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MONOGRAPH NO.3
JUNE 1975

METRICATION

ACTIVITIES RELATIONSHIPS AND HUMOR

K. Allen Neufeld, Editor

MCATA Publication of the Mathematics Council of The Alberta Teachers' Association

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Activities, Relationships and Humor

Line drawings by Norma Larson, ATA

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Editorial

K. Allen Neufeld
University of Alberta

"Why didn't they wait until all of the old-timers had died off before introducing metric units!"

That statement has a negative aspect to it, but you'll have to agree there also is a lot of *humor* in it, and humor usually creates a very positive atmosphere.

"I hear, and I forget,
I see, and I remember,
I do, and I understand."

This statement also contains some negativism; forgetting is usually an undesirable attribute when it relates to teaching and learning. The positive aspect, however, is the development of understanding through *activity*.

"Your height in centimetres is approximately 100 units greater than your mass in kilograms - if you're normal!"

If you are motivated to verify this final statement (and most people are -- they usually say, "You mean that works for everybody?"), then you will have *related* unfamiliar metric units *to your surroundings* - and what could be closer to you than your own body?

The articles in this monograph are based on these three elements: humor, activity and relationship to one's surroundings. If you are in the process of updating your own knowledge of measurement using metric units, or if you have the task of introducing metrication to your students, be sure to include these three most important elements. The authors have done an excellent job of helping to make your task just a little easier.

Good luck as you do your part to introduce metric units to some of the remaining ten percent of the world's population.

PART ONE
General Considerations

Part I

Canada Goes Metric

This article is an edited reprint from the proceedings of the metrication conference held at York University in March of 1974. Permission was granted by the editor, Lloyd R. Duncan.

by *Harold Don Allen*
Nova Scotia Teachers' College

Ladies and gentlemen; to borrow from a distinguished Canadian, "my fellow metricators":

One million metres is not a measure we often use in casual conversation (strictly speaking, one could call it a megametre), but I have found that it is the distance which one has to travel in Canada (in education) to be considered an "expert." Having got up at five and put in my million metres by ten today, and now, by twenty-one, being firmly entrenched as "enthusiast" if not "expert" within the Ontario establishment, I'm delighted! The new status symbol, in addition to the million-metre -- I almost said "mileage"! -- is, of course, the A8 calling card. You'll notice how they flash them within the Ministry of Ontario and they flash them within the Metric Commission.

In theory if not in fact, we're all of us in the same trade, so you can appreciate that I have before me what might be termed (in the jargon of our profession) a "challenging assignment" . . . challenging especially to that teacher who thinks not that "Happiness is Going Metric" but that "Happiness is Homogeneous Grouping."

Your experiences in the classroom will have taught you that if you short-circuit the ritual of "teach--test--reteach," there are times when you regret it . . . at least, that's the reality of my twenty-odd years. So what do you do when confronted with a room full of highly knowledgeable people . . . sprinkled with newcomers here to learn . . . all, really, here to find out? I will willingly err on the side of telling you things you already know. Let me offer two justifications for that erring, if indeed it is that.

In January, I acquired a rather remarkable diploma -- I think for the feat of surviving eight air trips within the Land of the Free, four of them on a Sunday of curtailed flights, and making my way from Truro, Nova Scotia, in early morning, to Biloxi, Mississippi, by sundown. I was a participant, and modest contributor, at the International Conference on Metric Education.[1] A group of fifty corralled me in what otherwise would have been an empty room, and had me fill them in on some of the things we in Canada have been trying to do. In the course of my talk, I made passing reference to the White Paper on Metric Conversion in Canada which was published in 1970 and which offers, at this point, some fairly basic insight into the rationale for Canada's apparently drastic decision. Spontaneously within that audience there developed considerable interest in this white paper (available from Information Canada for 50¢). But this was Biloxi, Mississippi, and in that room, dozens of key American educators, vitally interested in metric education, apparently and actually had not heard of the United States Metric Study. They were reaching out for an unimposing Canadian document, lacking awareness of the most remarkable effort in metric conversion and metric education. Commissioned by Congress and bringing together in most impressive fashion arguments for and against metric changeover, the study, aptly titled A Metric America: A Decision Whose Time has Come,[2] no doubt was highly influential when the vote was taken in the House committee. So, if they hadn't heard of the United States Metric Study, and perhaps some of us hadn't known of Canada's White Paper, you've an inkling why I may dwell on some things that you might feel need not be said.

I encountered a second such situation in our nation's capital when I was a guest of the Metric Commission, Education Sector.[3] At one side of me at the sector meeting sat our good friend Frank Barrett, representing textbook publishers of Canada. On the other side was a gentleman with whom I found myself in casual conversation. He officially represented one education-related group vitally interested in metric conversion and it came out that he had not heard of the term SI. Système International d'Unités (SI) is the modern, international metric, to which we are converting our thinking if we are the physics teachers, the chemistry teachers, of a generation past.

