specific to the introduction of the metric system into schools can be described in fairly precise terms. A perception of the significance of the problem may be appreciated by considering the following points:

(1) It is essential that teachers become aware of why the Metric System is being introduced and gain some appreciation of the implications that this change has for society in general as well as Education in particular.

(2) A Program of In-Service Education must be organized. The program should be so designed as to emphasize the approach to teaching measurement and to help teachers gain a facility with metric units so that they can begin to "Think Metric." It must emphasize teacher involvement in workshop sessions and de-emphasize converting from one system to the other. Also the program organized

on a provincial basis should be one which will create maximum spin-off so as to generate increased activity at the local level.

(3) The Metric System should be integrated in the present curriculum so as to provide maximum exposure with minimum disruption to the core of present programs. This introduction will have implications for Mathematics curriculum, but consideration must be given to its immediate or long-term effect on all curriculum areas.

(4) The implementation procedures must be effected in a manner so as to cause the minimum panic among teachers, producing meaningful organized change.

The most immediate problem in curriculum modification will affect the mathematics program. Metrication has implications for mathematics. Such implications include a change in approach in the teaching of measurement, an earlier introduction of the decimal fraction, greater stress on place value and a changed emphasis on fractions. However, other considerations are also important. The plan of the introduction of mathematics programs using metric measure needs to be considered. The use of curriculum outlines on measurement for an interim period is another course of action. The provision for metric exposure for students in junior and senior high schools also is a consideration.

There are as well general implications to this problem of going metric. For most people the change to the metric system will require learning and adopting a new language of measurement. A new system of measurement must be learned for itself -- the ability to think in terms of metres, litres and kilograms will require a process of re-thinking. To view the world around us in terms of metric units suggests that the problem of the introduction of the metric system in Newfoundland schools will be a greater problem for teachers than for the students or the curriculum.

The problem, then, is of considerable scope. In the chapters which follow the researcher will attempt to outline some of the problems which exist and a possible approach to solution.

III. SIGNIFICANCE OF THE STUDY

This internship has broad significance for education in Newfoundland schools. Metrication is a current problem. It has to be faced now if the curriculum is to be modified to suit the society in which its clients function. The problem of metric conversion in schools is also short term in duration, since once completed it will be self-generating in nature. Consequently the study's significance can be viewed from the point of view of its timing. It is a present problem being faced in our school system.

The study has significance in another way as well. Since the author is presently Metric Consultant with the Department of Education and has been charged with the responsibility of initiating and co-ordinating the introduction of the metric system in Newfoundland schools, the directions and recommendations outlined in this report had immediate effect on the final plan and procedure of implementation. In a sense, then, the study directly influenced curriculum change.

On the other hand, the study served to assist the author in crystalizing and formulating the provincial plan. It allowed the author a mechanism for critical analysis and systematic documentation of the problem and aided in the development of various facets to its successful conclusion. This is an important benefit. Very often in curriculum development or educational change one becomes extremely involved in a variety of activities without taking the opportunity to view the problem from a global perspective and to outline general aims and directions.

The study serves as an accurate on-going account of the program as it is developed and initiated and could thereby provide significant assistance to similar future projects. In effect, the situation may be viewed after final implementation, and a critical evaluation of the program may be made suggesting possible failures and limitations and thereby providing input to future activities.

IV. BACKGROUND INFORMATION

A. A Brief Historical Review of the Development of the Metric System to the Present International System of Units (SI)

The metric system dates back to the sixteenth century when the Flemish mathematician, Simon Stevin, published an arithmetical theory concerning decimal fractions, and this event, together with his proposal for a decimal system of measurement, virtually laid the foundations for the metric system. However, it was not until 1791, when twelve members of the French Academy of Sciences were appointed to establish a decimal system based on the real world, that the metric system was actually created. Because the decimal system of numeration had proven to be easily taught, a measuring system was selected with a decimal basis. This new system used the base unit ten. All other units were to be a multiple of ten of the base unit. This system greatly simplified conversion from one unit to another by either multiplying or dividing by a power of ten.

As a result of the committee's proposals, and the increasing need for more accurate measurements to investigate and substantiate scientific theories, as well as the need for international standards of measurement in communicating the results of research and study, the metre and kilogram were enacted into law in France a few years later. It took until 1840 though, before these units were in general use in France and other parts of Europe. It was not until 1875, however, that the Treaty of the Metre was signed in Paris. The treaty established a General Conference on Weights and Measures, which now is an International Treaty Organization to which over forty nations formally adhere, and which meets periodically[1] to adopt new definitions. Over the years the General Conference has steadily extended and refined the metric system. In 1960 the Conference adopted its International System Units (Systeme International d'Unites) or SI which is the universally recognized metric system in all languages. The international system of measurement is the first complete, internationally harmonized system of compatible scientific measurement units. It is based not only on the metre, kilogram and second but also includes thermal, electrical, mechanical and radiation units. For convenience it is called the "international metric system." All modern industrial nations assure the compatability of their scientific measurement systems, at the highest levels of precision, through international metric measurement standards. At present SI rests on seven independent units for measurement and two supplementary units. SI derives the units for all the quantities needed in science, technology, and everyday life from these seven independent units.[2]

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[1]Every four years with the last meeting in 1971.

[2]See Appendix.

B. The Advantages of the Metric System over the Imperial System

The most obvious virtue of the metric system is its decimal nature. To convert from a smaller unit of measure to a larger unit, it is necessary only to multiply by 10, 100, 1000, etc. and to convert from a larger unit of measure to a smaller unit it is necessary only to divide by 10, 100, 1000, etc. This means that once a person understands the basic unit of length measurement, the metre for example, all other units of length measurement are related to it by a multiple of ten. Similarly, if you understand the basic unit of capacity measurement, the litre, all other capacity measurements are related to the litre by a multiple of 10. This greatly simplifies the whole system of measurement because it eliminates memorizing a great number of conversion figures which are so very necessary in the imperial system. The following quotation, taken from the Twentieth Yearbook of the National Council of Teachers of Mathematics, sums up the apparent reason for world-wide acceptance of the metric system of measurement.

> From the point of view of teaching and learning it would not be easy to design a more difficult system than the present English system; in contrast, it would seem almost impossible to design a system more easily learned than the metric system. (page 17)

A second advantage the metric system has over the imperial system is that for <u>everyday usage</u> a person will have to learn only three basic units of measurement and their prefixes instead of the dozens of units that are required in the imperial system. The three basic units are:

metre -- for measuring length
gram -- for measuring mass
litre -- for measuring capacity

Once a person has a feeling and understanding of each of these basic units all that is necessary then is to learn the prefixes and their meaning to understand and use the metric system.

In the metric system then, the value of the basic unit is changed simply by placing a prefix in front of it. With the three basic units: metre, litre, and gram, the prefixes: "kilo," "hecto," "deci," "centi," "milli," etc., will change the quantity of the basic unit by a multiple of ten. Some prefixes are used more commonly than others. Usually multiples of 1000 of the basic unit are preferred. To illustrate:[3]

Greek prefixes	-- kilo	(thousands 10^3)
	-- hecto	(hundreds 10^2)
	-- deca	(tens 10^1)
Basic Unit	-- no prefix	(one 1)
Latin prefixes	-- deci	(tenths 10^{-1})
	-- centi	(hundredths 10^{-2})
	-- milli	(thousandths 10^{-3})

If length measurement is expressed in relationship to the basic unit -- the metre, then:

1000 metres	--	1 kilometre
100 metres	--	1 hectometre
10 metres	--	1 decametre
1 metre	--	10 decimetres
1 metre	--	100 centimetres
1 metre	--	1000 millimetres

[3] Not all prefixes have been shown here. See Appendix B. list.

Similarly, if capacity measurement is expressed in relationship to the basic unit -- the litre, then:

1000 litres	--	1 kilolitre
100 litres	--	1 hectolitre
10 litres	--	1 decalitre
1 litre	--	10 decilitres
1 litre	--	100 centilitres
1 litre	--	1000 millilitres

Similarly, if mass measurement is expressed in relationship to the basic unit -- the gram,[4] then:

1000 grams	--	1 kilogram
100 grams	--	1 hectogram
10 grams	--	1 decagram

A third major advantage of the metric system is that the three basic units, metre, litre, and kilogram, are all related. The litre as well as the kilogram is defined in relation to the metre. A cube which is 10 cm by 10 cm by 10 cm (1000 cm^3) has a capacity of one litre. This relates the unit of length to capacity. A kilogram is the mass of 1000 cm^3 (a litre) of distilled water at its greatest density, 4°C. Similarly, a 1 cm^3 container has a capacity of one millilitre and the mass of water at 4°C held by this container is 1 gram. Thus a relationship exists between the three units of length, capacity and mass.

A fourth advantage of the metric system is its universality. It is a universal system in two ways. Since presently over 90%

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[4]In the SI, the gram unit of mass proved to be too small for practical application; therefore, the kilogram has been officially designated as the standard unit for mass.

of the countries of the world are now using the metric system, communication in international trade will be improved with total use of this system. However, it is universal in another more significant sense. The SI metric system utilizes a symbol for each of its units. These symbols are universal in that they are standard, no matter what language is being employed. The use of the symbol rather than the word is encouraged so as to develop this universality. In other words, 81 kilometres reads 81 km with km the symbol for kilometre. This symbol "km" remains common throughout all languages thereby making communication in measurement units much easier. The symbols for metric units give us a universal language. A list of the base units of SI with appropriate symbols is contained in Appendix A.

Whereas SI derives the units for all the quantities needed in science, technology, and everyday life from the seven base units, the imperial system has over eighty denominate units of measure which are haphazard and illogical in their relations one to another.

Another advantage with the adoption of the metric system is that many awkward proper and improper fractions, numerators, least common denominators, greatest common divisors, and mixed numbers

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The common units for mass measurement are kilogram, gram, milligram, also ton (1000 kilograms).

The metric system distinguishes between mass and weight by using different units. Mass is measured in kilograms, but weight is measured in new tons. Weight is defined as the pull of gravity between two objects and can be 0 (in space for example) while mass remains the same throughout the universe.

will receive much less emphasis with the greater stress on the decimal system. This no doubt will simplify calculations greatly and make the whole system more compatible with the computer.

C. Metrication in Canada

Recent History

Canada's move toward nationwide adoption of the metric system was officially initiated on 16 January 1970, when the White Paper on Metric Conversion in Canada was presented in the House of Commons by the Hon. Jean-Luc Pepin, then Minister of Industry, Trade and Commerce. On this occasion he made these comments:

> Changing to the metric system will have important benefits for the Canadian consumer. These benefits will derive principally from the inherent simplicity in general use. The ease of conversion from one metric unit to another -- from kilograms to grams, for example, -- will simplify the arithmetic in making value comparisons of competitive consumer products.
>
> For these reasons and for many others which are indicated in the White Paper, the Government believes that the adoption of the metric system is ultimately inevitable and desirable for Canada. However, no legislative action is contemplated which would make mandatory a general use of the metric system in place of inch-pound units. (Boire, 1973, p. 5).

The Canadian White Paper on Metric Conversion was one of those rare government policy statements endorsed by all political parties.

For approximately 100 years before the submittal of the White Paper to Parliament, Canada had slowly been going metric, as had many other nations. The Weights and Measures Act of 1873, adopted by the Second Parliament, stated that the metric or decimal system might be legally used. "... no contract or dealing shall be deemed to be invalid or open to objection, on the ground that the weights or measures expressed or referred to in such contract or dealing are weights or measures of the Metric System." (Department of Consumer and Corporate Affairs, 1973, p.4).

As in several other countries, in the late 1930's, 35mm cameras and film were becoming popular. The scientific community had been using metric units for the most part since before the turn of the century. The Canadian pharmaceutical industry converted to the metric system in the early 1960's and metric units were universally prescribed by Canadian physicians. Metric conversion in the health and welfare sector was launched by the Canadian Hospital Association in 1966. The estimation has been made that over 75 percent of all Canadian hospitals are now using metric units for their internal operations while using customary measures in communicating with the public. (Boire, 1973).

Three basic principles of accepted Canadian Government policy in the area of metric conversion were identified in the White Paper:

1. The eventual adoption in Canadian usage of a single coherent measurement system based on metric units should be acknowledged as inevitable and in the national interest.

2. This single system should come to be used for all measurement purposes required under legislation, and generally be accepted for all measurement purposes.

3. Planning and preparation in the public and private sectors should be encouraged in such a manner as to achieve the maximum benefits at minimum costs to the public, to industry and to government at all levels. (Government of Canada, 1970, p. 8).

According to the White Paper, the federal government should assume a leading role in the planning and the process of metrication. The flavour of the Paper is reflected in the following statement:

> The Government accordingly accepts eventual conversion as a definite objective of Canadian policy, and proposes means of study and consultation whereby the pace and the methods of change may be determined in the national interest. No legislative action is contemplated which would make mandatory a general use of metric in place of inch-pound units, although some legislation may prove desirable to foster familiarity with metric units. (Government of Canada, 1970, p. 5)

The question of Canadian metrication has become more and more a subject of public discussion during the past few years. Considerable coverage in the press has been devoted to the subject and a number of national organizations have voiced their views on metrication before the government with suggestions for action ranging from initiation of studies to immediate adoption. The Consumer's Association of Canada, the Canadian Home and School and Parent-Teacher Federation, the Agricultural Institute of Canada, and the Canadian Chamber of Commerce are among those organizations expressing support for conversion.

In 1968, the Canadian Teachers' Federation passed a resolution encouraging conversion to the metric system. Most provincial departments of education have reported a trend toward more metric teaching (Government of Canada, 1970).

Even though no specific time limit was set for conversion, the White Paper stated that information on the metric system should be made readily available to the public and that introduction of the metric system should be encouraged wherever the benefits were clear and the costs minimum.

Organization

In order to implement these objectives, the Canadian Government established the Metric Commission by Order in Council in June 1971. Their first meeting was held in January 1972. The 17-member Commission, chaired by Stevenson M. Gossage, reports to the Ministry of Industry, Trade and Commerce. The members represent all regions of Canada.

The Metric Commission has the objective of developing an overall national conversion plan. It is organized to help each sector make its own conversion plans and to monitor the progress of the sectors in implementing these plans. As indicated in an early bulletin, the Commission may call upon officers and employees in any department or agency of the government as necessary, or may engage organizations or persons having specialized or technical knowledge for advice and assistance.

The Commission has established 11 Steering Committees, each responsible for the co-ordination of a group of economic sectors with related interests. Each Steering Committee is chaired by a member of the Metric Commission. The Steering Committee of prime interest to this study is Number 10, which covers information, education and training. In addition, an Interdepartmental Committee was formed which is responsible for co-ordinating metric conversion within the federal government. A complete listing of the Steering Committees is provided in the Metric Commission Bulletin which is reproduced in the Appendix C.

The Commission has further established over 60 Sector Committees, reporting to the Steering Committees. Each is responsible for a particular industry, group of industries or interests and is preparing the basic plans for converting the sector for which it is responsible in collaboration with individual firms and associations. The chairman of each Sector Committee is a member of the responsible Steering Committee.

The continuing task of the Steering Committees and their respective Sector Committees is to monitor the progress of conversion and suggest any necessary modifications to plans in order to meet changing conditions.

The sector plans are guides for the individual firms and organizations concerned. While there is no obligation on any firm to conform to them, they represent the best judgement of the industry on how to go about the process of conversion.

Schedule

The White Paper did not set a deadline for the completion of conversion. The scheduling of metric coversion in Canada is obviously complicated by the fact that as yet the United States has not made a decision to convert, and the United States' market represents a major share of Canada's exports of manufactured goods.

Despite the uncertainty in the United States' plans, Canada is nevertheless proceeding to develop tentative schedules. In September 1973 the Canadian Metric Commission outlined target dates for conversion. The four phases of investigation, planning, scheduling and implementation are all planned to be completed by the end of 1980 when, hopefully, the day-to-day transactions in the economy would be entirely metric. The investigation phase has now been completed and the planning phase is now reaching its peak. The scheduling phase should be substantially complete in 1976. According to this schedule, implementation should commence in 1975 and reach its peak in 1977-78, though some industries would no doubt continue operating with imperial units for a longer period (Bank of Montreal, 1974).

It was reported recently by Mr. Paul Boire, Executive Director of the Canadian Metric Commission, that the Metric Conversion Committee of the Road Transportation Association has proposed a plan, beginning in January 1974, for tentatively achieving essentially complete conversion of the highway systems in Canada by the end of 1979. It is hoped that the highway signs from coast to coast will be converted over a one-month period by 30 September 1977. In the area of meteorology, tentative plans have been made to give weather forecasts and reports in SI units starting April 1975. Temperatures will be provided in whole degrees Celsius after an interim period of no longer than six weeks of dual reports. In September of 1975, precipitation amounts for rain and snow are expected to be reported in SI (American National Metric Council, November 1973).

In Canada, education is the responsibility of the individual provinces. There is no federal education department. While some school boards are in the process of converting to the metric system at certain grades, it is expected that the general emphasis on SI in the primary grades will commence in the fall of 1974 perhaps reaching a peak in activity during the 1975-76 school year.

General Approach

It is a bit early to attempt to characterize fully the metric conversion approach to be followed in Canada, since the ground rules and strategy are still in the formative stage. Nevertheless, some features are beginning to emerge.

According to Boire (1973), the basis of the Canadian approach to metric conversion is that it is a voluntary process, with each firm and organization being guided by its appreciation of its short- and long-term interests. A corollary of this approach is that each unit of the economy is expected to identify the opportunities for change and to bear its own costs, just as it will reap the benefits arising from the change.

Fundamental concern for the consumer is reflected in the Consumer Packaging and Labelling Act directed at controlling the information given to the consumer on the labels of all prepackaged goods. In 1973 there was dispute as to whether a producer of prepackaged goods may sell a product identified exclusively in metric measurement terms. The intent of the draft legislation was to protect the consumer during the changeover period by providing for both customary and metric measurements on prepackaged goods, and no provision had been made for the customary unit to eventually disappear. Accompanying this concern, however, was the fear that if dual labelling were allowed to persist indefinitely the consumer would ignore the metric measure, and the time required before thinking metric would be unnecessarily prolonged, as was learned in Britain. Accordingly, the Executive Director of the Metric Commission recommended that the Act be amended to allow labelling in metric units alone (Boire, 1973). Recently the Act has been rephrased to require dual labelling, except where the package is already a standard metric size or becomes so, in which case metric-only labelling is legal (Metric Association, November 1973).

Publications providing guidance to producers and to consumers are already in evidence in Canada, despite the early stage of their conversion (Department of Consumer and Corporate Affairs, 1973a, 1973b; Metric Commission, 1973).

The Metric Commission is in the process of initiating a major public information and education program, in phase with the individual sector plans for commercial and industrial conversion. It is also expected that the Commission will begin publication of a newspaper covering progress of metric conversion (Metric Information Service, December 1973). An orientation to the metric system in general and its history and application to Canada specifically, is provided by Allen (1973).