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[1]International Conference on Metric Education, directed by Dr. John M. Flowers, University of Southern Mississippi, held at the Sheraton-Biloxi, Biloxi-Gulfport, Mississippi, January 21/23, 1974. In this connection see H.D. Allen "Canada Leads U.S. in Metrication," *The Teacher* (Nova Scotia Teachers Union), 12:11 (February 15, 1974).

[2]United States Metric Study, *A Metric America: A Decision Whose Time has Come*, National Bureau of Standards Special Publication 345 (Washington: United States Government Printing Office, 1971). Price $2.25

[3]Metric Commission, Steering Committee 10, meeting of October 10, 1973.

It would seem that the benefits of metric conversion are as fully "self-evident" as any of Euclid's axioms! The two cited in every study are the universality of the system (now the dominant system, or becoming so for 90 percent of the human race), and the simplicity, the coherence, of the system (which, for us as educators, is at least as important a reason). Historically, metric is the only *system* of measures that man has produced . . . the only system created to be just that, a system. Historically, it was in the reign of Elizabeth I that two units of some antiquity, the yard, a fairly basic anatomical measure, and the mile, the thousand (double) paces of the Roman legion (as it marched across Europe two thousand years ago), were legislated into coexistence with a factor of one thousand, seven hundred sixty--that is a "system" only after the fact! To us, in what we like to think of as enlightened perspective, a good question would be, "What has been the resistance to a clearly needed change in something very fundamental in our lives?" *Newsweek* recently published an article on the American scene, and quoted from a charming little verse from the England of 1883. It recalled for me Kipling's "Recessional," and that line, "lesser breeds without the law." It goes like this:

> Then down with every metric scheme
>   Taught by the foreign school
> We'll worship still our father's God
>   And keep our father's rule--
> A perfect inch, a perfect pint,
>   The Anglo's honest pound,
> Shall hold their place upon the earth
>   Till time's last trump shall sound.

Eighty years later, Britain quite reversed that attitude! In *Popular Science*, as a follow-up to a good article on metric conversion, there was delightful "anti-" letter which had this sentence (with which we, as educators, I think have to cope): "It's silly to junk the reliable, workable system we have and crucify the American public on a metric cross."[4] Lot's of luck! Something I don't think we've seen in Canada, that an Australian colleague tells me about, that's the phenomenon where in Australia they've moved further into metric measures than we, and publicity has reached out to the man in the street, and there have been those, possibly of an older generation, who sincerely believed that if they ignored it long enough, it would go away. We in Canada, I would gather, have no such illusion.

I'm going to talk to you about metrication (if you would, "metrification") and, in particular, metric education -- from the vantage point of its effect on people. My university physics is more than twenty years old . . . they pounded it at me, at McGill, in the best of traditions. I can recite how MKSA symbols were written -- for multiples, with capital letters. They may still do that in college physics texts, but the metric of tomorrow (and, hopefully, today) is SI, and it knows other rules. So while I have the intellectual foundation that the science teacher should have (and which makes him, potentially, a leader in metric

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[4]Edward Edelson, "Here Comes the New 'Yardstick' in Your Life," *Popular Science*, 203:5, November, 1973, and "PS Readers Talk Back," *Popular Science*, 204:2, February, 1974.

change-over), I too have had unlearning to do. I recall the fine spring day when we took the big green college bus and headed a couple of kilometres out of town. We had a plan of a plot of land. As an exercise, we calculated its area (it was pleasingly irregular, having a stream as one boundary, a curving road as another) and had come to the conclusion that it closely approximated our new unit of land area. We went out, walked the land, and (in the jargon of the younger generation) got a "gut feeling" for what a hectare really is. There would be an easier way, when you think of it! Run one hundred metres, then consider the square inscribed on your path. You'll have the hectare. As most city people never did grasp the acre, this will be progress, and perhaps significant progress if we are to teach measurement concepts as we never really have before.

I've learned from all kinds of people, from questions they have asked and from some they didn't ask. One of my ways of tuning in on how real people out there think is perhaps unusual for a teacher (teachers are intimidated in this direction, by tradition), but very satisfactory. There is a social institution which can have no parallel and that is the open-line radio broadcast where the listener phones in and where (as a colleague in the publishing industry expresses it) radio becomes "a public confessional." Whatever is on their mind, they say . . . and all the neighbors down the block listen in and nod. I have chalked up a good many tens of hours (not a fundamental metric unit, but you know what I mean!) on open-line programs in little Maritime communities.[5] It is a rather unique way to think along with people, and to learn, as a result, how people think. They will listen to you for, say, twenty minutes. By then they know what some of the uncertainties or reservations seem to be. Then they pick up the phone. What they have taught me I am happy to share because I think there are lessons to be learned. We in education are very dependent on the good will of the people out there -- as someone said to me in teacher training, "they send us the best children they have" -- they support us, and without their backing we can do little.

A young housewife assured me that one thing for sure was going to happen in metric change-over -- people were going to be cheated, they were going to be "taken." All I could counsel her was that, while I respect the role of government in consumer protection, I also comprehend and respect a militant consumerism, the kind that (when there's cheating) can hit back where it hurts. One older lady brought home to me some facts of life that I share with you: most of us, I guess, are old enough to have recognized a mathematically periodic variation in skirt length over recent years. A few years after my college days, skirts got conspicuously shorter. Nobody was speaking metric measurement in those days (not in girl watching, in any event), but there was something to be learned from the phenomenon. Anyone who complained to a clothing merchant that a dress this long was costing fully as much as a dress this long, was told that essentially the same labor went into a short skirt as a long skirt, and that labor really was the factor determining cost. Years passed, styles changed, and skirts got longer again. The same matron, on noting that prices were up, was informed, she assures me, that more

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[5]Tapes and typescripts of a number of these "open-line" hours have been deposited with Nova Scotia Teachers' College Library, to which enquiries may be directed.

material was involved, so of course the cost was more! I'm worried that metric conversion will be the future scapegoat when, as now, inflation likely will be the real contributing factor. Conversion need be no fiscal ogre. On the contrary, coupled with intelligent "product rationalization," it can be an economizing factor.

Some people are more than a bit frightened at the prospect of metric conversion, a little timid, bewildered, confused. They've little need to be. I'll not forget an elderly lady who called in while I was on the air on a rather pleasant morning talk show. She needed to know how much a kilometre was. Without stretching my arms too much before the microphone, I tried to put across to her (without resorting to conversion factors) how far a kilometre was along a road . . how long it might take to walk. She assured me that this was not what she had in mind. Her need was to eat a kilometre! I suggested that she might be thinking kilogram, and she brightened audibly, "Yes, that's the word! Every day I'm to have in my diet a kilogram of salt . . . ." I suggested a measure in the gram or milligram range . . . and urged a friendly chat with her physician or pharmacist, a chance to see measured out the amount that had been suggested, and she seemed happy. But you see that she had been genuinely confused, anxious, and glad that she could call me. I was glad too. Another call I'll not forget was from a retired school teacher who attacked me at great length and with no uncertainty in her voice, saying: "This metric--it is hard. I've taught it, and I know it's hard." She had little use for people (nine-tenths of the world) who'd not make the effort to learn our ways. Metric is hard . . . I have no doubt she was right. It is very possible to teach metric in such a way that it is hard . . .and this is a matter that we must give thought to. This SI is in every sense so simple . . . if you do it right. If you don't, you confound yourself and complicate the issue and are in real trouble.

I think we all know that modern metric had its roots in the 1790s in what an anti-metric America once termed "atheistic French revolutionary thinking." The system was, throughout, to be built on tens, and at the outset they did go a bit far. Why, they wanted a ten-day week and a ten-hour day, and of course they started the calendar again, l'an un, Year One of the French Revolution! They looked to a right angle divided into one hundred parts, called grades--which you could still find in a trigonometry syllabus into this century, though they appear to have seen no practical use. That initial concern with 'tens' was to evolve and be refined. The tens, of course, derives from tens numeration (and ultimately from the fact that early man reckoned on ten fingers) . . . and it's beautiful "reinforcement." Any Grade I teacher can well appreciate the soundness of grouping by tens and thinking in tens, in numeration, in money, in all measurement. I can remember our Grade III teacher (in my first principalship) -- her "thing" was boxes of drinking straws . . . with elastic bands around every bundle of ten, and ten bundles of each box (*that* was "one hundred"). If all measurement reinforces that kind of thinking, then, clearly (I think) the interest of the young child is being served. I claim that SI is simple iff you do it right -- that's the mathematician's i-f-f, "if and only if." I suggest that the way to take on these concepts is by immersion. I know no other way. I think the only parallel we have is the learning of a second language. Now, I am a self-confessed product of the English schools of Quebec of twenty-five years ago . . . when I could boast a first-class standing in French (Language and Literature) and yet be able to do little other than pass Quebec's High School Leaving Examination -- French was a "required subject"! Nonetheless, despite (not because of) all that, I can communicate most effectively in French (and I guess effectiveness is a criterion) simply because, fifteen years later, I took on principalships in communities like Chibougamau -- the northern Quebec mining field -- and Arvida, in Saguenay-Lac St. Jean. My schools were English. But Chibougamau is 90 percent French. Saguenay-Lac St. Jean is 99.5 percent French. You learn, you learn fast when you have to, when you're truly immersed in a "learning situation." There just may be a parallel there, in terms of measurement learning. Immersion may be a logical, even necessary first step to absorbing and truly learning measurement concepts.