D. The Metric Commission and Education

In the organization of the Metric Commission, Steering Committee Number 10 has been assigned the area of education and training. This Committee is under the chairmanship of Mr. Willis M. Hall, Assistant Director of Youth Education, Department of Education, Halifax, Nova Scotia. Other members of the Committee represent various bodies interested in the problem of education and training. The committee is responsible for co-ordinating plans in its field and advising the Metric Commission on their applicability to the overall program.

Education is, of course, a provincial responsibility. It is up to the provincial Department of Education to say what will be taught. The Metric Commission can only suggest and see that information on decisions is made as widely as possible. However, increased activity in metric has been visible during recent years in various provinces of Canada. Individual provinces vary in the degree of intensity of metric activity in Education. However, it is fairly obvious that Ontario, Manitoba, and Nova Scotia have been the first to become widely active.

Activity in other probinces has begun to increase in recent months. The desirability of a firm policy of committment on the part of Department of Education is a most obvious variable on progress in metrication. Newfoundland has now received this commitment from its Department of Education and this will pay dividends in the acceleration of activity which will take place over the next two years.

V. IMPLICATIONS OF METRIC CONVERSION FOR EDUCATION

The implications of Metric Conversion for Education has been a recent topic in research articles and dissertations in various journals, publications and magazines. The main emphasis of these writings has been directed at creating awareness so that educators may be more cognizant of the need to modify curriculum and teaching strategies to facilitate the influences of this change. The research in this area does provide a framework around which one may discuss the implications of metric conversion for education in general and for mathematics education in particular.

A useful publication for studying problems of education in general was the U. S. Metric Study Interim Report: Education (United States Department of Commerce, 1971). This publication presented: (a) the educational advantages and disadvantages of both the metric and the customary systems of units; (b) the current usage of metric measurements in American schools, and trends in that usage; (c) the ways in which education would have to change as the United States accommodates to increased world-wide use of the metric system, under a planned national program or without such a program; (d) recommendations for ways in which to take best advantage of the changes. This publication dealt specifically with the study of this paper and was indeed a help in formulating some procedures for implementation, implications of that procedure, and guidelines for teacher preparation.

In a chapter of a book by Kelloway (1968) entitled Metrication, the author rationalized the change from the archaic imperial units to the universal metric units. In doing so he pointed out the educational advantages of the metric system and suggested that a positive view be taken of the change.

Murphy and Polzin, (1969) reviewed the research studies on the teaching of the metric system and measurement. One of the conclusions the authors drew from their study was that relatively few research studies in the area of measurement and the metric system have been conducted.

The writer reviewed recent educational journal articles related to instruction and in-service education to help in formulating the think metric concept. Bright and Jones (1973) make the statement:

> Unfortunately, the approach often used to teach the metric system - conversion from the metric system to the English system and vice versa - promotes confusion and dislike for the only common measurement system whose components are meaningfully related to each other (p.16).

In the above mentioned article a student activity approach to teaching the metric system is described by a grade four classroom teacher. A significant quotation of the description follows:

> . . . They first estimated the measurement. . . . and then performed the measurement. . . . Estimation acted as a motivation for accuracy in that the boys and girls wanted to check their guesses. . . . They also seemed to enjoy the change to guess the answer before verifying their estimates . . . Estimation practice seem to have several consequences. It helps develop the concepts of multiples of numbers, especially multiples of powers of 10. Further, it may aid the growth of mental concepts of spatial visualizations. It certainly does force children to make visual comparisons among dimensions of objects. (page 19)

The article concludes with:

> Experience with the units will breed familiarity with the actual sizes of the respective units, and it is this familiarity that allows people to make a smooth transition to the metric system. This familiarity, in turn, will free people to THINK METRIC. (page 20).

In another article, Sheffield (1973) writes:

> I remember how I dreaded the metric system all through high school and college. But then, as I recall, I never once <u>experienced</u> the metric system. It was always rote memory of conversion and solving meaningless problems. . . . We were never given any reason for having to learn the metric system. It was in the curriculum and it had to be covered. (page 22).

The teacher has changed this approach and in its place describes an alternative method of learning: (Sheffield, 1973)

> . . . We labelled doors, walls, windows. Things we couldn't label like the playground, school bus, and sidewalks we put on a chart. We had an olympic event and measured results of running and jumping by the metric system. We marked a path of a kilometer on the playground and let those who were athletic run it. (page 24).

King and Whitoman (1973), write:

> . . . As we teach the program, two facts are becoming increasingly apparent. First, the children thoroughly enjoyed measurement activities and are gradually discovering the properties of the metric system. Having had extensive experience with the treatment of measurement in conventional programs, we are very pleased and excited about an activity approach to teaching measurement. Our experiences have convinced us that measurement should not, and in fact cannot, be 'taught'. Learning to measure is a gradual process related to the personal experiences of each learner. (page 259).

Helgren (1973) writes that in the past "schools approached the use of the metric system in a way that gave it little encouragement." He indicates that the following are some of the poorly conceived practices:

1. Metric measure was not studied as a system by itself.
2. People were not taught to THINK METRIC.
3. Textbooks often contained only a single unit on the system and problems were merely conversion from one system to the other.
4. The unit on the metric system was frequently at the end of the textbook. As a result, it was seldom taught. Teachers had little knowledge of the system, and it was omitted because of lack of time. (page 256).

Even though the above comments are directed to the educators in the United States, the situation in Canada is probably very similar. Helgren also indicates what should be done in the field of education to go metric.

1. Teach the metric system by itself so that teachers and pupils learn to think in this language of measure. Do not try to learn or teach the metric system through conversion problems, and do not try to learn conversion factors. Learn the metric system by itself. THINK METRIC.

2. Change mathematics and science textbooks so that only metric units of measure are used.

3. Select one member of the faculty to be the metric authority for the school. He can get the information and materials necessary to enable the school to go metric.

4. Teach the metric system to all prospective teachers, for the change to the new system is not just a mathematics or science project. (Helgren, 1973).

Vietts (1973) points out -

> The initial emphasis in instruction should be placed on teaching the fundamental units -- metre, gram, and litre -- and the prefixes that indicate the multiple and submultiple of ten. (page 270).

Vietts also continues with:

> . . . assignments could include making measurements of parts of buildings, or items in and around the house, and finding perimeters, areas, and volumes in metric measurement. (page 271).

In Branscomb's (1971) review of the "U. S. Metric Study Interim Report on Education," it is reported:

> Students in U. S. schools are not taught to 'think metric'. If they encounter the metric system of measurement at all, it is in connection with science and math classes. Even there, experience with the metric system is cursory and fades soon after the course is completed. Education today simply does not give students a sense of metric measure to take into the world and use. . . . There is no attempt to make the understanding and use of the system instinctive. (page 61).

The U. S. Metric Study makes the following comment about teaching measurement:

> . . . measurement should not and really cannot be 'taught' through a series of planned lessons. Learning to measure (especially in a relatively unfamiliar system) is a gradual process related to each child's experiences. Until a child has had the opportunity to experience in concrete, comparative terms what a gram and a kilogram, or a centimeter and a meter are, the term 'five centimeters plus seven centimeters' is meaningless to him. Again it is much like learning a new language. We have discovered that we cannot teach a new language (which the metric system really is) by teaching the vocabulary and grammar of this language. The most effective way to learn the new language is to use it in meaningful, everyday oral expressions. So too with the metric language, children will learn it best if it is not 'taught' but experienced and used in some activity in the context of situations in which a child is actively involved. (U. S. Metric Study, page 15, 1971).

It is in the context of the above information that in-service programs should be planned and developed. This report further emphasizes that in-service training should be strongly activity based because "teachers generally teach as they are taught" (U. S. Metric Report, 1971).

King and Whiteman, 1973, state that in addition to teaching the metric system of measurement, the in-service should also "stress the teaching strategies of an activity approach to learning." (page 258)

It also states that:

> We believe that a . . . workshop, which actively involves teachers in estimation and measurement activities, can adequately prepare teachers for the task of teaching the metric system. (King and Whiteman, 1973, page 259).

Irving (1972) points out:

> One major concern is the in-service training of elementary school teachers, and it is pointed out that the emphasis should be in the demonstration of teaching strategies and tactics. (page 22).

The review of related readings seems to suggest a number of general implications. Metric Conversion will have effect on several subject areas in the school curriculum. Any subject with measurement sensitive sections may need revision. But in the field of mathematics the implications seem most pertinent. Certainly the subject will be affected in light of the obvious fact that measurement is taught in the mathematics programs. But a change in the approach in teaching strategy in this area is suggested. The inference seems to be that the metric system will afford an excellent opportunity to reassess and modify the approach to teaching measurement. The advantages of approaching the subject from an activity based setting seem to be the main emphasis. Child involvement in the measuring activity is seen as a fitting instructional strategy which will create meaningful learning.

From the review of related research and the researcher's own perception of the problem, the following are seen as the primary implications which metric conversion will have on mathematics.

1. A modified approach to the teaching of measurement which emphasizes involvement and activity.
2. A greater stress on the place value concept.
3. An earlier introduction of the decimal fraction.
4. Increased use and emphasis of estimation.
5. A de-emphasis on involved computation with fractions.

6. In-service training programs for teachers which emphasize activity and the think metric approach so that teachers may gain a facility with metric measure and, as well, an exposure to the activity approach to teaching measurement.

VI. METRICATION IN NEWFOUNDLAND SCHOOLS

A. Introduction

The implementation of the metric system in Newfoundland schools will involve a number of distinct stages. This section will outline a blueprint in the sequential and integrated introduction of these stages. It will consider the following areas as part of this developmental model.

1. The promotion of general awareness among educators.
2. A provincial in-service training program for teachers.
3. Curriculum modification as it relates to both the mathematics program and other curriculum areas.
4. Instructional strategies in the teaching and learning of measurement.

The main emphasis of this study was concerned with the development and provision for an in-service training program conducted on a provincial basis. Evalaution of the effectiveness and the extent to which stated objectives were met is included as well. In addition this section will discuss the modification of the existing curriculum. General approaches to in-service training and teaching methodologies will be discussed in an attempt to emphasize an improved approach to the teaching of measurement and the encouragement of the Think-Metric approach.

B. The Creation of General Awareness

Change is on-going in education. Educators are continually promoting change or are adjusting to change. Often the change is self proposed with the intention to modify existing curriculum, teaching strategies or organizational patterns so as to bring about more effective learning in the classroom. Often change will result from forces from without. The demands made upon the school by society will sometimes result in a modification of the school's program so as to meet the needs and demands of society.

Conversion to the metric system results in a change in the measuring instruments in society. Education is being affected in this case by an external force. This external force will require a change in the program which the school must provide and as well will require a change in the behaviour and thinking of the teachers who are the professional practitioners in the educational community.

Any plan for implementing change should begin by developing a general awareness of the background and rationale for the change. If an appreciation for the why, what and when for the change is not developed then resistance may be more prevalent. In the education community, change agents are instrumental in the promotion and the effecting of modifications.

Superintendents, supervisors, administrators and teachers all fulfill to varying degrees the role of the change agent. Consequently the introduction of the metric system in education might begin by a development among educators in all parts of the province of a general awareness concerning metric conversion. This may be accomplished by meeting with groups of educators to outline basic information and plans and by disseminating material through various educational publications. In effect, it is essential that educators become aware of the reasons for the introduction of the metric system, the progress that Canada is making as a nation, the general directions which the Department of Education plans to make to initiate such a change, and the implications that the metric system will have in the school system and the curriculum.

To accomplish this end it was necessary to meet with groups of educators in various parts of the province. The theme of the address given to these groups was "Metrication - Why - What - When - How.". The researcher met with every superintendent in the province through their regional meetings, every supervisor of instruction, approximately ten groups of principals and about fifteen groups of teachers. No attempt was made to teach these people the metric system. Instead the emphasis lay with the reasons for the change, why the metric system was being adopted, the implications with respect to in-service education and curriculum and the approach that would be taken to metric in-service training and the teaching of measurement. These meetings were held during the months of November and December 1974 and January 1975. They afforded the researcher an opportunity to gain significant feedback on any future directions and were significant inputs into the moulding of an in-service program. They allowed a climate for change to be created, since lines of communication were opened among the various groups. Appendix D contains the transparencies which were used for these presentations which set the tone and general description of the effort.

It is the researcher's opinion that these meetings were invaluable in future activites. Educators understood more fully the rationale for the change and became more amenable to its introduction. These meetings also set the stage for initiation by the Department of Education, since the appropriate channels and lines of authority were considered.

C. A Provincial In-Service Training Program

Metrication has implications for teachers, teaching and children. For teachers, the development of a knowledge of metric units is a necessity. Consequently in-service training should be provided so as to allow teachers to be exposed to the metric system and to gain some facility with it. Although the most obvious objective of such in-service training would be to increase the teachers' knowledge and understanding of the metric system, a more subtle but equally important objective should be the development of a different approach to the teaching of measurement. The in-service training program then should attempt to incorporate measurement activities as a component, so that teachers will have exposure to an activity approach to the learning of measurement concepts.

The provision for in-service training on a provincial basis in the Metric System was done in a relatively short period of time. Since the curriculum is changing as a result of the demand of society, in-service training ought to take place before changes are fully introduced. Consequently one assumption in the development of a provincial in-service training program was that one person cannot provide adequate in-service training for all the teachers of this Province. A structure was to be created whereby a number of teachers in various areas are exposed to metric units to the degree that they may serve as resource people at more localized in-service sessions at the school or district level. In effect, then, a sequenced approach was created whereby the Department of Education supplies the initial leadership and direction resulting in the school boards providing the follow-up activities.

To achieve such a structure the Department of Education sponsored a number of two-day regional conferences throughout the Province. The objectives of these conferences were:

1. To provide initial activity and leadership in the area of in-service education in metrication.
2. To provide key people from various boards exposure to the background information on the metric system, an examination of basic metric units, and an opportunity to work with these units in workshop activities.
3. To provide a basic in-service package which may be incorporated as meaningful input into the in-service programs of schools or boards in this Province.
4. To allow participants the opportunity to discuss the main issues, the implications for the curriculum, and the overall approach of implementation of the metric system in school districts.

The provincial organizational framework for these conferences is shown in Appendix E. A total of five regional conferences was planned. These were designed for junior high school teachers since initial curriculum modification was taking place at that level. The section referred to as "other areas" relates to areas of the Province which could be realistically served by these regional conferences. These include Ramea, Burgeo and parts of the Northern Peninsula and Labrador. A more individualized approach was needed here and this was carried out distinct from the regional conferences.

D. A Major Consideration in the Planning and Development of these Conferences

School boards were notified well in advance of the date of the conference. They needed to be made aware of the objectives of the two-day in-service program so that confusion concerning the intention was eliminated. The following are a set of guidelines which were sent to the school boards.

Guidelines for Selection of Participants

1. Your school board may send five participants to this conference.
2. These five should include four practicing teachers plus one person from the board's central office. This person might act as a future co-ordinator in metric and may evaluate the applicability of the conference in terms of school board follow-up.
3. Since initial activity will take place at the junior high school level, it seems appropriate that teachers of junior and senior high schools should be participants.
4. Since one objective is to provide an initial training seminar on which boards may build more local in-service programs, then the selection of participants might consider the teachers' ability and willingness to become resource people at more local sessions. These people could work in co-operation with the district office in either district or school centered workshops.

It should be noted that the number of participants would vary depending on the size of the school district but that one objective would be to keep the total number at each conference to a limit so that workshop sessions could be effectively conducted.

Another major consideration is the composition of the programs. It was felt that the conference should have variety in topic and effective use of media resources but major emphasis should be placed on activity sessions where teachers actually use metric measuring devices and learn metric by doing.

E. Piloting the Model

Prior to the launching of this provincial in-service program consideration was given to trial testing or piloting the model. This was done in two ways. Firstly, each of the workshops on the various metric units was conducted on four separate occasions in various school board sponsored workshops on the metric system. These took place in Clarenville, St. John's, Baie Verte and Springdale.

These workshops were usually one day in duration. The program was conducted in its entirety by the researcher. The program involved a general session with a slide presentation on the Why, What, When and How of Metric Conversion, followed by three one-hour activity based workshops. The units of length, mass and capacity were covered in these sessions. Active involvement utilizing the equipment available and the workshop sheets provided allowed the teachers to gain a 'feel' for the various metric units. These activities were invaluable, since modification was possible in the activities and the general approach to some of the workshops. Some of the findings as a result of these trial runs which were significant in the development of the program were:

1. It was important to give a general orientation at the beginning of the in-service so as to answer many underlying questions concerning metric implementation. If possible this address should be kept minimumly technical and involve a slide presentation which would outline some humorous considerations with the topic.
2. It was discovered that the best workshops were those that were introduced using a filmstrip on the unit involved. This allowed participants to get a general framework and develop some reference points which were used as aids in the activities.
3. The equipment used also was a topic of evaluation. The single-pan scales for the mass workshop were not at all accurate and, as a result, the effectiveness of this workshop was inhibited. Different types of scales were needed to eliminate this problem.

4. The necessity of a good physical set-up was one tangible recommendation that was learned from the pilot stage. Since the use of media (films, filmstrips and slides) was an integral part of the program, the need for a darkened room was essential. In Baie Verte one of the in-service days produced frustrations as a result of poor preparation on the part of the school board's organizational group. Sixty teachers were crowded into one classroom. No drapes were available and as a result the media component was lost. While the activity sessions went well, the teachers were suffering from the overcrowded conditions. The researcher found the strain intensified greatly by continually having to adjust to difficult conditions.
5. Another thing learned as a result of these pilot workshops was the value and usefulness of a short test at the end of the day. This was very popular and allowed participants the opportunity to see how much they actually learned.
6. It was also realized that the 'Think Metric' approach was accepted but only after involvement in activities took place. When teachers became involved, then they admitted that it was possible to think in terms of metric units and forget the former system.

7. Evaluation sheets were completed by all participants. The single comment which was expressed most often was a positive reaction to active involvement.

It is important to note that each of these four centers received one-day workshops. However, all of the components of a two-day conference were included in at least two of these areas. In other words the program might vary slightly to accommodate the unit of capacity, for example, instead of mass.

The second step in the pilot stage took place on March 13 and 14, 1975, in Grand Falls. A two-day regional conference was sponsored by the Department of Education. This conference saw fifty-eight participants (mainly teachers) from nine school boards in the central Newfoundland area attend the two-day affair. Since no other dates had been set for other regions, this conference could be seen as a trial run. If the format was wrong, the approach not suitable, or the concept itself unworkable, it was still possible to change the directions for other areas. Also it afforded the opportunity to evaluate the components of the program for any minor modifications which might be considered necessary.

A copy of the program developed by the researcher is contained in Appendix F, but in short the conference included a general session on the first day on basic background, four workshops of one-hour duration each over the next two days and a panel discussion and general discussion on implications for teaching and curriculum on the final afternoon.

All of the workshop sessions were organized and developed by the researcher. A copy of each of the workshops on length, mass, capacity, area and volume are contained in Appendix I. The general sessions took the form of a slide presentation combined with relevant films. At the end of each day the participants were given a short test to allow them to judge how much they had learned. These tests were developed by the researcher mainly for the objective of providing motivation and positive reinforcement. A copy of these tests are contained in Appendix H.

The conference was considered by the author to be a very definite success. Evaluation forms were overwhelmingly positive. Only minor modifications were seen necessary at this time. These included the use of the film The Decision as part of the first session and the use of another film other than the one used in the theory and approach section of the morning agenda. A copy of the evaluation form is included in Appendix G. A summary of the evaluation forms developed by the researcher is contained in the next section. Since the objective of the evaluation form was to receive as much feedback as possible to aid with future endeavours, the form was designed to be very open-ended. It did allow however for significant feedback to be received.

As a result of these pilot endeavours the researcher discovered that the program had merit and did provide a comprehensive two-day package on the metric system. Consequently, dates were set for the continuation of the provincial program. The dates for the next three regional two-day conferences were as follows:

April 15 - 16, 1975	-	St. John's Region - 4 school boards
April 29 - 30, 1975	-	Clarenville Region - 7 school boards
May 21 - 22, 1975	-	Corner Brook Region - 7 school boards

The 'other areas' mentioned before will be attempted early in September 1975.

One assumption concerning this program is that school boards will take up from this initial leadership and organize their own follow-up workshop so as to involve more teachers. As a result of the Grand Falls regional workshop, many of the school boards have expressed a willingness to do this. The following summarizes their reaction to this.

1. Follow-up activities can be effected because the participants at the regional conference were the type of people willing to become involved.
2. The provision by the Department of Education of kits of metric materials for follow-up workshops allows activity workshops to be run at a minimum cost to the school district.

3. The booklet, "A Workshop on the Metric System," which was given to all participants was viewed as an excellent summary of the regional conference. It would allow teacher involvement in follow-up activities with a minimum of preparation required by the teacher.
4. It was deemed necessary that the provincial metric consultant be made aware of the progress of follow-up activities so that he might monitor progress on a provincial basis.

As of three weeks after the Grand Falls regional meeting, only one board had done follow-up workshops. However, five others were actively involved in planning such workshops. Others had indicated that for administrative and other reasons they wished to conduct their program early in the 1975-76 school year. Since this initial feedback several developments have arisen which indicate a willingness on the part of the school boards to become committed to the introduction of this change. Two more school boards, one at Grand Falls, the other at Gander, have held follow-up workshops. Three others have set up committees to plan for workshops in September. The Notre Dame Integrated School Board has set September 24, 25, and 26 to service their geographically large district. They have requested the author to serve as a support resource person in this activity.

F. Summary of the Evaluation of Pilot Regional Conference

In order to gain relevant feedback from the pilot regional conference, an evaluation form for each day was made available to each participant. The evaluation forms were kept general and open-ended so as to allow for the widest scope in comments received. The objective at this point was to receive as much feedback as possible in the greatest detail as possible. Copies of the evaluation forms are contained in Appendix G. A summary of the comments received are contained below.

The general session on Day One was received very well. Most people found the talks interesting and informative. It was the general feeling that this type of background was necessary in order to create a necessary awareness for the overall implications. Comments like "The session gave me fuller realization of the background behind why Canada is going metric," were common reactions to the first session. Many expressed the view that the "theory and approach" session set the stage for the workshops and also brought the metric system into context with respect to education. The only slightly negative reactions involved the style of presentation employed by the Director of Metric Conversion (see Appendix F) and the detail into which he went with various concerns at the federal level. Some thought that this tended to cause the session to drag.

The evaluation forms allowed for a separate reaction to each of the workshops. The most predominant positive comments concerned the use of the filmstrips as a means to introduce and "set up" the workshops and the activity element of each session. Each evaluation form expressed in some way the usefulness of active involvement on the part of the participants. Comments like "I like the active involvement," or "We weren't talked to, we were involved," occurred very often throughout the sheets. Also many expressed the view that they began to 'Think Metric' and to gain an appreciation for the metric units. Many expressed the view that estimation as a prelude to measuring was an excellent instructional strategy.

One very definite criticism came out of the mass workshop. The inaccuracy of the single-pan scales was pointed out by many, and this technical problem seemed to impede the success of this workshop. Others felt that there was not sufficient time to complete all of the activities.

The final session on Day Two was general in nature. It was designed to give the participants an opportunity to discuss what they saw, what they considered were some problems to be faced and a general opportunity to ask questions. This section of the agenda was very unstructured beforehand but ran very smoothly. The evaluation forms showed a very positive reaction to this section. People expressed the view that many of their questions were answered and also that it was a fitting occasion to gather together some conclusions which may have been drawn over the two-day period. The feedback on this section was most positive despite the fact that it was designed as a general "talk" session with no activities.

The evaluation form also asked for a rating of the two-day conference in general. There were a total of fifty-eight participants in this conference. They were asked at the end of the evaluation form to rate the conference as Excellent - Good - Fair - Poor. 81% indicated that they considered the conference as excellent and 19% considered it to be good. Some general comments at the end included: "Must be the best workshop I've every attended," and "I now have a completely new outlook on how to introduce metric." These types of comments were not isolated cases but seemed to indicate a very positive reaction.

Subsequent to the pilot conference in Grand Falls the following changes have been made as a result of the experiences gained.

1. The first session will be modified to include the film, The Decision, a Metric Commission publication on metric conversion in Canada.
2. The film, The Metric System, used in the second half of the morning session will be changed and The Measure of Man will be used instead.

3. The single-pan scales will have to be replaced with more accurate ones.
4. All the activities in each workshop will be reviewed so as to eliminate repetition and thus cut down on their duration.

These modificatinns are mainly mechanical in nature and may appear trivial. However they were significant components of the total success of this in-service package. It was felt that the essence and germ of the two-day in-service program was sound and that the basis of the program needed minimum change and would serve well in future conferences.

VII. CONCLUSION

In conclusion, the program of in-service education on the metric system is now ready to be implemented throughout the rest of the Province. The program has been developed slowly as a result of inputs from the general awareness program which was conducted at the beginning, and the pilot testing which was carried out in January and February of this year.

It is important to note that this program involves only junior high school teachers. In-service education must also be provided on a provincial basis for elementary school teachers. The plan at this point is to devote the 1975-76 school year to this end. Whether the organizational framework to conduct this program will be a duplicate of the one now being conducted will be decided as a result of the experiences gained over the next several months, as well as an evaluation of the needs and capabilities of the various school boards in this regard. An in-service program for elementary teachers will be conducted but its format has not at this point been finalized.

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APPENDIX A

APPENDIX A

SEVEN BASIC SI UNITS

	Attribute	Name	Symbol
1.	Of length	the metre	m
2.	Of mass	the kilogram	kg
3.	Of time	the second	s
4.	Of electric current	the ampere	A
5.	Of temperature	the kelvin	K
6.	Of light intensity	the candela	cd
7.	Of modular substance	the mole	mol

TWO SUPPLEMENTARY UNITS

1.	Of a plane angle	the radian	rad, (^{r})
2.	Of a solid angle	the steradian	sr

APPENDIX B

APPENDIX B

LIST OF METRIC PREFIXES AND THEIR SYMBOLS[1]

Prefix	Factor by which the unit is multiplied	Symbols
tera	10^{12}	T
giga	10^{9}	G
mega	10^{6}	M
kilo	10^{3}	k
hecto	10^{2}	h
deca	10^{1}	da
deci	10^{-1}	d
centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a

[1]The prefixes, detailed rules, symbols and spellings are found in Canadian Standards Association, <u>Metric Practice Guide</u> (Rexdale, Ontario: Canadian Standards Association, 1973).

APPENDIX C

National Metric Conversion Committee Structure

APPENDIX C

Metric Commission
Commission du système métrique

Steering committees
Comités directeurs

sectoriels

1	2	3	4	5	
Air transport / Transports aériens	Iron & steel mills & foundries / Sidérurgie et fonderies de fer	Electrical / Fabrication d'équipement électrique	Mines / Mines	Construction / Construction	Agr… & … / Agr… et p…
Railway transport / Transports ferroviaires	Metal fabricating / Fabrication des produits en métal	Radio, television, communications, electronic equipment & parts / Radio, télévision, communications, équipement électronique et pièces	Petroleum & natural gas industry & services / Industrie du pétrole, du gaz naturel et services	Non-metallic mineral products / Produits minéraux non métalliques	Foo… / Alir…
Water transport / Transports par eau	Machinery / Fabrication de machines	Aircraft & aircraft parts manufacturers / Fabricants d'aéronefs et de pièces	Petroleum refineries, wholesalers & gasoline service stations / Raffineries de pétrole, grossistes en essence et stations-service	Structural & architectural metals / Charpente métallique et produits métalliques d'architecture	Bev… / Boi…
Bus & truck transport & storage / Transports par autocar, camionnage et entreposage	Motor vehicle & parts manufacturers / Fabrication de véhicules automobiles et de pièces		Natural gas distribution & transport / Transport et distribution de gaz naturel	Engineers / Ingénieurs	Tob… / Pro…
Communications / Communications	Truck body, trailer & miscellaneous vehicle manufacturers / Fabricants de carrosseries de camions; fabricants de remorques et véhicules divers		Non-ferrous metals / Transformation des métaux non ferreux	Real estate, land surveyors and town planners / Immeubles, arpenteurs et urbanistes	
Electric power / Énergie électrique	Railroad rolling stock / Matériel ferroviaire roulant		Rubber & plastic products / Produits en caoutchouc et en matière plastique		
Meteorology / Météorologie	Shipbuilding & boatbuilding / Construction de navires et d'em-		Chemical & chemical products / Produits chimiques		

Structure nationale des comités de conversion au système métrique

6
- Agriculture, fishing & trapping / Agriculture, pêche et piégeage
- Food / Aliments
- Beverages / Boissons
- Tobacco products / Produits du tabac

7
- Textiles / Textiles
- Clothing / Habillement
- Leather / Cuir
- Miscellaneous manufacturing industries / Industries manufacturières diverses

8
- Forestry / Forêts
- Wood / Bois
- Furniture & fixtures / Meubles et articles d'ameublement
- Paper & allied industries / Industries du papier et activités annexes
- Printing & publishing / Imprimerie, édition

9
- Health & welfare / Services médicaux et sociaux
- Amusement & recreation / Divertissements et loisirs
- Services to business management / Services fournis aux entreprises
- Accommodation & food services / Hébergement et restauration
- Consumers, home economics & retail trade / Consommateurs, économie domestique et commerce de détail
- Labour organizations / Syndicats ouvriers
- Personal services / Services personnels

10
- Elementary & secondary schools / Écoles primaires et secondaires
- Vocational centres, trade schools & business colleges / Centres de formation professionnelle, écoles de métiers et collèges commerciaux
- Post-secondary non-university educational institutions / Établissements d'enseignement post-secondaire non universitaire
- Universities & colleges / Universités et collèges

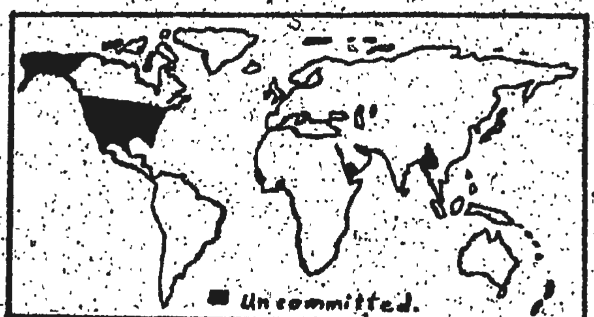
11
- Federal government interdepartmental committee for metric conversion / Comité interministériel fédéral de la conversion au système métrique

APPENDIX D

WHY GO METRIC?

1. For the sake of:

INTERNATIONAL TRADE AND COMMUNICATIONS.



The Metric Global Village.

95% of all countries are Metric
90% of world's population uses Metric
80% of World Trade uses Metric
50% of Canadian manufactured goods go to Metric countries

■ Brunei, Burma, Liberia, Sierra Leone, Southern Yemen, and the United States of America.

2. SI has just a few easily defined units.

3. The multiples and sub-multiples are powers of ten.

4. There is a direct relationship between the units of length, mass and volume.

5. The multiples accord with our number system.

6. Most other countries are already metric.

7. Increased accessibility of data.

SELECTED DATES IN METRIC HISTORY

1795 - Introduced in France.

1866 - Metric units legal in England

1873 - Metric units legal in Canada.

1875 - 17-Nation Metric Convention in Paris, established The International Bureau of Weights and Measures.

1960 - Paris Conference adopted the "Systeme International d'Unites" (S.I.)

1965 - Government of United Kingdom decreed conversion to metric by 1975.

1968 - U.S.A. Government set up Committee.

1970 - Federal Government issued a "White Paper" "... The eventual adoption of the metric system should be an objective of Canadian policy."

1971 - Appointment of Mr. S. M. Gossage as Chairman of The Canadian Preparation Commission for Metric Conversion.

1971 - Canadas' Consumer Packaging and Labelling Act requires metric values in retail packaging.

1972 - U. S. Senate approved metric conversion bill.

1974 - U. S. House of Representatives stalled passage of the bill.

S.I.

SYSTÈME INTERNATIONALE D'UNITES

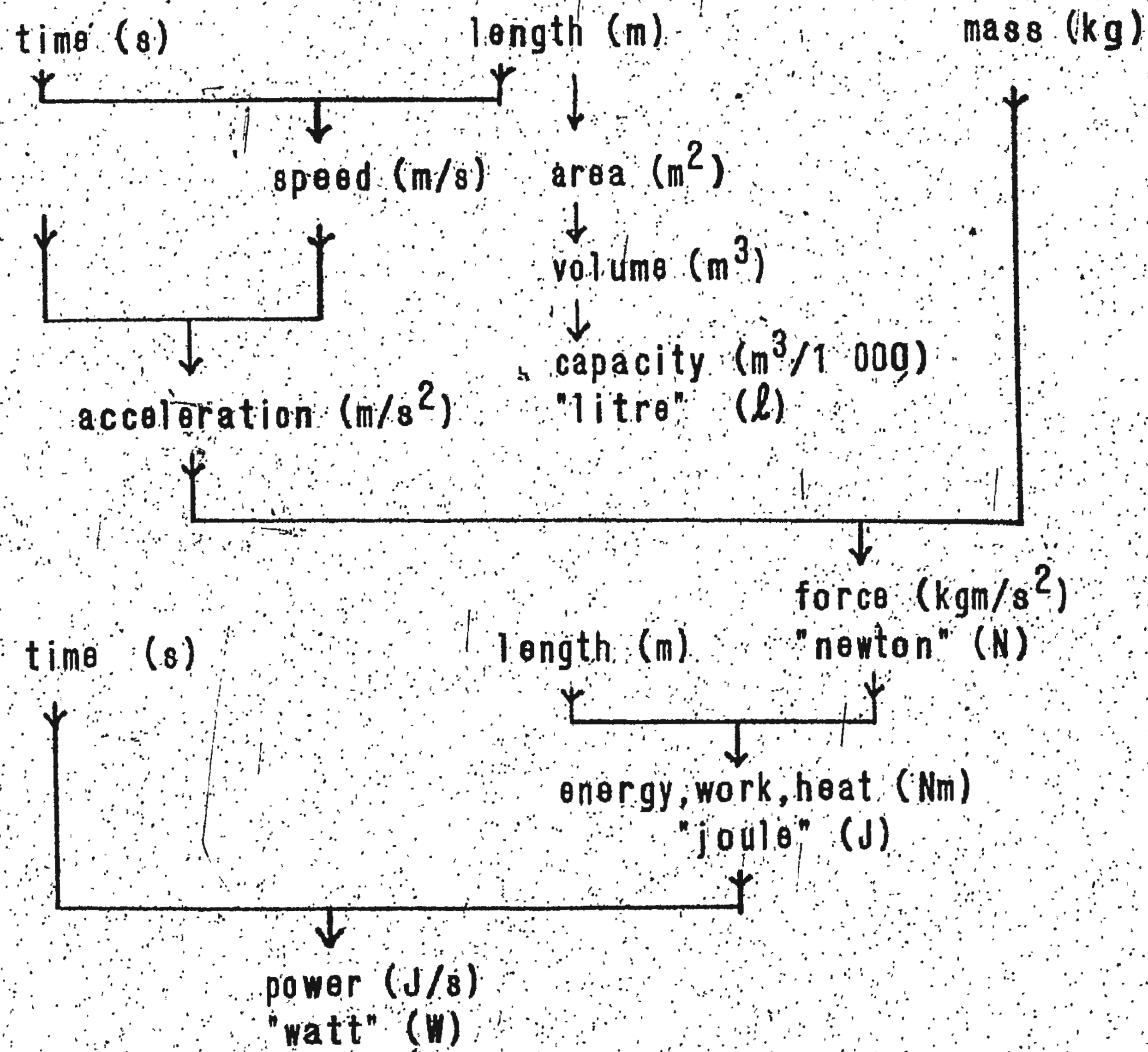
SEVEN BASIC SI UNITS.

Attribute	Name	Symbol
1. Of length	the metre	m
2. Of mass	the kilogram	kg
3. Of time	the second	s
4. Of electric current	the ampere	A
5. Of temperature	the kelvin	K
6. Of light intensity	the candela	cd
7. Of modular substance	the mole	mol

TWO SUPPLEMENTARY UNITS.