One day in the Truro paper we published a rather remarkable map of our town. I use the Truro paper. It works well. You see, no self-respecting young lady in teacher education is going to listen to a college instructor talking in a lecture room about something she won't be using for another year, and not turn off when he walks out of class - it's probably a part of good mental health! Nevertheless, if something's in the town paper, or on local radio (even if he put it there), she is likely to find it a topic of conversation in the boarding house over supper . . . at that point she may not even realize that she is learning! The map of Truro town streets was dimensioned solely in metres and kilometres. On it were marked strategic points one kilometre from the building where our students go to classes. A fringe benefit, of course, was that by making a classroom of the community we reached into schoolrooms and reached the adults. It eased the way, I feel quite sure, for our girls in their teaching, to try a metric immersion approach.

You know, this may surprise you, but many of the "problems" of metric conversion, when you look right at them, really aren't there! Halifax, from Truro, is a nice, neat, sixty miles; it's a nicer, neater, one hundred kilometres. When you get down to it, local people think of it neither way. By car, it's an hour and twenty minutes on the Trans-Canada. When you buy gasoline, the litres will be more than the gallons, but who watches either click over? Dollars and cents clicking over - that's what you watch. So often measurement is not in terms of the units we stress in the classroom, but of other, more directly relevant concepts.

Some of my students joined me for a special tour of Colchester Hospital in Truro. We wanted to see if a Canadian hospital really was as metric as some claim. Well, in a hospital as in a school, budget is a very real consideration. Good equipment is hardly likely to be discarded solely because it's "unmetric." Granting that, Truro's hospital was a wholly metric place. If you're born there, your mass is recorded in kilograms, your length in centimetres, your temperature in degrees Celsius, and your time of arrival is noted from a twenty-four hour clock. That's the kind of information which the hospital communicates to its computer. I suspect they still tell a mother what she wants to hear! An adult may "weigh-in" on an old scale down the hall - the reading being in pounds and quarter-pounds, but there's a chart on the wall (wholly lacking in concepts of precision or "rounding") which produces the kilogram readings for hospital records. All clinical thermometers are Celsius, with 37° the sign of good health.

My children have a feeling for Celsius which you might envy. We spent a pleasant summer in a Laurentian cottage, agreeably apart from electric light and other urban things but with a Celsius thermometer on the porch. *Celsius only*. They're not that good at the "five-ninths, nine-fifths, add thirty-two, subtract thirty-two" thing, but who cares! They do know that on a brisk August morning if it's ten or twelve, you get a sweater on, but sunny August days warm up, and once it's twenty you're fine in shirt-sleeves. When it edges toward thirty, you peel off all unnecessary clothes! We never did see thirty, but twenty-eight suggested swimming trunks . . . and our thoughts were far from the zero that brings ice to the ponds. One of Australia's "metric conversion" postage stamps, a clever set of four put out to promote the change-over a while back, shows a likable cartoon character (common to all four stamps) learning the new meaning of thirty-eight degrees. Lying on a beach, tongue hanging out, toasted a fairly rich shade of red, he gasps out "38^0C" (and, purely as an aside, 100^0 Fahrenheit)! Our girls at Teachers' College have the chance to get such a "gut feeling" (if you would) for Celsius temperature. Outside the main entrance is mounted a thermometer, pointedly "Celsius only." Look at it each morning and you learn! It's hard here in Canada to get a Celsius-only outdoor thermometer. You may have to cheat a little. Take a "dual" one, then reach for the white paint or white correcting fluid. Presto! -- Celsius only!

One thing we must note -- it's a sobering thing -- is how bad a job, for better or worse, has been done with the teaching of the traditional system. Most of us have little feeling for the measures. When you think back to the textbooks, all of them, of decades gone by . . . a page starting by naming the units, then stating the relations, then you were into computation . . . sixteen ounces to the pound, five and one-half feet to the rod, four pecks to the bushel (you remember these things!), and then you proceeded to word problems and computation. I think at this point the concepts were lost to the paperwork and you were doing calculations with things that might have been just so many words. I doubt that too many teenagers today could look at the other end of this room (down where the sign says, "Litre is Sweeter") and give an estimate in yards, in metres, in anything. Measurement concepts have not really been learned and I'm not sure that a textbook, seatwork approach lends itself to the internalizing of such concepts. Other types of activities should be given a chance.