1. Of a plane angle	the radian	rad, (^{r})
2. Of a solid angle	the steradian	sr

SOME DERIVED UNITS.



pressure: force per area (N/m^2)
"pascal" (Pa)

SI PREFIXES

Prefix.	Multiplying factor	Symbol
tera-	10^{12}	T
giga-	10^{9}	G
mega-	10^{6}	M
kilo-	10^{3}	k
hecto-	10^{2}	h
deca-	10^{1}	da
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ
nano-	10^{-9}	n
pico-	10^{-12}	p
femto-	10^{-15}	f
atto-	10^{-18}	a

MOST COMMON UNITS IN METRIC

QUANTITY	UNIT	SYMBOL
LENGTH	METRE	m
VOLUME	LITRE	l
MASS	KILOGRAM	kg
TIME	SECOND	s
TEMPERATURE	DEGREE CELSIUS	°C

World Wide Conventions

THE INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

RECOMMENDATION R1000 (1969)

SYMBOLS:

mm	cm	dm	metre m	dam	hm	km
m		d	litre			k
mg			gram g			kg

A symbol is not an abbreviation,
not followed by a period,
not pluralized,
has a space between numeral and symbol,
e.g. 152 g

DECIMAL NOTATION:

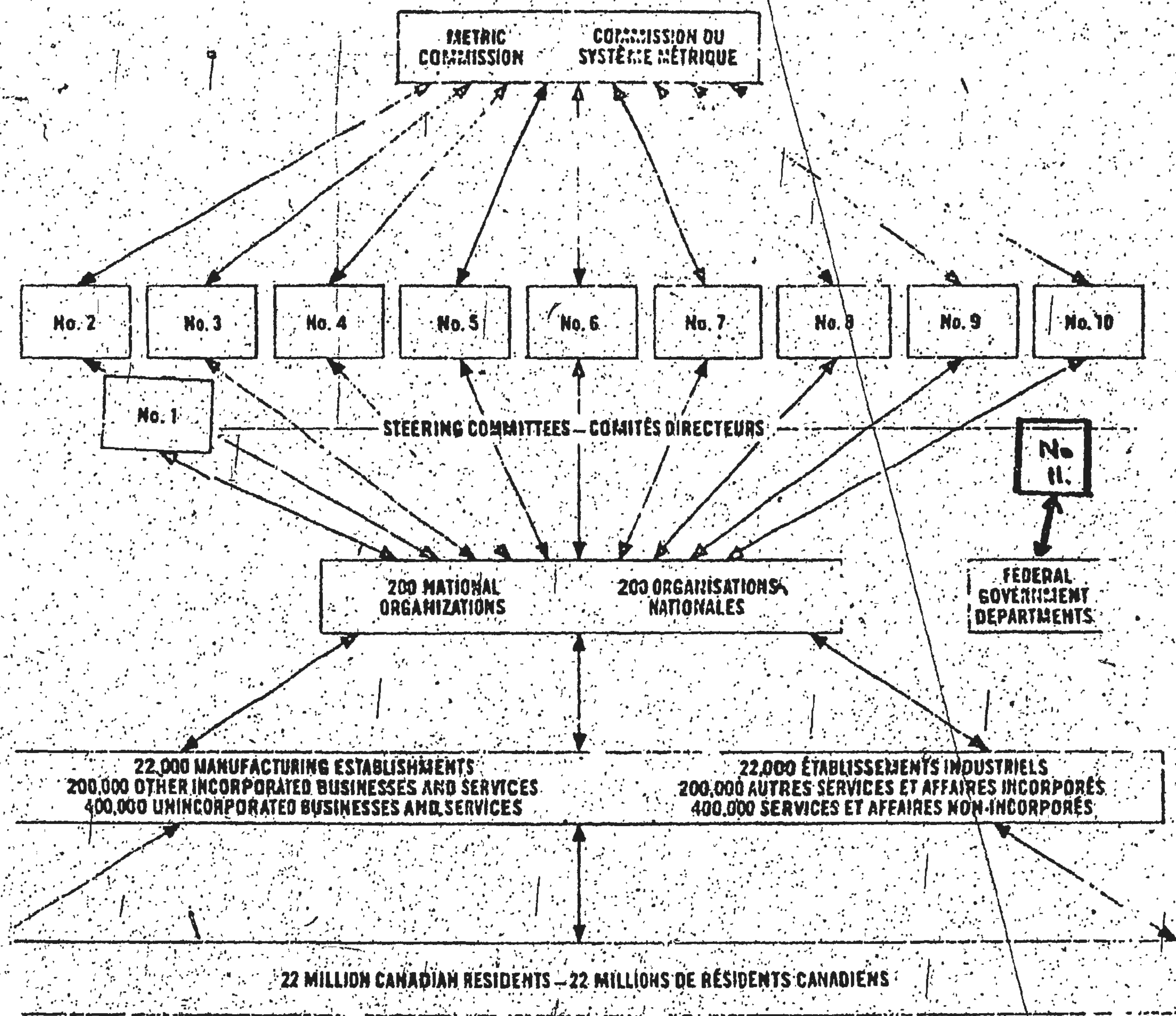
Spaces, not commas, between periods of 3 digits,
e.g. 6 946 572.408 69

Decimal point is a period or a comma

Initial zero before the decimal point for numbers less than 1, e.g. 0.54 or $0.75

WHEN ?

NOW



White Paper on Metric Conversion in Canada.
January 1970.

THINK METRIC

APPENDIX E

APPENDIX E

REGIONAL CONFERENCES -- METRICATION

EAST	CENTRAL	WEST	ST. JOHN'S	LABRADOR	OTHERS
6-10 people per district	6-10 people per district	6-10 people per district	4-12 people 4 districts	3 districts	Individual Workshops
LOCAL INSERVICE	LOCAL INSERVICE	LOCAL INSERVICE	LOCAL INSERVICE	LOCAL INSERVICE	LOCAL INSERVICE

Note: Local Inservice would involve District People with Department Consultant.

EAST	CENTRAL	WEST
Conception Bay Centre	Exploits White Bay	Bay St. George
Conception Bay North	Gander Bonavista	Humber - St. Barbe
Avalon North	Green Bay	Deer Lake
Pentecostal	Exploits Valley	Bay of Islands - St. George's
Burin R. C.	Notre Dame	St. Barbe South
Burin Integrated	Terra Nova	Channel - Port aux Basques
Placentia - St. Mary's	Cape Freels	Port au Port
	Bay d' Espoir	Pentecostal
	Pentecostal	

LABRADOR	ST. JOHN'S	OTHERS
Labrador R. C.	St. John's R. C.	Vinland
Labrador East	Avalon Consolidated	Straits of Belle Isle
Labrador West	Ferryland R. C.	Burgeo
	Conception Bay South	Ramea

APPENDIX F

METRIC CONFERENCE

CENTRAL NEWFOUNDLAND REGION

Sponsored by

DEPARTMENT OF EDUCATION

March 13th., 14th., 1975

Grand Falls

DAY 1 — 1ST. SESSION — MORNING

09:30 – 10:00	**OPENING REMARKS** – Greeting from Minister of Education Honourable Gerald Ottenheimer
10:00 – 11:15	**GENERAL SESSION** – Metric Conversion — A General Overview A. J. Cochrane, Director, Metric Conversion
11:15 – 11:30	**COFFEE BREAK**
11:30 – 12:15	**THE METRIC SYSTEM** – Theory and Approach – George Williams, Metric Consultant
12:15 – 14:00	**LUNCH BREAK**

2ND. SESSION — AFTERNOON

14:00 – 15:00	**WORKSHOP NO. 1** – Linear Units – George Williams 25 Participants
	WORKSHOP NO. 2 – Mass Units – Sharon Basha 25 Participants
15:15 – 16:15	**WORKSHOPS ON LENGTH AND MASS** Repeat – Groups Switch

EVALUATION OF FIRST DAY'S PROGRAM

DAY 2 — 1ST. SESSION — MORNING

09:15 – 10:30	WORKSHOP NO. 3 – Capacity, Area, Volume George Williams – Sharon Basha 2 Group Sessions
10:30 – 10:45	COFFEE BREAK
10:45 – 12:00	INTERRELATIONSHIPS AMONG UNITS AND CELSIUS TEMPERATURE
12:00 – 13:30	LUNCH BREAK

2ND. SESSION — AFTERNOON

13:30 – 14:15	MEDIA – Films and Filmstrips
14:30 – 16:00	GENERAL SESSION Discussion on 1. Curriculum Modification 2. Teaching Methodology 3. Follow-up Activities 4. Implications for Mathematics

EVALUATION OF SECOND DAY'S SESSION

M E T R I C
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M E T R I C
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M E T R I C

APPENDIX G

APPENDIX G

EVALUATION SHEET

Metric Conference
Grand Falls -- March 13-14, 1975

DAY 1

General Session -- Morning

1. Were the objectives of this session made clear?
2. Did the speakers fulfill the objectives?
3. What do you consider to have been positive aspects of this session?

____

____

4. What areas do you consider to be done poorly?

____

____

5. Additional comments on the first sessions.

____

____

Workshop on Length

1. Were the objectives made clear?
2. Did the workshop fulfill these objectives?
3. What did you consider were positive aspects of this session?

____

____

4. What aspects of this workshop were done poorly?

____

____

5. Did the activities help you begin to Think Metric?

6. Additional comments on the length workshop.

____

____

____

Workshop on Mass

1. Were the objectives of this session made clear?

2. Did the speakers fulfill the objectives?

3. What do you consider to have been positive aspects of this session?

____

____

4. What areas do you consider to be done poorly?

____

____

5. Did the activities help you begin to Think Metric?

6. Additional comments on the mass workshop.

____

____

____

DAY 2

Workshop on Area and Celsius Temperature

1. Were the objectives made clear?

2. Did the workshop fulfill these objectives?

3. What did you consider were positive aspects of this session?

____

____

4. What aspects of this workshop were done poorly?

____

____

5. Did the activities help you begin to Think Metric?

6. Additional comments.

____

____

____

Workshop on Capacity and Volume

1. Were the objectives made clear?

2. Did the workshop fulfill these objectives?

3. What did you consider were positive aspects of this session?

____

____

4. What aspects of this workshop were done poorly?

____

____

5. Did the activities help you begin to Think Metric?

6. Additional Comments.

General Session -- Afternoon

1. Were the objectives of this session made clear?
2. Did the session fulfill these objectives?
3. What did you consider were the positive aspects of the session?
4. What aspects were covered poorly or not at all?
5. Additional comments.

Additional comments on 2 day conference.

How would you rate the conference?

Excellent ___ Good ___ Fair ___ Poor ___

APPENDIX H

APPENDIX H

At the end of each of the two days of the metric conference a short test was provided to allow participants to judge how well they were doing in the process of metrication. The test was relatively simple in nature but did relate directly to thinking metric and to the activities in which they had been involved.

The test was a very popular component of the program and supplied a type of reinforcement for the teachers as well as motivation for learning more. The tests served then as a post test to the activities and most teachers found it stimulating in trying to do as well as they could. The tests used for this purpose are reproduced in this appendix.

APPENDIX H

CAN YOU THINK METRIC?

Test — Day 1

1. A metre is about the height of:

    a. a door
    b. a kitchen counter
    c. a chair seat

2. A new lead pencil is about:

    a. 50 millimetres
    b. 100 millimetres
    c. 200 millimetres

3. The width of a telephone book is about:

    a. 22 cm
    b. 50 cm
    c. 73 cm

4. The width of a dollar bill is about:

    a. 15 cm
    b. 12 cm
    c. 7 cm

5. The thickness of a dime would be about:

    a. 5 millimetres
    b. 1 millimetre
    c. 0.1 millimetre

6. The height of a chair seat is approximately:

    a. 50 cm
    b. 100 cm
    c. 1000 cm

7. The length of this line is about ______________________________

    a. 4 cm
    b. 7 cm
    c. 13 cm

8. The height of an ordinary wall is about:

   a. 5 m
   b. 2.5 m
   c. 7 m

9. The length of this page is approximately:

   a. 30 cm
   b. 20 m
   c. 50 cm

10. A gram is about the weight of:

    a. an apple
    b. a dime
    c. an unused piece of chalk

11. A new born baby weighs about:

    a. 3 kilograms
    b. 30 kilograms
    c. 300 kilograms

12. A litre of water weighs about:

    a. 10 g
    b. 100 g
    c. 1000 g

13. A slim bride would weigh about:

    a. 80 kg
    b. 50 kg
    c. 120 kg

14. The mass of a large apple would be approximately:

    a. 1 kg
    b. 150 kg
    c. 800 kg

15. The width of one lane of a highway is about:

    a. 10 m
    b. 15 m
    c. 4 m

16. A heavyweight boxer would weigh approximately:

    a. 200 kg
    b. 95 kg
    c. 70 kg

17. The height of a tall man is about:

    a. 20 centimetres
    b. 2 metres
    c. 1000 centimetres

18. A race horse has a mass of approximately:

    a. 500 kg
    b. 100 kg
    c. 200 kg

19. The symbol for kilogram is:

    a. Kg
    b. kg
    c. kg.

Test -- Day 2

1. The symbol for the standardized metric system is:

   a. MKS   c. SI
   b. CGS   d. MSU

2. The meanings of milli, centi and kilo respectively are:

   a. 1000; 100; 10   c. 10; 100; 1000
   b. 0.001; 0.01; 1000   d. 1000; 100; 0.001

3. A measuring cup will hold about:

   a. 2 millilitres   c. 250 millilitres
   b. 25 millilitres   d. 1 litre

4. The symbol for centimetre is:

   a. cc   c. cm.
   b. CM   d. cm

5. The area of this sheet of paper is about 6 square:

   a. metres   c. centimetres
   b. decimetres   d. millimetres

6. Water freezes and boils respectively at:

   a. $32^{o}C$ and $212^{o}C$ c. $0^{o}C$ and $100^{o}C$
   b. $100^{o}C$ and $200^{o}C$ d. $0^{o}C$ and $10^{o}C$

7. A litre of water has a mass of about:

   a. 100 grams   c. 1000 millilitres
   b. 10 grams   d. 1000 grams

8. The volume of an average-sized marble is about 1.5 cubic:

   a. millimetres   c. decimetres
   b. metres   d. centimetres

9. The base unit of capacity in the metric system is the:

   a. gram   c. metre
   b. litre   d. cubic centimetre

10. The meanings for deci and deca respectively are:

   a. 10; 0.1   c. 100; 0.01
   b. 0.01; 10   d. 0.1; 10

11. The volume of air in the average classroom would be about 200 cubic:

   a. centimetres   c. millimetres
   b. metres   d. decimetres

12. One teaspoonful of cough syrup would be about:

   a. 0.5 millilitres   c. 5 millilitres
   b. 1 millilitre   d. 10 millilitres

13. A millilitre of water has a volume of 1 cubic:

   a. decimetre   c. metre
   b. centimetre   d. millimetre

14. Normal body temperature is about:

   a. 51.2°C   c. 36.5°C
   b. ~~42.7°C~~   d. 28.5°C

15. The length of a swimming pool built to olympic standards would be about:

   a. 5 metres   c. 0.5 kilometres
   b. 50 metres   d. 500 metres

APPENDIX I

APPENDIX I

Each participant at a metric regional conference was supplied at the end of the two day inservice with a booklet, prepared by the Metric Consultant, entitled A Workshop on the Metric System. This booklet was intended to do two things in particular. Firstly, it served as a fairly comprehensive review of the two day program outlining many of the main points which were discussed and containing many of the handouts and work sheets which were used during the conference. It was designed to serve as well as a resource book upon which follow-up-inservice could be moulded. Teachers and supervisors could now organize local inservice utilizing any of the ideas, activities and approaches suggested in this workshop which they deemed applicable. This booklet is, I feel, a vital component to the successful follow-up to the regional conferences which were held. This booklet is provided in this appendix.

A WORKSHOP ON THE METRIC SYSTEM OF MEASUREMENT

SI

M E T R I C

T
H
I
N
K

Prepared by
George Williams

Introduction

This handbook has been prepared to provide a basic guide for follow-up workshops at the local level. It will provide participants at regional conferences with a resource book containing many aspects covered in the two day program. It will hopefully then serve to give directions and guidance in future workshops. To this end many of the pages utilize large print so as to serve as masters for overhead transparcies. The booklet also contains a complete list of the activities conducted during the various workshop sessions.

The booklet is in no way a completely final document. Localized in-service projects may wish to expand or modify some of the program which is outlined in light of particular needs. It does however allow resource people to have a reference from which to mould their own in-service programs.

The workshop booklet contains a number of sections. Many of the more general points covered in the conference are discussed in the first section. A collection of possible overhead transparacy masters are outlined in Section Two. Section Three contains the activity workshops on length, mass, capacity, area, volume and interrelationships. Some general topics are discussed in the latter part of the guide in an effort to give further general background.

Going Metric

By introducing the White Paper on Metric Conversion in January 1970, the Federal Government began the process of the eventual adoption of the metric system in Canada. The White Paper says that adoption of the metric system is "utimately inevitable and desirable for Canada".

The Government White Paper includes the following broad principles:

1. The eventual adoption in Canadian usuage of a single coherent measurement system based on metric units should be acknowledged as inevitable and in the national interest.

2. This single system should come to be used for all measurement purposes.

3. Planning and preparation in the public and private sectors should be encouraged in such a manner so as to achieve maximum benefits at minimum cost to the public, to industry and to government at all levels.

With reference to the above guidelines, no specific time for conversion was set in the White Paper. To initiate and co-ordinate Metric Conversion in all sectors of the economy the Federal Government established in June 1971 - the Metric Commission. This organization is charged with the responsibility of overseeing conversion to the Metric System in Canada. It was established to fulfil the following objectives:

(a) To initiate, co-ordinate and undertake investigations and studies relating to implications of conversion to the metric system in different sectors of the economy.

(b) To prepare an overall program for conversion in the metric system which will ensure a co-ordinated effort in order that
- (i) the benefits of conversion are achieved at minimum cost
- (ii) conversion to the metric system as a whole is effected to the best advantage to Canada

(c) furnish, publish and disseminate information concerning conversion to the metric system.

The introduction of the Metric System for Canada has implications for Education. The Department of Education hopes to provide a leadership role in the areas of in-service education and curriculum implementation. To accomplish these broad aims the following plans have been initiated and will evolve over the next two years.

1. In-Service training will be initiated in the form of a number of regional conferences. These two day training seminars will be held in various parts of the province, firstly for junior high school teachers and later for Elementary teachers.

2. Localized in-service will be encouraged as a result of these conferences. Participants at regional conferences will act as leaders in metrication in their schools or districts.

3. Curriculum change will begin at the junior high school level in the 1975-1976 school year and in the 1976-1977 school year for primary grades.

4. Interim guidelines for teachers will be prepared outlining suggestions with respect to instruction in metric during the initial changeover period.

There are other areas which will need consideration as well. The promotion among teachers of a general awareness of the metric system and its implications for education is a necessary concern. The approach to learning the metric system is another important area. As will be suggested by the activities which follow in this booklet the approach to learn the new system will be one of encouraging people to "Think Metric". This in effect treats the metric system as a separate distinct system in itself and necessitates the learning of a new language of measurement.

WHY GO METRIC

The metric system has many benefits, the most obvious of which is its decimal nature. First, to convert from a small unit of measure or vice versa it is necessary only to divide or multiply by 10, 100, 1000 and so on. Secondly, with increasing adoption of the system internationally, the metric measures have precisely the same significance in every country. In general then reasons for going metric can be seen from the two points of view - Simplicity and Universality.

WHY IS IT INEVITABLE?

In the field of trade and commerce, 80 per cent of the world trade is conducted in the metric system. Many Canadian companies are already deeply involved with metric measurements, particularly those that export to Europe, South America, or the emerging nations of Asia and Africa. More than 50 per cent of Canadian manufactured goods are exported to metric countries. The need for Canada to adopt a universal system of measurement has become urgent if we are to maintain our position as one of the major trading nations of the world. Canada must be prepared to supply its goods in the manner that importing countries desire, which is more and more in the metric system.

Secondly, over 95 per cent of the world's population uses, or is converting to, the metric system. Countries like India, China and Japan have adopted the metric system in recent years while Australia, New Zealand, Ceylon, Ireland and Britain are well advanced toward complete metric conversion. A commitment should be forthcoming shortly in the United States to go metric as well. In July, 1971, a very comprehensive report was sent to Congress strongly recommending the United States government to adopt the metric system of measurement. As of early 1974, almost all multinational American corporations are committed to converting inside the USA.

Thirdly, the change to the metric system in commerce, industry and science appears inevitable because the world is rapidly becoming a close-knit society and Canada cannot afford to remain in isolation. Canada really has no other choice but to go metric. Industry will benefit from improved trading abilities and opportunities in world markets. The major Commonwealth countries, key outlets for Canadian manufactured goods, are all going metric. A survey conducted by the Canadian Standards Association revealed that more than 95 per cent of Canadians polled could see an advantage to switching to the metric system.