I always like to use "real" things when doing metric. There's an artificial, sterile world in the hospital or laboratory. I don't want students to associate metric with erlenmeyer flasks, graduated cylinders and triple-beam balances. I want them involved with the kinds of things they live with. What I would do is what Jack Bell tells about the school in England that had the most simple, sensible approach. You go out and buy the best metre stick you can find. You put it, literally, on red velvet, outside the principal's office, and it becomes the standard for the whole school. At this point, each class replicates the standard. As a learning experience, it's sound. For mass, replicate a standard kilogram. For capacity, a litre. Your litre might derive from a laboratory standard, say, a one hundred millilitre graduated cylinder emptied ten times into a quart milk bottle. The litre line on the bottle (with an indelible pen) would provide the standard to replicate.

We need planning at this point. You sense this, I'm sure. We need longer-range planning, and we have every indication from our good friends in Ottawa that this planning has been going on and will be going on. We are starting to feel the impact at this point. When you don't have sound planning, you know what happens.

An executive of Eastern Provincial Airways told me one conversion story. Cockpits not so long ago were converted so that instruments read knots rather than miles per hour. (The American influence in retarding the metrication of international air travel has been real.) Then they were short in their peak season and leased a DC-9 from Aer Lingus, the Irish airline. The dials read kilometres per hour! The flight crew learned. They learned fast! We all can, you know. But you see here the possibility of double, two-stage, change-over, and you hope that proper planning can minimize the phenomenon. The only time I've written a letter to the *Globe and Mail* was when they ran a front-page feature story telling us how inflation was reaching the point that price calibrations on scales in supermarkets no longer could give the price for the more expensive commodities.[6] Real cost was going to be involved in converting those scales to higher price ranges, it was pointed out. My effort was to urge them to look one step ahead and take into consideration eventual conversion to a new system of units.

I think it is very important for all of us that there be the quickest possible change-over, in all sectors, to metric sizes. The pharmaceutical industry prides itself in its leadership in metric standardization -- and rightly so. A tube of toothpaste today is 25 millilitres, 50 millilitres, 75 millilitres, 100 millilitres, or 150 millilitres -- as simple as that. (The "old days" knew 29 sizes, and price and size comparisons were incredibly awkward.) Now, to buy a tube of toothpaste, you reach for the tube, that's about it. It's true in virtually all shopping. Who reads the small print? But if you're going to read the measurement, no doubt for price comparison, then it's there and its simple (which might encourage the consumer to do it more often). An unfortunate approach to change-over is represented by the "quart" milk carton, dually labelled "1.14 litres" . . . everyone thinks, and quite rightly, "a quart of milk." There really is no transfer when the size is conventional and the label dual--metric tokenism! Perhaps a logical "first stage" -- but, hopefully, an abbreviated one.

All of us know the views on metric education of our national body, the Canadian Teachers' Federation. I think many of us in our minds applauded when CTF called upon the Government of Canada for rapid change-over and when they insisted that "dualism" (where old measures persist alongside the new) impedes learning.[7] I think we all have arrived at the conclusion that this is so. I have pedagogical points which I'm anxious to make. I think the most important message that I have - a reminder for Ottawa and an observation that has important ramifications for your classroom - is that metric *is* decimal. That's what it's all about. That's its main virtue. It is decimal like the numeration system, like Canada's monetary system. Metric is decimal.

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[6]"40 to 50% of Retail Food Scales Cannot Accept High Prices," *The Globe and Mail*, September 8, 1973.

[7]CTF News Service, "The Metric System--Immersion vs. Conversion," *The Teacher*, 11:14, April 1, 1973.

I go into our hardware store and the old gentleman who owns it takes aside the self-confessed metricator and says, "I want to show you something." He shows me, typically, a box of screw-eyes from a brand new shipment, observing: "A hundred; they used to come by the gross. Now, often when I order two dozen of something, they come as two tens and four singles." Such decimal thinking (thinking in terms of grouping by tens) I think is on the increase. In a metric world it will make even more sense.