WHY IS IT IN THE NATIONAL INTEREST?

The majority of Canadian business and industrial leaders favor adopting the metric system. The inch-pound system is a costly drawback for companies producing equipment for metric countries because drawings and specifications have to be converted to metric measurements.

Metric measure is now international in medicine, and Canada's pharmaceutical industries have used it for some years. The Canadian Hospital Association estimates that fully 85 per cent of Canada's hospitals are either ~~using~~ the system or implementing conversion.

Secondly, exports should increase five to 10 per cent if Canada adopts the metric system.

Thirdly, the longer we wait, the greater the cost of conversion will be.

Fourthly, adopting the metric system can benefit industries in two important ways:

(a) It offers an excellent opportunity to re-examine and streamline the whole method of operation. In Britain, for example, the fastener industry reduced the number of nuts and bolts to do a job from about 60 varieties to only nine varieties. The changeover therefore offers a great opportunity to simplify and improve production efficiency. In Britain, Lord Ritchie-Calder, chairman of the Metrication Board, had some optimist comments on the changeover:
"It is an opportunity for spring cleaning. We are concerned that the change to metric should be the occasion for improvement in quality of life. We look for more intelligible units of sale, better designed, more rational packaging and greater ease in calculating unit costs to ensure value for money."

(b) When it comes to stocking materials and components, the varieties one needs to carry as a result of working in metric units are substantially reduced. Reports from Britain indicate that the saving on inventory normally exceeds the cost of carrying Imperial system spare parts during the transition period.

WHY IS IT A SINGLE COHERENT SYSTEM?

It is the application of the decimal number system to measurements.

This means that converting from one unit of metric measurement to another within the system is just a simple matter of moving the decimal point either to the right or left. The units that the metric system employs are almost always related by powers of 10. For example, the metre, the basic usit of length in the metric system, is equal to 10 decimetres, or 100 centimetres, or 1000 millimetres. Therefore, converting 36.81 metres to centimetres requires only shifting the decimal point two places to the right.

Also, the metric system utilizes a consistent system of prefixes to designate multiples and submultiples of its basic units. Greek-derived prefixes are assigned to the multiples ("deca" equals multiplication by 10, "kilo" equals multicipation by 1000). Latin prefixes are assigned to the submultiples ("deci" equals division by 10, "centi" equals division by 100, and so on).

Secondly, over the years the General Conference on Weights and Measures has steadily extended and refined the metric system. In 1960 the Conference adopted the International System of Units (Systeme International d'Unites or SI). At present SI rests on seven "base" units for measurement and two supplementary units.

SI derives the units for all the quantities needed in science, technology, and everyday life from the seven base units. In contrast there are 53 denominate units of measure in the Imperial system and there is no definite pattern in the relationship of the units. The customary Imperial units are non-systematic with respect to multiples and submultiples: the relation between cups, quarts, gallons, hogsheads, and barrells; the relation between inches, feet, yards, rods, and miles must all be memorized.

Thirdly, the metric system allows a saving of up to 20 per cent in calculation time when compared with the Imperial system. Teachers of mathematics will agree that an important percentage of a child's time and the teacher's as well, could be saved in arithmetic courses if the simple, interrelated metric decimal units were substituted for the Imperial system of measure. Such monstrosities as proper and improper fractions, numerators, least common denominators, greatest common divisors, and mixed numbers can be forgotten and replaced with the decimal system.

Fourthly, the interrelationship of the basic units makes the metric system coherent. To illustrate:

A cube of water at 4°C 10 centimetres by 10 centimetres by 10 centimetres weighs 1 kilogram and holds 1 litre or 1000 cm^3.

Similarly:

1 millilitre (1 cm^3) has the mass of 1 gram when filled with water at 4°C.

CONCLUSION

In conclusion the metric system:

(a) is a simple method by which to communicate measurements;
(b) achieves a high degree of accuracy in all measurements;
(c) lays down a basis for deriving from the base units, in a coherent way, all other units that might be necessary.
(d) has precisely the same significance in every country;
(e) rationally relates all measures; and
(f) offers an opportunity to standardize in industry.

SEVEN BASIC SI UNITS.

Common Everyday Metric Units

The metre (m)

The base unit of length is the metre. Originally this was intended to be one ten-millionth of the distance from the equator to the North Pole. The metre was later defined as the distance between two lines engraved on a metal bar near Paris. Today the metre is defined in terms of krypton radiation. For practical purposes in the classroom the metre simply becomes the length of a metre stick.

Reference should not be made, any more than is necessary, to imperial versions of metric units. However, for those who are steeped in the imperial system some comparison is bound to be made. For these "oldtimers" the metre might be described as about 10% longer than the yard. This kind of description should not be stressed with young students if mentioned at all.

Common objects or familiar markings can act as the most meaningful visual representations of the metre. It might be described roughly as half the height of a door, the width of a single bed, the height of a three-drawer filing cabinet, the perimeter of this page, or the height of a man's hip, a woman's waist, or a young teen's bottom rib above floor level.

The litre (l)

One tenth of a metre (0.1 m) is called a decimetre (dm) about the width of a fist. If a cube is made with each edge 1 dm (decimetre) long the cube has a volume of 1 cubic decimetre (dm^3). This volume is nicknamed the litre (l or l). The litre is about 10% less than the quart.

Eventually we may purchase milk in 1, 2 and 4 l (litre) containers. Cherries and other small fruits may come in ½, 1, 2, 4 and 8 l boxes and baskets. The actual sizes will be determined by those directly concerned with the packaging market.

The gram (g)

A litre of water has a mass of 1 kilogram (kg). The original kilogram mass consists of a solid metal cylinder and is still kept near Paris. Its quantity of matter is said to be 1 kg. A kilogram mass is about 10% more than that of 2 pounds. In SI the base unit of mass is the kilogram, not the gram, but for this treatment "gram" is emphasized since it is the term to which prefixes are attached.

A gram mass is comparatively small, equal to only one one-thousandth of a kilogram. A medium sized raisin or a smartie (coated candy) has a mass of about 1 g and a nickel has a mass of about 5 g. The receiver on a desk telephone has a mass of about 300 g, while the entire telephone has a mass of about 2 kg.

Packages of butter, cheese, meat slices, etc., will probably be available in masses of 500, 250 and 125 g or other modules as may be determined by the food industry. Thus the term "gram" will be a common household expression.

Scientifically speaking, grams and kilograms are units of mass, not weight. Weight is an invisible force - the downward pull of gravity on a mass - and in SI forces are measured in newtons, not in grams or gram-forces or kgf (kilogram-force). It is therefore proper to refer to a package of butter as having a mass of 500 g, not as having a weight of 500g.

Generally speaking, however, the term "weight" has been far more popular than the term "mass". This mass-weight dilemma is not easily resolved particularly in the sphere of education where correct usage should be encouraged.

It is recommended that the use of the term "mass" be introduced in the schools, wherever feasible, in reference to measurements made in terms of grams and kilograms. The term "weight" should be reserved to mean the gravity force pulling downwards on a mass - a comparatively advanced concept. It is recognized that "weight" will continue to be used by the public as in the past, and that for students it would not be prudent to make a strong issue of the mass-weight problem. The important issue is that if a student comes across the term "mass", he or she should associate it with grams and kilograms.

The Second (s)

The second is the base unit of time and this is one measure which is unchanged as we switch to metric. The second is a recognized SI unit, but other common units of time, such as the minute (min), hour (h) and day (d), although non-metric, are permitted for use with SI because of their universal acceptance.

The Degree Celsius, (°C)

The unit of temperature for common use is the degree Celsius. The reader may have seen, in literature on SI, that the kelvin is the base unit of temperature in the modernized metric system.

Most common metric terms

The following are the most common metric terms in everyday use.

Quantity	Unit	Symbol
Length	metre	m
Volume	litre	l
Mass	gram	g
Time	second	s
Temperature	degree Celsius	°C

Naturally there are multiples and submultiples of these units, such as the kilometre and millimetre. Some of these are outlined in the next few sections.

It should be stressed that the metre, litre, gram, second and degree Celsius, while most common in daily life, are not the set of base units of SI. The terms "base" or "basic" should therefore not be used in connection with this set of 5 units of which only the metre and second are base SI units. They are simply "common metric units".

The Use of Prefixes in the Metric System

In the metric system the value of unit is changed by placing a prefix in front of it. With the three most common units - Metre, Litre and Gram - the prefixes, "kilo", "deca", "centi", "milli" etc. will change the quantity of the basic unit.

The relationship of these quantities is very simple once these units and assigned prefixes have become familar. Some prefixes are used more commonly than others.

COMMON PREFIXES

kilo (thousands 10^3 - 1000)
hecto (hundreds 10^2 - 100)
deca (tens 10^1 - 10)

Basic Unit no prefix (one 1)

deci (tenth 10^{-1}, 1/10)
centi (hundredths 10^{-2}, 1/100)
milli (thousandths 10^{-3}, 1/1000)

LENGTH - THE METRE (m)

Unit	Symbol
kilometre - 1000m	km
hectometre - not commonly used	hm
decametre - not commonly used	dam
Metre	m
decimetre - not commonly used	dm
centimetre - (0.01 m)	cm
millimetre - (0.001 m)	mm

CAPACITY - THE LITRE (ℓ)

Unit	Symbol
kilolitre - 1000ℓ	kℓ
hectalitre - not commonly used	hℓ
decalitre - not commonly used	daℓ

Litre	l
decilitre - not commonly used	dl
centilitre - not commonly used	cl
millilitre - (0.001l)	ml

MASS - THE GRAM * (g)

Unit	Symbol
kilogram - (1000g)	kg
hectogram - not commonly used	hg
decagram - not commonly used	dag
Gram	g
decigram - not commonly used	dg
centigram - not commonly used	cg
milligram - (0.001g)	mg

* **NOTE**: In SI, the gram unit of mass proved to be too small for practical applications, therefore, the kilogram has been officially designated as the standard unit of mass.

RULES OF SI

One of the main advantages of SI is that there is a unique symbol for each unit. The word symbol has been designated to refer to the signs used to represent the various units, for that is what they are symbols not abbreviations. These symbols remain the same in all languages. This makes for greater clarity and reduces the chance of mistakes.

The following are basic rules for the use of these symbols:

1. Only one prefix can be used at a time. Compound prefixes are incorrect.

2. Symbols are never pluralized: 1 kg, 45 kg (not 45 kgs).

3. A full stop after a symbol is not used except when the symbol occurs at the end of a sentence.

4. When symbols consist of letters, there is always a full space between the quantity and the symbols: eg 45 kg (not 45kg).

   However when the first character of a symbol is not a letter, no space is left: eg 32°C (not 32 °C).

5. All symbols are written in lower case except when the unit is derived from a proper name. eg m for metre A for ampere.

6. Symbols for SI units should always be used and unit names not written out (except in the case of the litre). eg 16 mm^2 and not 16 square millimetres.

7. Symbols are always written in roman (upright type). The only exception is the symbol for litre, where the script ℓ is preferable or if not the word written out.

OTHER RULES OF SI

8. Decimals should be used instead of fractions: 0.75 instead of 3/4.

9. Where a decimal fraction of a unit is used a zero should always be placed before the decimal marker eg 0.45 kg not (.45 kg).

10. The thousands marker:

   A practice in some countries is to use a comma as a decimal marker, while the practice in North America, the United Kingdom and some other countries is - at this time - to use a period (or dot) as the decimal marker. Further

in some countries using the decimal comma a dot is frequently used to divide long numbers into groups of three. Because of these differing practices, spaces must be used instead of commas to separate long lines of digits with respect to the decimal marker.
eg 52897 is written 52 897.
A space is optional with a four-digit number.
eg 1 457 or 1457.

METRICATION

What ?

Why ?

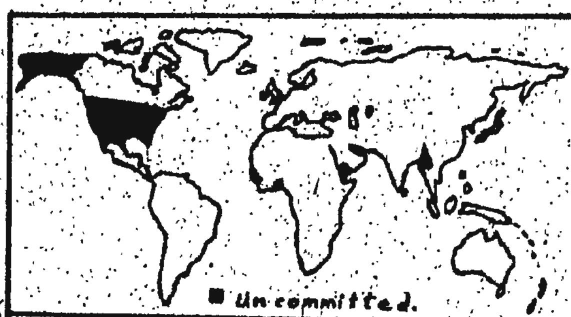
When ?

How ?

WHY GO METRIC?

1. For the sake of:

INTERNATIONAL TRADE AND COMMUNICATIONS.



The Metric Global Village.

95% of all countries are Metric
90% of world's population uses Metric
80% of World Trade uses Metric
50% of Canadian manufactured goods go to Metric countries

■ Brunei, Burma, Liberia, Sierra Leone, Southern Yemen, and the United States of America.

2. SI has just a few easily defined units.

3. The multiples and sub-multiples are powers of ten.

4. There is a direct relationship between the units of length, mass and volume.

5. The multiples accord with our number system.

6. Most other countries are already metric.

7. Increased accessibility of data.

SELECTED DATES IN METRIC HISTORY

1795 - Introduced in France.

1866 - Metric units legal in England

1873 - Metric units legal in Canada.

1875 - 17-Nation Metric Convention in Paris, established The International Bureau of Weights and Measures.

1960 - Paris Conference adopted the "Systeme International d'Unites" (S.I.)

1965 - Government of United Kingdom decreed conversion to metric by 1975.

1968 - U.S.A. Government set up Committee.

1970 - Federal Government issued a "White Paper" "... The eventual adoption of the metric system should be an objective of Canadian policy."

1971 - Appointment of Mr. S. M. Gossage as Chairman of The Canadian Preparation Commission for Metric Conversion.

1971 - Canadas' Consumer Packaging and Labelling Act requires metric values in retail packaging.

1972 - U. S. Senate approved metric conversion bill.

1974 - U. S. House of Representatives stalled passage of the bill.

S.I.

SYSTEME INTERNATIONALE D'UNITES

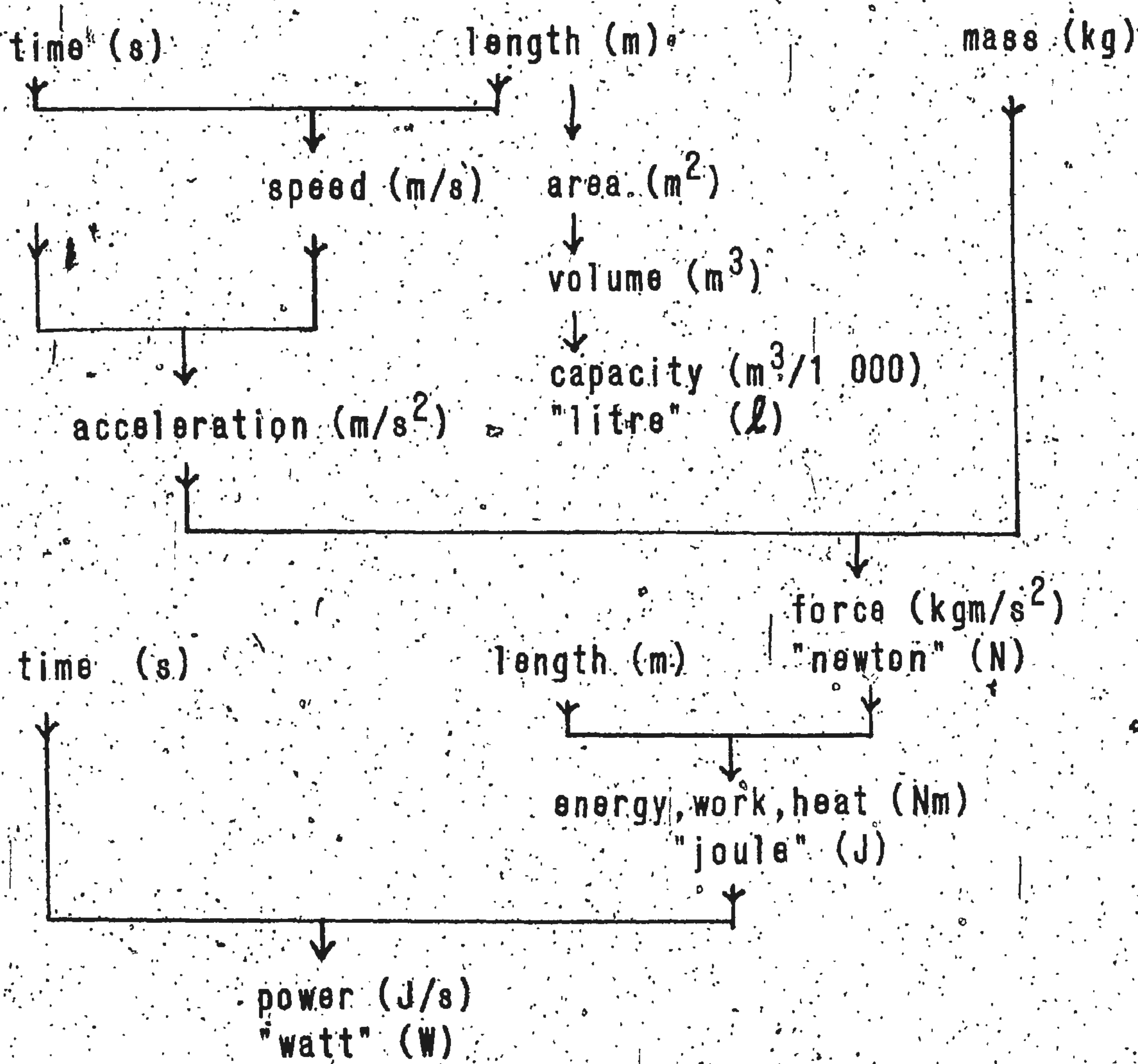
SEVEN BASIC SI UNITS.

Attribute	Name	Symbol
1. Of length	the metre	m
2. Of mass	the kilogram	kg
3. Of time	the second	s
4. Of electric current	the ampere	A
5. Of temperature	the kelvin	K
6. Of light intensity	the candela	cd
7. Of modular substance	the mole	mol

TWO SUPPLEMENTARY UNITS.

1. Of a plane angle	the radian	rad, ($\_^r$)
2. Of a solid angle	the steradian	sr

SOME DERIVED UNITS.



pressure: force per area (N/m^2)
"pascal" (Pa)

SI PREFIXES

Prefix	Multiplying factor	Symbol
tera-	10^{12}	T
giga-	10^{9}	G
mega-	10^{6}	M
kilo-	10^{3}	k
hecto-	10^{2}	h
deca-	10^{1}	da
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ
nano-	10^{-9}	n
pico-	10^{-12}	p
femto-	10^{-15}	f
atto-	10^{-18}	a

MOST COMMON UNITS IN METRIC

QUANTITY	UNIT	SYMBOL
LENGTH	METRE	m
VOLUME	LITRE	l
MASS	KILOGRAM	kg
TIME	SECOND	s
TEMPERATURE	DEGREE CELSIUS	^{o}C

World Wide Conventions

THE INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

RECOMMENDATION R1000 (1969)

SYMBOLS:

mm	cm	dm	metre m	dam	hm	km
m		d	litre			k
mg			gram g			kg

A symbol is not an abbreviation,
not followed by a period,
not pluralized,
has a space between numeral and symbol,
e.g. 152 g

DECIMAL NOTATION:

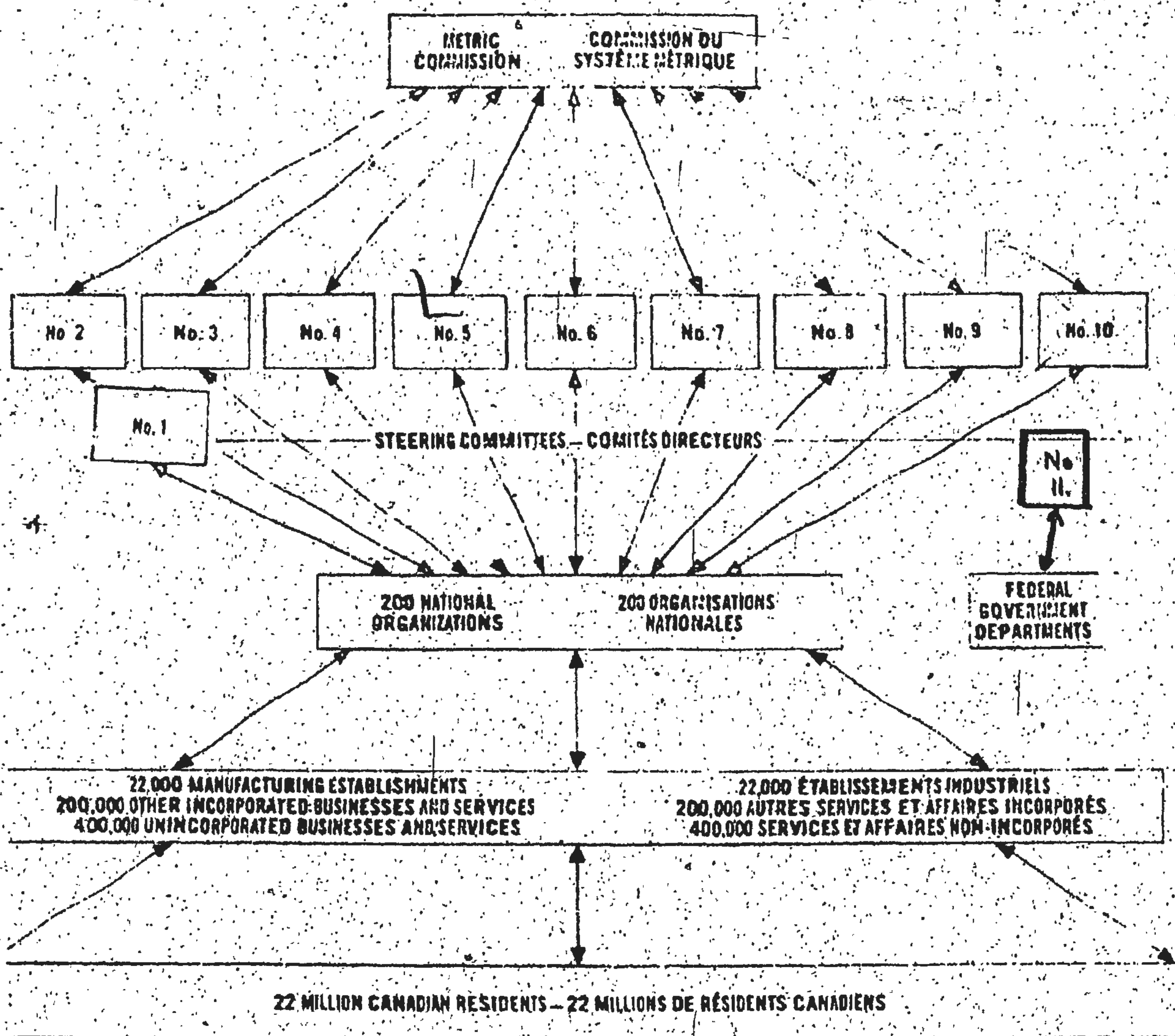
Spaces, not commas, between periods of 3 digits,
e.g. 6 946 572. 408 69

Decimal point is a period or a comma

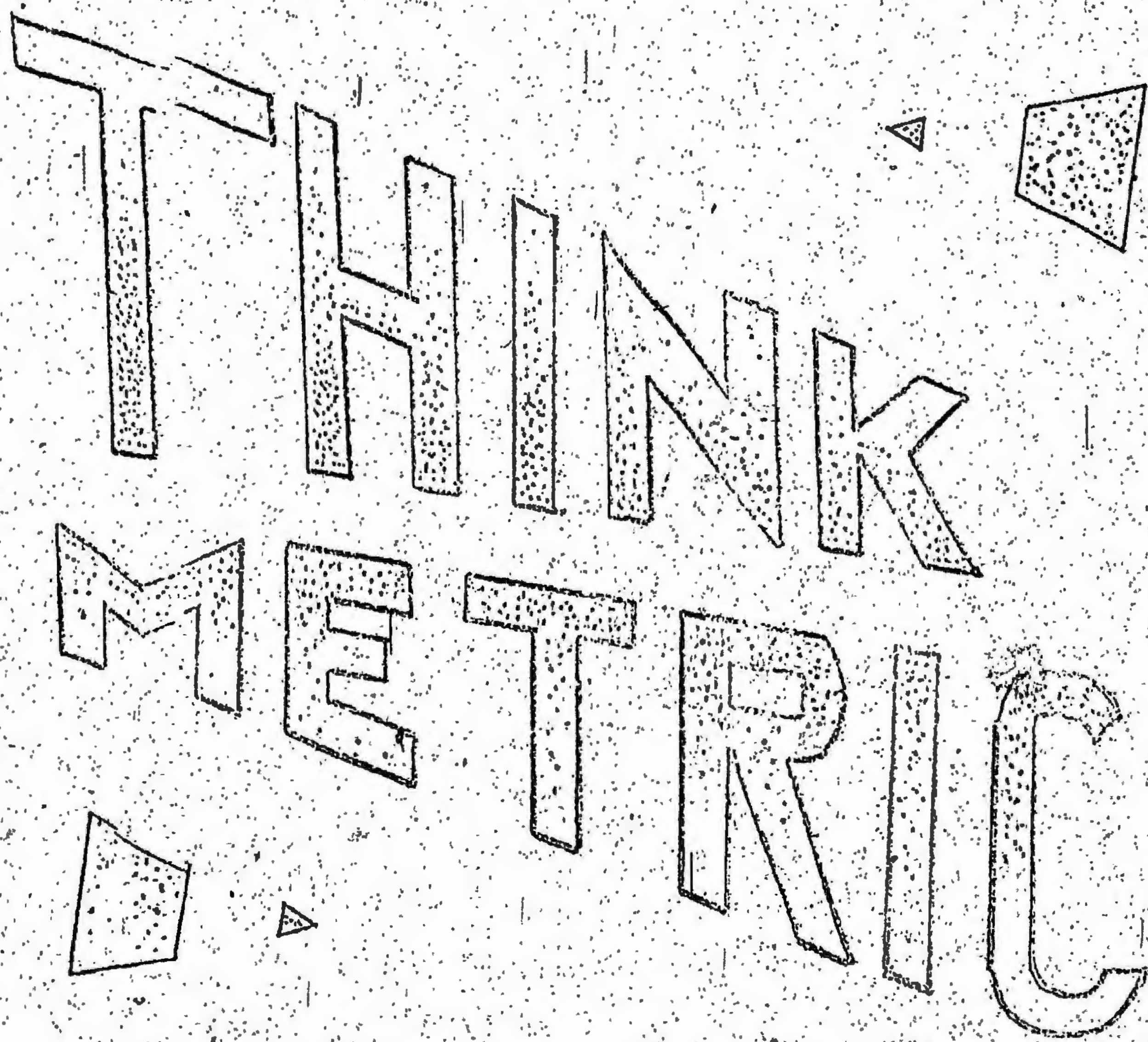
Initial zero before the decimal point for numbers less than 1, e.g. 0.54 or $0.75

WHEN ?

NOW



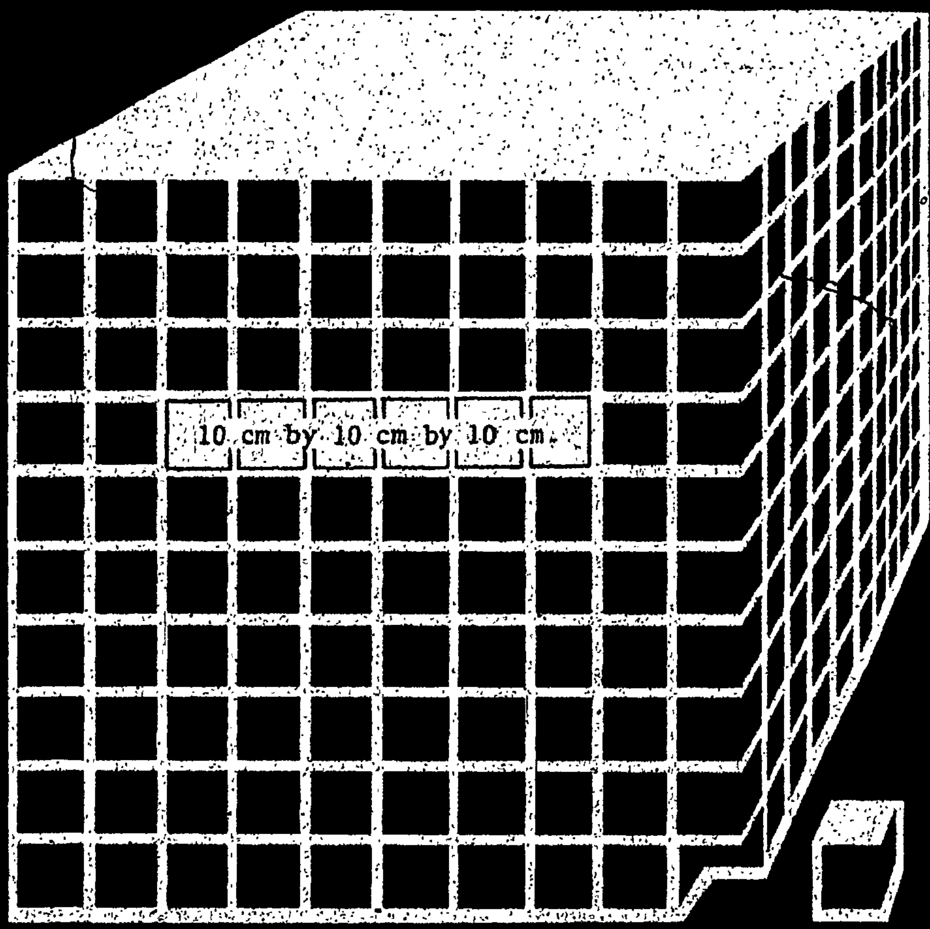
White Paper on Metric Conversion in Canada.
January 1970.


THINK
METRIC

ACTIVITY

WORKSHOPS

LENGTH MEASUREMENT

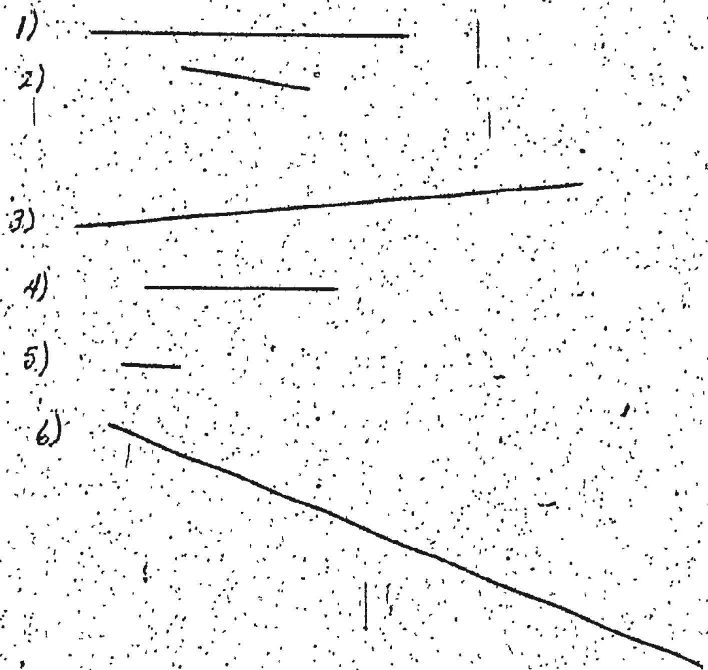


LINEAR MEASUREMENT

Activity Workshop A

Material: 30 centimetre ruler

Activity: Measure each of the following lines in both centimetres and millimetres. Record your answers in the blanks provided.



1) a. ________ cm b. ________ mm

2) a. ________ cm b. ________ mm

3) a. ________ cm b. ________ mm

4) a. ________ cm b. ________ mm

5) a. ________ cm b. ________ mm

6) a. ________ cm b. ________ mm

Now Try Some of Your Own

7) a. ________ cm b. ________ mm

8) a. ________ cm b. ________ mm

9) a. ________ cm b. ________ mm

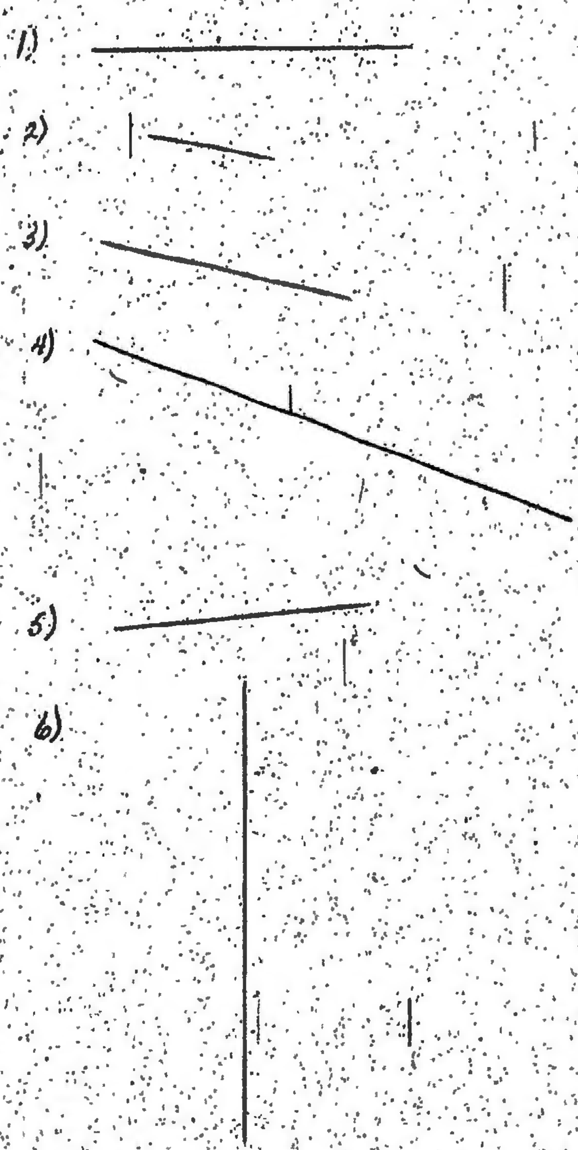
10) a. ________ cm b. ________ mm

LINEAR MEASUREMENT

Activity Workshop B

Material: 30 centimetre ruler

Activity:
1) Estimate the length of each of the following lines in centimetres.
2) Record your answer in the Estimated column.
3) Measure each of the lines.
4) Record your answer in the Actual Colum.



	Column		
	Estimated	Actual	Error
1.	______	______	______
2.	______	______	______
3.	______	______	______
4.	______	______	______
5.	______	______	______
6.	______	______	______

LINEAR MEASUREMENT

1. Activity Workshop C

"WHAT ABOUT ME" Exercise

Materials: 30 centimetre ruler; or tape

Activity: 1) Estimate the measures of the following parts of your body.
2) Record your answer in the Estimated Column.
3) Measure each part of your body.
4) Record your answer in the Actual Column.

Length	Estimated	Actual	*Error
1. of your little finger	______	______	______
2. around your wrist	______	______	______
3. around your ankle	______	______	______
4. around your forehead	______	______	______
5. around your neck	______	______	______
6. from finger tips to elbow	______	______	______
7. your height	______	______	______
8. of their arm	______	______	______
9. around your waist	______	______	______
10. the length of your pace	______	______	______

LINEAR MEASUREMENT

Activity Workshop D

Materials: Metre stick, 10 metre tape.

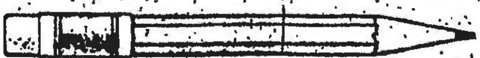
Activity:
1. Estimate the measure of each of the following in metres.
2. Record your answer in the Estimated column.
3. Measure each of the following.
4. Record your answer in the Actual Column.

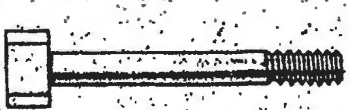
	Estimated	Actual
1. Length of Room	______	______
2. Width of Room	______	______
3. Height of Door	______	______
4. Length of chalk board	______	______
5. Perimeter of this Room	______	______

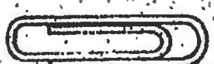
LINEAR MEASUREMENT

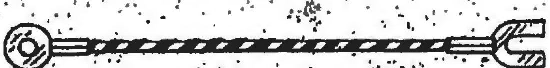
Activity Workshop E

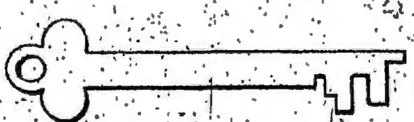
Estimate the length of each object in centimeters.
Then find the length of each object to the nearest centimeter.

1. 

2. 

3. 

4. 

5. 

6. 

7. 

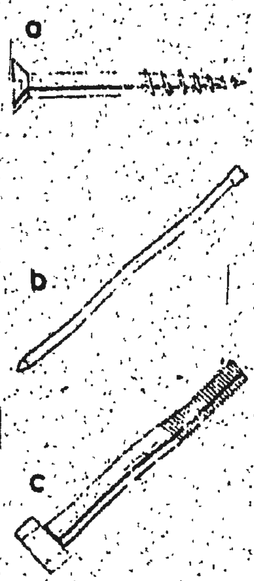
8. 