Canadian money is decimal money, we assert. Well it might be, for the rash of hurried decimalization of the 1960s has wholly freed the world of pounds and rupees with nondecimal subdivisions. Look particularly to Canada's dollars, the folding money: one, two, five, ten, twenty, fifty, one hundred -- just the sequence that a metric man would have ordered! Such a "preferred decimal sequence" you also would look for in metric "masses" for the science lab. You'd hope to find them, too, on grocery shelves. Time will tell. Ottawa has leadership to offer in this area. So, interestingly, Canada's bank notes, as evolved, provide a model for all decimal measures. (Note that two and five are exact divisors of ten.) Coinage, quite frankly, is a bit of a mess! We could do with a two cents and a twenty cents. The twenty-five cents (quarter dollar, the Americans call it) should be living on borrowed time. Our coinage concepts we inherited, at least in part, from Spain. A few years ago, a bulldozer in Lower Sackville, Nova Scotia, brought home this point. Ploughing into a mound of earth it hit an improbable jackpot -- silver dollars rolled out, Spanish milled dollars, "pieces of eight." (That's not metric!) The Spanish dollar coin at times literally was halved and quartered, like so many pieces of pizza, and a quartered eight-real piece gave you two reals, or "two bits" (which persists as slang for 25 cents). My point is that metric is decimal (I maintain this!), and decimal does not half, quarter, and eighth. When you find a litre measure divided into eight parts (and there are several brands on the market!) think about what the teaching aid is attempting to do and whether it is appropriate to your aims.

If you're a secondary mathematics teacher, or ever have been, pose for yourself the rather sobering question, "Who needs fractions"? There's no glib answer to that question. Certainly, there is need for non-decimal fractions. Children need the rationals, their structure, properties, operations, algorithms, and so on. They need skill in manipulating rationals. Ratio means fraction. The linear equation (even with integer coefficients) needs fractions for exact solutions. So fractions are needed, even in an essentially metric and decimal world. But that leads to the next question. At what level are children going to have these needs? At what level is it appropriate that we offer this material (which many now find difficult, even distasteful) in the total pattern of educational development? I don't have pat answers to that, but I do urge that it has to be thought through. You may come to the conclusion that much fraction work has come all too early (is there such a concept as "fraction readiness"?) and that more than some, in a metric world, could only be defended by that quaint Victorian phrase, "mental discipline"!

I am something of an antiquarian, unapologetically so. I collect old mathematics texts. I love them and what I find in them, representing what teachers were honestly trying to do in the classroom.[8] I find challenge in them. A term I learned from my Grade IX arithmetic teacher was "apartment-house fraction". It had fractions in the numerator and denominator (and it wasn't a good one unless they had four-figure denominators. One consolation, the answer often was absurdly simple, say I!). They're a challenge . . . I did enjoy them, the way some, I suspect, enjoy the cross-words of the *Times* of London. The question is, do they represent a "universal need" in terms of the "real world"? Or did they ever? I suspect not. Even as I leaf through current texts and find a child in Grade V adding "five-sixths and one-half and thirteen-fifteenths," or in Grade VI taking seven-fourths and dividing it by four-fifths, I wonder. I can let you in on this much--from hitherto unpublished memoirs of a textbook writing team! Try to produce a set of "word problems" on non-decimal fractions, problems that children can identify with, based on their world. You're in trouble . . . once you've used up "three-sevenths of a week" and "five-sixths of a pizza"! You think about that. Do right by "metric" (no "one-third of a metre"!) and your examples tend to derive from vestiges of non-decimal measure . . . quarter hours, thirty-degree angles, and such. Reach for the pizza! No, I have no clear-cut answers. I suggest that the role -- the emerging, redefined role -- of the non-decimal fraction needs to be looked at most carefully. Right through elementary grades, it has a place, but a redefined place and purpose, in computation and measurement and problem solving "strands." The level where needs occur, the level where it is appropriate to teach, must be redetermined, particularly if students are to have deeper grounding in decimal fraction concepts and computations (which "going metric" would seem to imply). I do suspect that there may be fairly "inevitable" conclusions, but only after very considerable "thinking through" and "talking through." I do say this (to indicate one line of investigation): a great deal of computation involving non-decimal rationals, as for example the collecting of terms and solution of a linear equation with rational coefficients, can be quite eliminated by "multiplying through" . . . not necessarily by the "least common denominator," any common multiple of the denominators will do.

Ottawa has done its work well (we say at this point) in providing Canadian standards reflecting international "metric" usage.[9] Those of us who perhaps pioneered in Canadian metric education, doing our best to second-guess Ottawa in the

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[8]For a glimpse of the attractiveness of some older material, try H.D. Allen, "Relieved Beggars and Watered Gin," *The Teachers Magazine* (Provincial Association of Protestant Teachers of Quebec), XLVII, 237 May, 1967, and "Nineteenth-Century Canadian School Mathematics," *McGill Journal of Education,* IV, I, Spring, 1969. My own favorite is "The Verse Problems of Early American Arithmetic," *Journal of Rutgers University Library* XXXIII, 2, June, 1970.