Estimate	Measurement
___ cm	___ cm
___ cm	___ cm
___ cm	___ cm
___ cm	___ cm
___ cm	___ cm
___ cm	___ cm
___ cm	___ cm
___ cm	___ cm

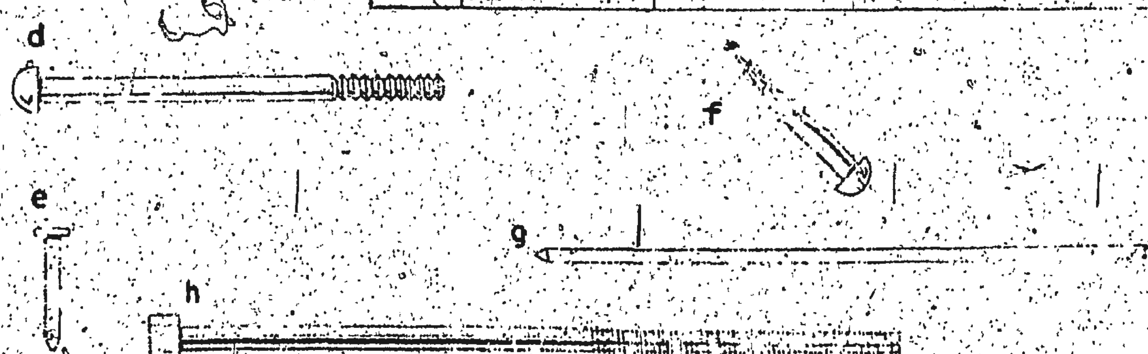
LINEAR MEASUREMENT

Activity Workshop F

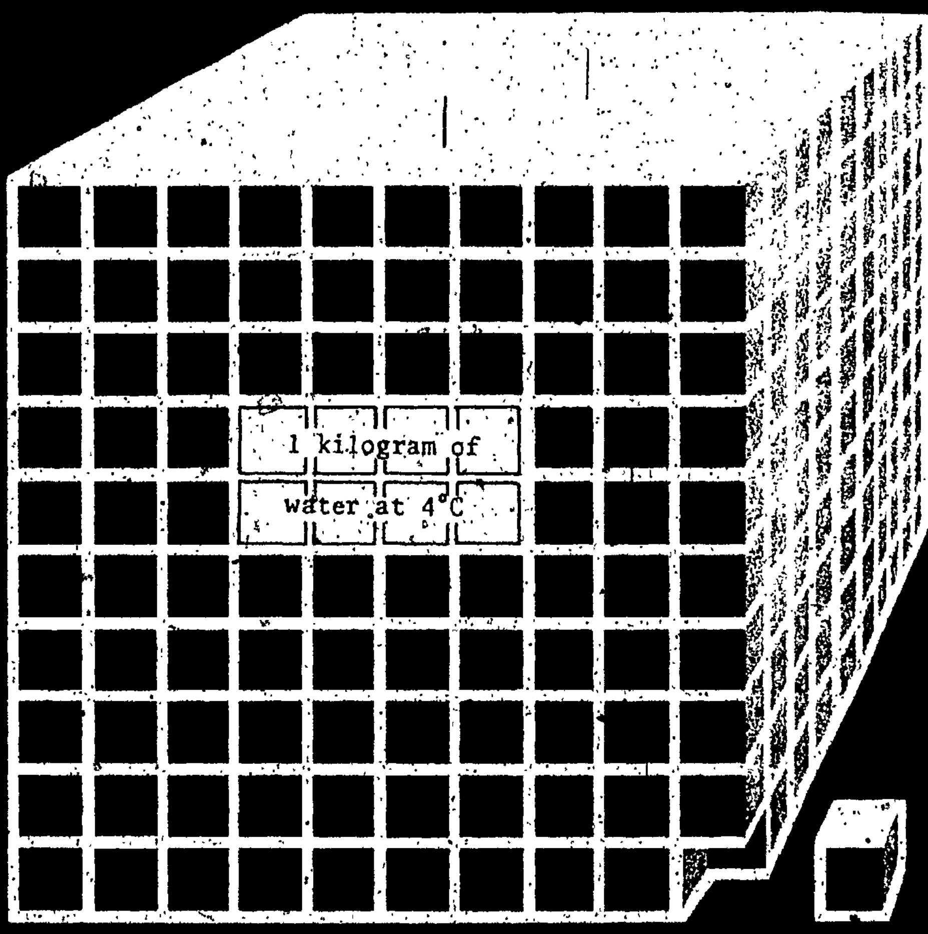
Estimate the length of each object in millimeters. Then find the length to the nearest millimeter. Record each measurement in two ways as shown in the table.



	Object	Estimate	Measurement		
12.	a	___ mm	36 mm	3 cm	6 mm
13.	b	___ mm	___ mm	___ cm	___ mm
14.	c	___ mm	___ mm	___ cm	___ mm
15.	d	___ mm	___ mm	___ cm	___ mm
16.	e	___ mm	___ mm	___ cm	___ mm
17.	f	___ mm	___ mm	___ cm	___ mm
18.	g	___ mm	___ mm	___ cm	___ mm
19.	h	___ mm	___ mm	___ cm	___ mm



MASS MEASUREMENT



MASS MEASUREMENT

Activity Workshop A

Material: Equal arm balance; single pan balance; set of gram to kilogram masses; blackboard eraser.

Activity:
1) Lift the various masses and get a feel for the size of the kilogram and gram as well as 5 g, 10 g, and 100 g.

2) Which is heavier, a kilogram or the blackboard eraser?
____

3) Place the blackboard eraser on one side of an equal arm balance.

4) Add masses to the other side until they balance.

5) What is the mass of the eraser? _______________g

6) Determine the mass of the eraser on the single pan balance.
_______________g (You should get more accurate results.)

7) Select another object of your choice (e.g. a textbook)

8) Is it heavier than a kilogram? _______________

9) Find its mass on the equal arm balance. _______________g

10) Find its mass on the single pan balance. _______________g

MASS MEASUREMENT

Activity Workshop B

Material: Single pan balance (metric); pencil; scissors; textbook; watch; piece of unused chalk; orange

Activity: 1) Estimate the mass of each of the following.

2) Record your answer in the Estimated Column.

3) Determine the mass of each of the following items. (Use the single pan balance)

4) Record your answers in the Actual Column.

	Estimated	Actual
1) pencil	______	______
2) scissors	______	______
3) a textbook	______	______
4) a shoe	______	______
5) a bag of beans	______	______
6) a watch	______	______
7) an orange	______	______
8) a piece of chalk	______	______
9) 5 Textbooks	______	______

MASS MEASUREMENT

Activity Workshop C

Material: Single pan balance; penny; nickel; dime; quarter; paper clip; a ring.

Activity: 1) Estimate the mass of each of the following.

2) Record your answer in the Estimated Column.

3) Determine the mass of each of the following. (Use the single pan balance).

4) Record your answer in the Actual Column.

	Estimated	Actual
1) penny	______	______
2) nickel	______	______
3) dime	______	______
4) quarter	______	______
5) paper clip	______	______
6) a ring	______	______
Take six objects from your pockets or purse		
7)	______	______
8)	______	______
9)	______	______
10)	______	______
11)	______	______
12)	______	______

MASS MEASUREMENT

Activity Workshop D

Material: personal scales

Activity:

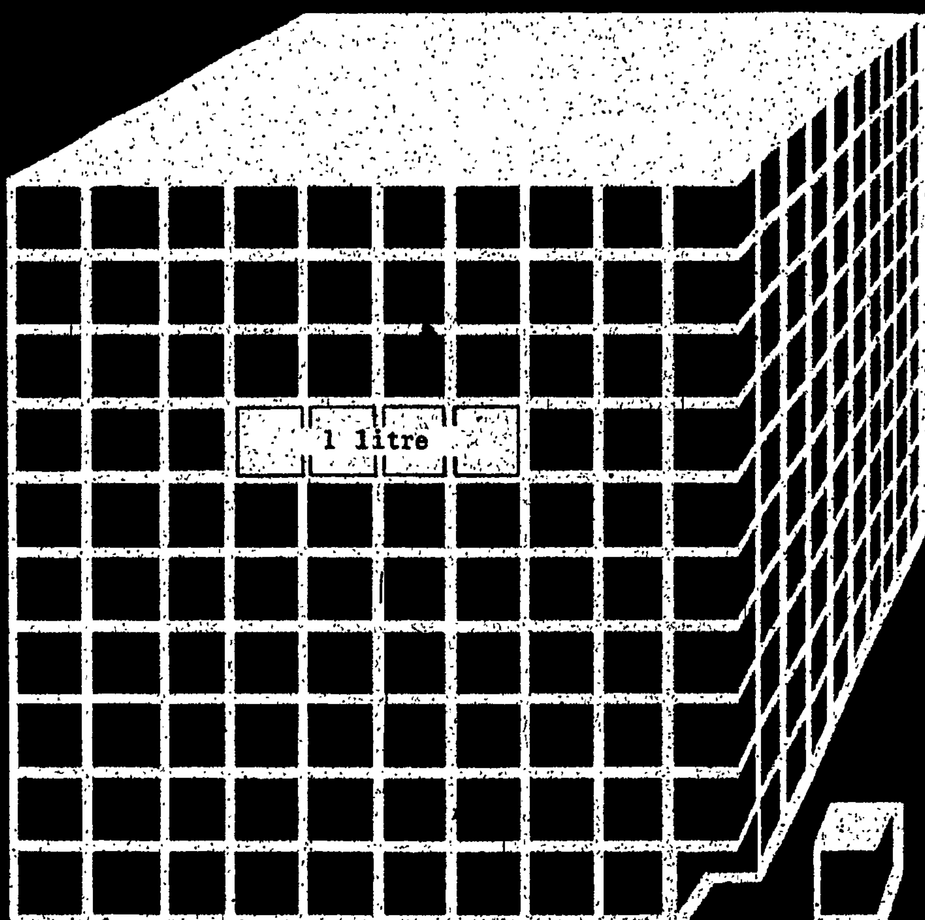
1) Estimate your mass in kg. ______________

2) Determine your true mass in kg ______________

3) What would you like your mass to be in kg ______________

4) What is the difference (positive or negative) in 2 and 3. ______________

CAPACITY MEASUREMENT



Capacity Measurement

Activity Workshop A

Material: Graduated containers (millilitre to litre); various containers.

Activity: 1) Fill a litre container with water.

2) Pour this litre of water into various shaped containers to get a feel for the amount of liquid a litre consists of.

3) A litre is divided into smaller parts.

a) One tenth of a litre is called a ______________ and its symbol is ____________.

b) One hundredth of a litre is called a ______________ and its symbol is ____________.

c) One thousandth of a litre is called a ______________ and its symbol is ____________. Pour this amount into a graduated container.

Capacity Measurement

Activity Workshop B

Material: Graduated containers (millilitres to litres); unmarked containers.

Activity: 1) Pour water into an unmarked container until you think that you have the amount indicated in the question.

2) Pour this amount of water into a graduated container to check your estimate.

3) Record your answer in the Actual column.

4) Substract to find the difference (amount of error).

5) Record your answer in the Difference column.

	Actual	Difference
a. 50 ml	______	________
b. 250 ml	______	________
c. 10 ml	______	________
d. 1 litre	______	________
e. 50 ml	______	________

Use the space below for calculations.

Capacity Measurement

Activity Workshop C

Material: Litre, 1/2 litre containers; large vessels - pan bucket, pitcher, bottle, bowl.

Activity: 1) Pour 1 litre of water into the pan and measure with your ruler as accurately as possible the depth of the water. ________

2) Now pour 1 litre of water into the bucket and measure its depth. ____________

3) Now pour 1 litre of water into each of the other vessels and measure the depth in each ________ ________ ________

4) By looking at the depth of water in the vessels, estimate in litres the amount each will hold. Check your estimates by using the litre measure.

Vessel	Estimated	Actual
pan		
bucket		
pitcher		
bottle		
bowl		

Capacity Measurement

Activity Workshop D

Material: Graduated containers; gallon, quart and pint jars, pop bottle; juice can; coffee cup.

Activity: 1) Estimate how much water each container will hold in litres or millilitres.

2) Record your answer in the Estimated column.

3) Measure the actual amount the container holds by pouring the water into a graduated container.

4) Record your answer in the Actual column.

	Estimated	Actual
1) Gallon jug (Imperial)	______	______
2) Quart jar (Imperial)	______	______
3) Pint jar (Imperial)	______	______
4) Pop bottle	______	______
5) Juice can	______	______
6) Coffee cup	______	______

Capacity Measurement

Activity Workshop E

Material: Graduated Measuring Jug; stone

Activity: 1) Pour 200 ml of water into a measuring jug. Check the accuracy of your measurement

2) Slide a small stone carefully down the side of the graduated jug, making sure the water covers the stone.

3) Take a reading on the level of the water.

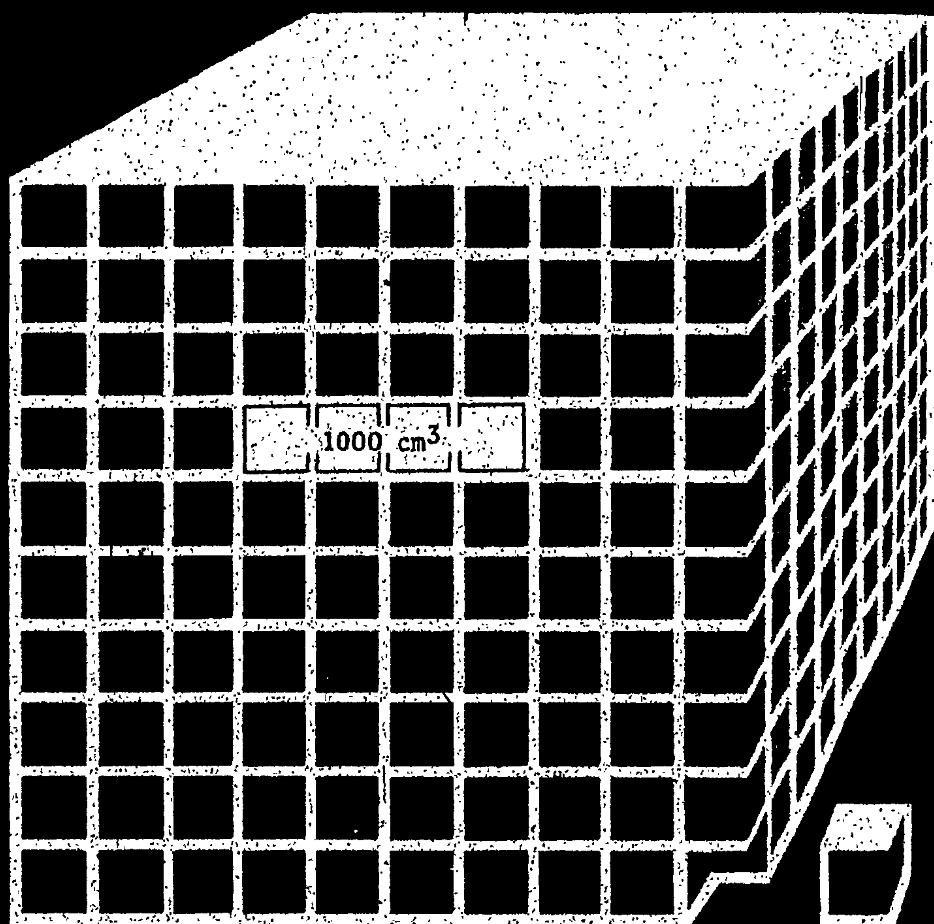
4) Find the difference in ml between the water level before and after putting in the stone. ________

This difference is the amount of space taken up by the stone. That is its volume.

Volume is usually measured in cm^3. One ml and on cm^3 take up the same amount of space.

5) Repeat the exercise for some other object.

AREA AND VOLUME MEASUREMENT



Area Measurement

Activity Workshop A

I. THE SQUARE CENTIMETER (cm^2)

EXERCISE - Using a cm^2 grid

1. Consider the area of your hand.

Estimate ________ cm^2

2. Place your hand on a cm^2 grid; outline in pencil from wrist joint around to wrist joint. Determine area as precisely as you can by counting squares.

Area ________ cm^2

3. Compare results.

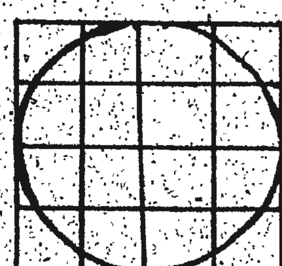
Error ________ cm^2

4. By drawing these shapes on a cm^2 grid, and counting squares, determine the area of their interior regions:

(a) A rectangle 5 cm by 3 cm ________ cm^2

(b) A right triangle with sides 5 cm, 12 cm, and 13 cm ________ cm^2

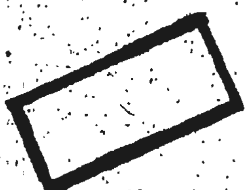
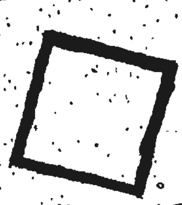
(c) A circle inscribed in a square, 4 cm by 4 cm ________ cm^2



Area Measurement - Activity Workshop B

Material: 20 centimetre ruler.

Activity:
1) Estimate the area of each of the following rectangles in square centimetres.
2) Record your answer in the Estimated column.
3) Measure to find the actual area.
4) Record your answer in the Actual column.

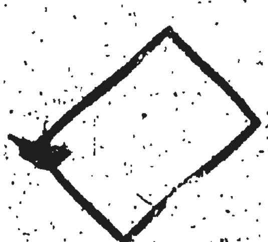
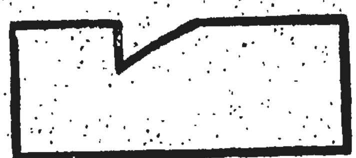
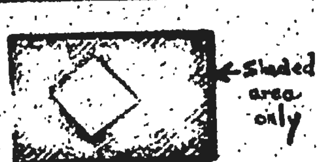
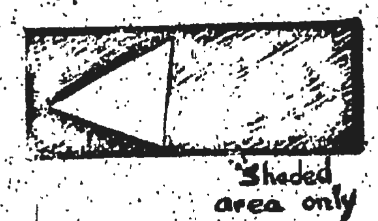
		Estimated	Actual
1)		______	______
2)		______	______
3)		______	______
4)		______	______
5)		______	______
6)		______	______

Activity IV-G   <u>Area Measurement</u> – Activity Workshop C

<u>Material:</u> 20 centimetre ruler

<u>Activity:</u> 1) Measure to determine the area of each of the following in square centimetres.

2) Record your answer in the <u>Actual</u> column.

		Actual
a.		______
b.		______
c.		______
d.		______
e.		______

Do Test II in Appendix C

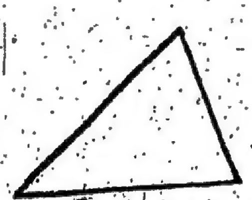
Activity IV-F <u>Area Measurement</u> - **Activity Workshop D**

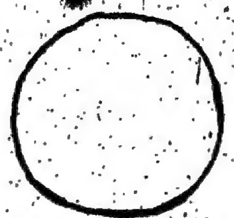
<u>Material</u>: 20 centimetre ruler.

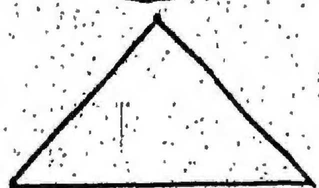
<u>Activity</u>: 1) Measure to determine the area of each of the following in square centimetres.

2) Record your answer in the <u>Actual</u> column.

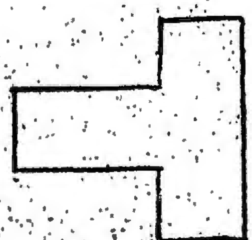
<u>Actual</u>

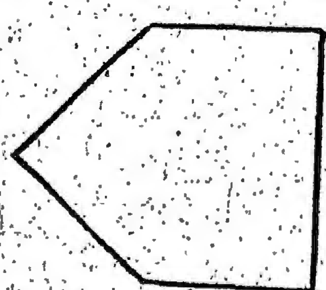
a.  ________

b.  ________

c.  ________

d.  ________

e.  ________

f.  ________

Activity IV-C Area Measurement - Activity Workshop E

Material: metre stick; metric tape; trundle wheel (optional)

Activity: Measure to determine the area of each of the following:
(Refer to Unit III for the linear measurements, if you wish)

1) Area of the floor ____________

2) Area of the ceiling ____________

3) Area of the largest wall ____________

4) Area of the smallest wall ____________

5) Total area of the walls ____________

6) Area of the windows ____________

7) Area of the door ____________

Now, determine the area of several other objects in the room:

8) ____________

9) ____________

10) ____________

11) ____________

12) ____________

Use the space below for calculations if necessary.

Activity IV-E Area Measurement - Activity Workshop F

Material: Straightedge; 20 centimetre ruler.

Activity: 1) Using only a straightedge (not a centimetre ruler), draw rectangles which you estimate have areas as indicated in question #4.

2) Measure to check your accuracy.

3) Record the actual area of the rectangle that you have made in the Actual column.

4) Actual

a. 4 cm^2 ________

b. 1 cm^2 ________

c. 7 cm^2 ________

d. 5 cm^2 ________

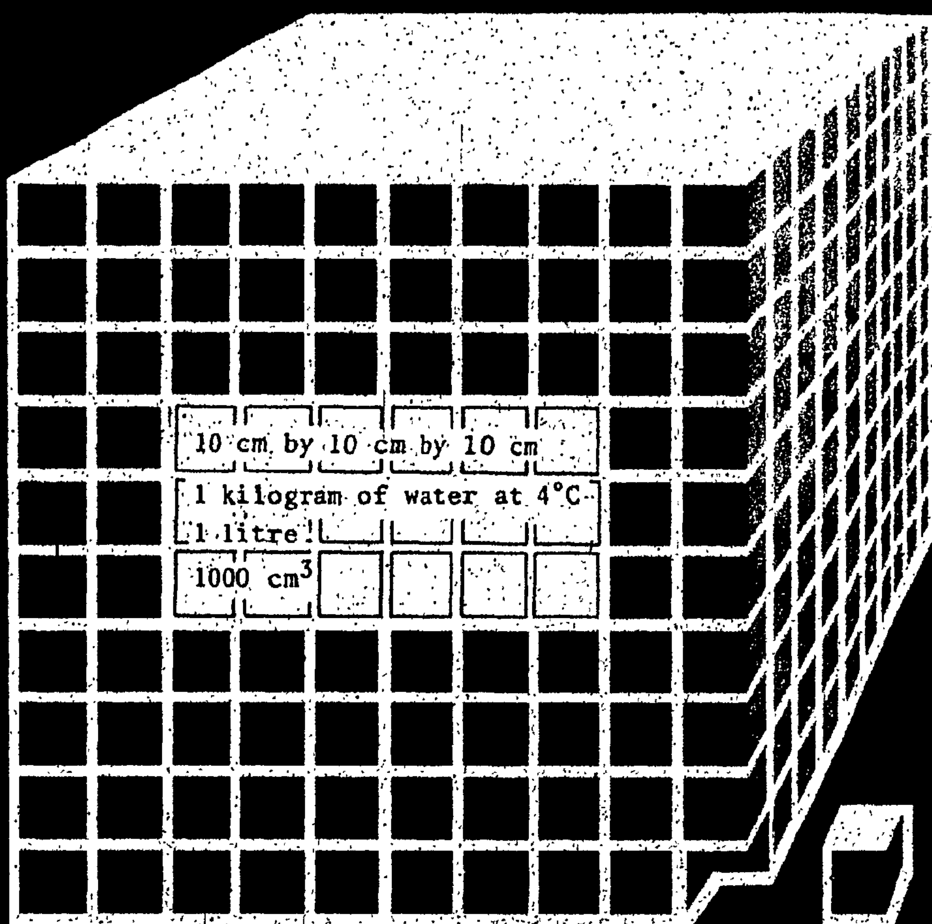
e. 6 cm^2 ________

Now try some trickier ones:

5) a. 2.5 cm^2 ________

b. 4.8 cm^2 ________

INTERRELATIONSHIP OF LENGTH, MASS AND CAPACITY



COMMON METRIC UNITS USED FOR METRIC INTERRELATIONS

This section shows the interrelation of length, mass, capacity, area, and volume, within the metric system.

Length - millimetre, centimeter, metre, kilometre

Mass - milligram, gram kilogram

Capacity - millilitre, litre

Area - square millimetre, square centimetre, square metre square kilometre

Volume - cubic millimetre, cubic centimetre, cubic metre

RELATIONSHIP OF METRIC UNITS

A cube of water at $4^{\circ}C$ 10 centimetres by 10 centimetres by 10 centimetres weighs 1 kilogram and holds 1 litre or 1000 cm^3.

Similarly a cube of water at $4^{\circ}C$ 1 centimetre by 1 centimetre weighs 1 gram and holds 1 millilitre or 1 cm^3.

WORKSHOP ACTIVITIES TO THINK METRIC

NOTE: In any activity using water, assume it to be $4^{\circ}C$.

1. Relating to capacity measurement, which metric unit is equivalent to:

   (a) 1000 cm^3 ________________

   (b) 1 cm^3 ________________

2. How many litres in a box measuring 20 centimetres by 40 centimetres by 20 centimetres?

   ________________ litres

3. A tablespoon holds 15 millilitres. How many cubic centimetres does the spoon hold?

   ________________ cm^3

4. How many litres are there in a cubic metre?

   ________________ ℓ

5. A container weighing 10 kilograms is filled with 40 litres of water. What is the total mass?

   ________________ kg

6. An empty container weighs 200 grams. When filled with water, it weighs 1.7 kilograms. What is the capacity of the container?

____________ l

7. Select a box.

	Estimate	Actual
(a) Estimate its volume in the metric system	______	______
(b) Estimate its capacity in the metric system	______	______
(c) Estimate its mass when filled with water	______	______

The "Mass - Weight" Dilemma

In SI, units of mass always contain the term "gram" (with kilogram as the base unit) apart from the one non-SI permitted unit "tonne" which is a synonym for megagram.

When referring to the force of gravity acting on a given, mass, the word "weight" is correctly used instead of "mass", and "weight" should properly be expressed in newtons.

The weight of an object depends on its mass and the accerleration due to gravity at the point where the mass is situated. Since this accleration varies from point to point in space an objects' weight varies. Over the Earth's surface this variation is within 0.5% which is not significant for low-accuracy work. For most people the distinction between expressions like," a kilogram mass" and "a kilogram weight" is not important.

A typical man may have a mass of 80 kg. We have been in the habit of saying that "the man weighs 80 kg". Is this wrong? The purist says, "yes this is incorrect". Others ignore the issue because they understand the intent of the statement. In Physics this statement is strictly unacceptable. In common usage it is not questioned by the majority. Teachers, in general, are advised not to make a serious issue of this mass-weight dilemma. However, they personally should use the word "mass" more and more in relation to grams and kilograms. In the Physics room, a clear distinction should be made between "mass" and "weight". Educators must be sensitive to the reactions of students and society, realizing that ingrained habits are not easily changed. Will "weight-watchers" become "mass-watchers"?

The use of estimating

The practice of estimating a measurement is very educationally worthwhile. It promotes and augments conceptualization. It reinforces the imagery of the unit that is being used; it makes one "think" of the attribute that is being measured.

Look (at the object to be measured) -- Visualize (the unit to be used) -- Estimate (really "counting" of units in your mind) -- Measure (using standard units and your skill of reading scales) -- then Compare (your measurements to your estimate) to sharpen and develop the whole conceptualization process.

Decimal Notation vs Fractional Notation

Because the metric system is based on the powers of ten, we should capitalize and exploit this principle. Parts of a unit are expressed by decimals. In most cases each place of decimal can be associated with a subunit, e.g. 6.75 m means 6 metres, 7 decimetres and 5 centimetres. The fractional notation 6 3/4 m does not have this added association to subunits.

Fractional notation for parts of a unit should be avoided with the exception perhaps of ½,¼ and maybe other unit fractions. These examples have a "visual imagery" impact and are therefore meaningful. But decimal notations will have greater dividends and lead naturally to other very important ideas such as precision.

Decimal notation should be introduced in specific content. For example, we have always introduced two places of decimals in the context of writing dollars and cents. "Two dollars and sixty-five cents" is written as "$2.65". In the same way "Two metres and sixty-five centimetres" can be written as "2.65 m".

THINK METRIC!!

It's more than just a cliche

Canada's on-going move toward the metric system as its standard measurement system has implications for teachers and the classroom. Over the next several years teachers will become involved in in-service training sessions, will see metric measure implemented into various parts of the curriculum and will be generally effected as a member of society by metric conversion. The teacher's role will be essential in providing the correct pedogical approach to teaching metric in the classroom. The term "Think Metric" which has become a common by-word in metric publicity campaigns is more than just a 'catch phrase'. For the teacher the "Think Metric" Concept has particular relevence.

The approach to teaching metric will not be one of straight conversi on from the Imperial to the Metric System. Through activities involving estimation and actual measurement with various devices, students will be encouraged to gain a feeling for what each unit means in terms of reality. The app roach will try to encourage them to view an object, quantity or state of being and estimate its measure in terms of metric units.

The students should be involved in activities in which they are actually measuring parts of their environment. The feeling generally is that measurement must be related to personal experiences. Until a learner has had the opportunity to experience in concrete, comparative terms what a gram, kilogram, metre and litre are, they remain meaningless to him.

For example, through activities involving length they discover that the height of a chair back is about one metre, the height of a door is approximately two metres, the height from the floor to some part of their body is one metre. From such experiences (and others) they then perhaps will approximate the height of a door knob from the floor to be one metre. They are beginning to Think Metric.

For the teacher the ability to Think Metric is imperative but the process of re-education may be more difficult. Any in-service for teachers activities involving metric will emphasize this hands on, activity oriented approach. Teachers will become involved in estimating and measuring with metric devices. However perhaps we need to begin to train ourselves to "Think Metric". But How?

Thinking Metric means that we associate the measure of any object with a metric unit.

Lets take the Celsius temperature scale as an example. To help us to think in metric we should learn a few guideposts upon which to begin our thinking process. The Celsius temperature scale is shown below with several temperatures names to describe various temperatures.

boiling point	$100^{\circ}C$
Body temperature	$37^{\circ}C$
Room temperature	$21^{\circ}C$
Freezing point of water	$0^{\circ}C$

By associating these temperatures in the Celsius scale with a definite state one can begin to appreciate the relevent temperatures in this scale.

Using the chart as reference see how well you do on the following.

1. A severe fever would be indicated by:

   (a) $40^{\circ}C$ (c) $27^{\circ}C$
   (b) $30^{\circ}C$

2. An ideal summer temperature would be:

   (a) $36^{\circ}C$ (c) $15^{\circ}C$
   (b) $28^{\circ}C$

3. The temperature in November in most parts of Newfoundland would be closest to:

   (a) $15^{\circ}C$ (c) $38^{\circ}C$
   (b) $5^{\circ}C$

Another example using mass might help to convey the process I am suggesting.

Listed below are a number of masses given in metric units. This range of masses with various applications might give an appreciation of the magnitude of each.

NOTE: Mass Kilogram kg 1 kg = 1000 g
gram g

100 kg	Heavy weight boxer
75 kg	Tall slim male
50 kg	Slim bride
10 kg	Good sized Christmas turkey
3 kg	New born baby
450 g	Pound of butter
25 g	Slice of bread
5 g	A Nickel

By associating these metric measure with a definite object one can begin to appreciate the significance and relative value of a particular object. As an exercise using the chart as a guidepost see how well you do on the following.

1. A gram has about the same mass as:

   (a) apple (c) pineapple
   (b) cigarette

2. A motor cycle would have a mass of approximately:

   (a) 170 kg (c) 250 kg
   (c) 200 g

3. The mass of a man's ring would be approximately:

   (a) 20 kg (c) 200 g
   (b) 10 g

4. A young child's mass would be closest to:

   (a) 70 kg (c) 35 kg
   (b) 10 kg

These examples are presented not necessarily as an exercise to help you think metric, but as a means to suggest an approach and process to becoming more versed in appreciating the metric system. In any Think Metric activity three things are essential. Firstly it is necessary to become aware of a number of guide points or references upon which to build your estimations and help you begin to Think Metric. Secondly estimating the measure in metric units is a second step. These estimates should be based on the references which have been established. Thirdly the actual measuring of the object with a metric measuring device helps identify the accuracy of the guess and creates direct involvement in the learning process.

Measurement - That's What Its all About!

The topic of measurement is one which will be most affected when the metric system is introduced into the School Curriculum. The most obvious change will be the Units of Measurement - they will be metric rather than imperial. However much more important changes in the teaching of measurement will occur as a result of the introduction of metric units.

Perhaps one of the real benefits to mathematics as a result of introduction of metric units will be a re-evaluation and hopefully a dramatic change in the teaching of measurement. This topic has long been one which has received an incorrect approach in many mathematics programs. The interrelations among units and the solving of area and volume problems through the use of formulas occupied a considerable stress in the program.

The best cliche which might suggest a more meaning approach would be "Learning by Doing" - Measure - Measure - Measure. The approach to teaching measurement should stress student involvement in the estimating and measuring of objects in his world. Through this activity oriented approach a more meaningful appreciation of the measurement units can take place. In fact before units are introduced at all children should be involved in making comparisons. The concept of measurement is one which requires careful development. The following four stages may crystalize the problem.

Firstly, it is necessary to identify and understand what is being measured. Also with this identification process comparisons among various objects are made. One is longer than another, the door is twice as high as it is wide. Further to this includes the ordering of various objects according to size. Such comparisons sharpen the understanding of the attribute which is being measured.

The second step includes the identification and selection of an appropriate unit. The unit must possess the same attribute as the one being measured. Non standard units may be used at the beginning and the use of such certainly reinforces what is being measured.

The third stage would include the actual measuring - the counting of the units. In this case the problems of counting part of a unit is inevitable. The metric system makes this easier since parts of a unit are graduated in the decimal system rather than the fractional. The units are subdivided into ten rather than halves, quarters, eights etc.

The final step involves Symbolization. The objective here is to express the measurement with some meaningful symbol. Here again the metric system shows its worth. Since the symbols for SI units are universal, adherence to SI symbols is not only necessary but adds to general communication.

An analysis of these four steps points out, I think, the complex nature of conceptualization of measurement. It shows as well that the third and fourth steps are perhaps the easiest to acquire but will not have true meaning unless preceded by careful development through Steps 1 and 2. Such development can only be obtained by emphasizing an approach to teaching measurement which gets students involved. Through active measurement using Metric units "Thinking Metric" will come more naturally.

RECOMMENDED LIST OF METRIC RESOURCE AND REFERENCE MATERIALS

1. Activity and Discovery In Mathematics. Don Mills, Ontario, General Publishing Company Limited.

   This series of four booklets is recommended as a source of activities and exercises for grades 4 - 9.

2. Adams, H. F. R., SI Metric Units. An Introduction. Scarborough, Ontario, McGraw-Hill Ryerson Limited, 1973.

   Recommended as reference.

3. Allen, H. D. Canada Measures Up - A Guide To Metric Practices. Agincourt, Ontario, G. L. C. Educational Materials and Services Limited.

   Recommended as a reference.

4. Amusements In Developing Metric Skills. Troy, Michigan, Midwest Publications Company.

   A good source of activities to stress relationships between metric units for grades 4 - 9.

5. Bates, J. H., Clifford, T. J. and Park, P. B. Exploring Metric Measure - Primary Teacher's Source Book. Scarborough, Ontario, McGraw-Hill Ryerson Ltd.

6. Bates, J. H., Clifford, T. J. and Park, P. B. Continuing Metric Measure - Junior Teacher's Source Book. Scarborough, Ontario, McGraw-Hill Ryerson Ltd.

7. Bates, W. W. How To Think Metric. Copp Clark Publishing Limited, Toronto.

   Recommended as a reference.

8. Branley, Franklyn M. Think Metric. Don Mills, Ontario, Fitzhenry and Whiteside Ltd.

   Recommended for library reference.

9. Cordin, P. W. Mathematics and Metric Measuring. Toronto, Ontario, Macmillan Company of Canada Ltd.

   This series contains six booklets plus a Teacher's Book:
   (a) Measuring Length
   (b) Measuring Weight
   (c) Measuring Time
   (d) Measuring Quantity
   (e) Measuring Area
   (f) Measuring Volume
   Recommended as a source of activities for grades 3 - 9.

10. Dalzell, T. H. Thinking Metric. Toronto, Ontario, Macmillan Company of Canada Ltd.

Recommended for problems and exercises.

11. Groundwork Mathematics. Toronto, Ontario, Macmillan Company of Canada Ltd.

A set of laminated cards for weight, length and capacity activities for grades 3 - 9.

12. Liddle, David M. We Go Metric. Toronto, Ontario, Griffin House.

Recommended for activities and exercises.

13. Luba, P. M., Fonseca, S. et al. Metric Activities K - 3 (A Teacher's Handbook). Don Mills, Ontario, Thomas Nelson and Sons (Canada) Ltd.

14. Marsh, L. G. Exploring The Metric World. Toronto, Ontario, The Copp Clark Publishing Company.

Recommended as a source of activities.

15. Mathematics, Book Society of Canada Limited.

Recommended as a source of activities.

16. May, L. J. and Jacobs, D. C. Measure Metric (Books A, B, C). Don Mills, Ontario, Longman Canada Ltd.

Recommended as a source of activities for grades 3 - 9.

17. The Metric System For the Farmer

Available from: Canada Department of Agriculture
Ottawa, Ontario
K1A 0C7

18. The Metric Trick. Toronto, Ontario, Holt, Rinehart and Winston of Canada Ltd.

Recommended for library and classroom reference.

19. Metrication, A Guide for Consumers

Available from: Department of Consumer and Corporate Affairs
400-269 Main Street
Winnipeg, Manitoba R3C 1B2
Telephone: 985-2366

20. Nicholls, R. H. Working With Metric Measures. Toronto, Ontario, The Copp Clark Publishing Company.

Recommended as a source of activities.

21. Saunders, J. G. Metric Mathematics. Don Mills, Ontario, Thomas Nelson and Sons (Canada) Ltd., 1971.

This is a series of four booklets plus a Teacher's Guide. They contain ideas for activities and exercises for students in grades 3 - 9.

22. Schools Council Publication. Metres, Litres, and Grams. Richmond Hill, Ontario, Scholastic Tab Publications, 1971.

Recommended for reference.

23. Vickers, Colonel J. S. Making the Most of Metrication. London, England, Gower Press, 1969.

Recommended for reference.