[9]Definitive studies on metric usage for Canada are: Canadian Standards Association, *National Standard of Canada: The International System of Units (SI)* (Reference Z234,2-1973, 29 pages, $2.50); and *National Standard of Canada: Metric Practice Guide* (Reference Z234,1-1973, 44 pages, $4). A four-page leaflet, Canadian Standards Association, *The International System of Units (SI): An Outline of Canadian Usage,* CSA Special Paper, June, 1973, provides a summary. Up to six copies may be obtained without charge from the CSA, Rexdale, Ontario.

seemingly endless interval before the Standards Council of Canada brought down its extremely important documents, were somewhat in the dark as to how we should spell (decametre or dekametre?), how we should symbolize (dam of dkm?), and how to handle some related considerations (decimal point or decimal comma? . . . thousands comma or thousands space?). Today no such questions are left unresolved. The documentation is before us. It seems to me that at long last we as educators can talk pedagogy, sort ourselves out, then go ahead and do our job. I think we have the right to look to Ottawa for leadership in national awareness of this metric commitment on the part of Canada . . . and the "logo" that has been adopted may be the symbol of that leadership on a great diversity of products over the years ahead. I think there's a definite and apparent need for co-ordination within that extremely complex organism that is federal government. Let me illustrate. A rather striking thing happened in our metric education efforts a few months back. I decided that one way to get our college community thinking "metric" would be to take the Truro weather data for a particularly spectacular month (then just ended) and to present it in the town paper in chart and story form . . . totally in international units. Across the river from Truro, in our "suburb" of Bible Hill, is a federal government weather office . . . and a most obliging weather officer. He gave me all I needed (covering a whole month) over the telephone: the precipitation, the daily "high" and "low." One thing came through, increasingly, in the conversation. He knew who I was, where I worked, and what I wanted to do, but when I talked about Canada "going metric," he thought I was talking science fiction! He is a federal civil servant. There is work to be done in this area of communications if leadership is to develop early in all sectors and if we in education are to be supported in the job we urgently seek to do.

Equally, I think we as Canadians have the right to look to our respective provinces and territories for leadership in their areas of special competence. Education immediately comes to mind, and this would include most aspects of adult education. It's a big job. We know that!

Canadians have the right to expect the schools to pass on to the young the benefits of thinking and living with metric units -- as a system -- and to me that means totally and effectively. I don't think that "metric" is this much a part of Science and this much Mathematics . . . that won't take any more than my high school French took . . . it's got to be a part of total living experience and I think it can be. Think of a school community, a team of teachers and learners. I don't think it's bad when the teachers themselves become learners . . . and leaders in learning, in a very real sense. I view "metrication" as a particular challenge to the young generation. It need be no burden to the older who, if you would, have a choice of two roads (you still reach for the package on the grocery shelf, and unless "metric" is your interest, you'll not likely read the small print). I think the challenge to the young recognizes that they will most benefit . . . and they will live on into a Canada that is metric . . . a world that speaks one measurement language. I like to see them meet this challenge.

One fine little community in Nova Scotia is just off the Trans-Canada (the tourists may not see it) and it has a well-earned reputation for people working together to get things done. That community is Brookfield. It's eight miles from Truro (you'll pardon the expression!). Junior high school students there have a big sign outside their school. In school colors it tells how many kilometres from Brookfield to Truro, and to all the other Nova Scotia communities they could fit on the sign. Junior high school students built it, from the ground up, from donated materials, spurred on by a dedicated mathematics teacher . . . with some technical advice from some of my student teachers. We were invited out to the unveiling last June. We were proud of their clean four-inch numerals (somewhat embarrassing!) on the big eight-by-four plywood sheet (one must be realistic!). We had made an earlier sign, somewhat similar, on the College grounds. In the summer, tourists hold up rush-hour traffic to pause and read. Yes, they copied us, more or less. That, in education, is the sincerest form of flattery, we all know. We live in the world of the present (eight-by-fours!), but we reach for the future. Schools and parents often approach us, and this is good. I'm not surprised to be hailed in the street by a total stranger . . . maybe Truro is too small a town to have "total strangers," at that. One man is a carpenter. He is very enthused at the prospect of metric measures for his children. He is interested. He is a potential leader for the community . . . one Canadian citizen. A mother recently told me on an open-line show that she had a boy in Grade X. He was doing metric, liked it, and found it simple. (She was rescuing me from the retired teacher who had insisted that metric was "hard.") I'm glad that we can still in Grade X produce that feeling . . . that "metric" is simple. Young children, one mother told me, are being instructed to buy rulers with centimetres on them. Well, if they're "dual" (and at this point, very likely, they are), I hope they have the courage to "shave off the inches"!

Dr. Daniel DeSimone, a leading personality in the move to "a metric America" and I had a most interesting discussion recently. He did bring up one point that I think has great relevance for us, and that is that there's (he'd want you to pardon the expression, I think) no "political mileage" in metric support. You'll not win votes by pushing for metric conversion. I hope that those who lead us in Ottawa have the courage to give us the firm leadership in this area . . . even though I must concur (as I talk with elderly voters and the less informed) that there may be less than "political mileage" in a forward thrust. There is a need and there is a priority. This I'm sure we all see. (All political parties have come out in the Commons in support of our metric commitment. It would be hard to oppose.) Dr. DeSimone spoke with some feeling about what he termed "phony issues" relating to metric change. He must cope with them in Washington. You may have met their Canadian counterparts in suburbia. People are saying that metric is not going to solve America's problems of international trade . . . that metric is not going to revitalize American industry . . . that metric will not solve all the problems of education in the United States. No, but it may help, it may ease the burden. It certainly is a step we're inclined to recommend taking, argues Dr. DeSimone. He suggests that what is called for is "the rule of reason" in guiding the change-over . . . that, after all, an entirely voluntary change-over is foreseen.

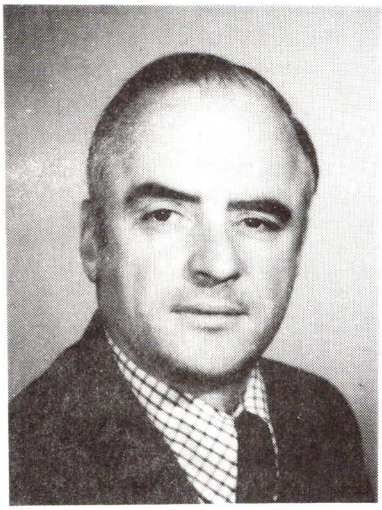
Metric is not hard. That we know. Unlearning the old, freeing oneself from old thought patterns, that's hard! I don't really know who first observed that, but it gets right to the heart of the problem. I do emphasize, however, the need for a certain caveat on teaching aids. In Biloxi in January, I got a notable silence when I observed that there were some superb teaching resources then and there on display . . . but that 90 percent I wouldn't take home! Which is to say that (for that cross-section of primarily American-produced products) the metric symbolism was wrong, pedagogy was wrong . . . colors were bright, but that's not enough. Now that we, at least in Canada, have the standards, the symbols, the preferred practices, we have some ideas, educationally, mathematically, about what we are trying to do. If you find centimetres subdivided to halves, ask yourself why! (The implication is measurement to the half-centimetre, which implies looking to the fourth.) If you find litres divided to eighths, and metresticks into fourths (in technicolor!), think about it again . . . your educational aims and whether they are being reinforced or whether they are being eroded. One aid which makes me shudder teaches place-value but garbles the SI and the symbols. Would you believe "myriameter" -- the textbook "unit" for ten thousand metres which has no use on earth! At the other extreme -- "capital m, little m, period" as the symbol for millimetre on an "aid" currently being widely promoted to teach "metric." As I say, we need to be discerning buyers. We're in a position to be just that. We can hope to see--and to influence--the sound products that will support the teacher in her classroom efforts to provide the advantages of modern metric for the young, and the not-so-young.

There no longer is an excuse for being wrong and it gives you a lift to know you're right, but you have to have a sense of humor in all this. This fine, sunny March day I would put down as 1974.03.06. I like it. It makes sense. Note the progression from larger to smaller units, while acknowledging the calendar's nondecimal subdivisions. I use it in metric correspondence, and I find that when people write back, they've picked it up. (We'll do a lot of "metric" teaching by good example, I suspect.) So, I see nothing wrong with "eighteen" or "eighteen o'clock." I think we can dispense with the military "eighteen hundred hours." But, as I say, you need a sense of humor. When I was flying on Air Canada (our government airline) this morning, I leafed through the boutique brochure. They were offering "Sculptured acrylic inflation ruler, measures 13 inches instead of good-old-days 12 inches, a perfect gift in these days of inflation." Now, as educators we realize it could have been worse. It might have been 39 inches replacing an inflationary "yard," or "one-third of a metre" - hardly decimal.

I'll tell you one more story, about "Miss 90-60-90," an anonymous, perhaps fictitious, Ottawa girl. I liked her. When I first came in she had brightened all these walls but I note every one has been squirreled away. Miss Buffy (actually a pale reflection of the British one published by Her Majesty's government) has already become a collector's item. When I was in Ottawa in October I asked for a pin-up for my office. There followed an embarrassed silence. "Oh, no"! someone volunteered. "There's a box full of them but we're not giving them out. We've got orders." "Ah, women's lib"! I suspected. So instead we have the gangly male basketballer and the diminutive girl jockey and if women's lib is any happier with that characterization, I just don't know. I don't think it has the visual appeal, but like Australia's cartoon postage stamps, it makes its point; it's official and acknowledges a commitment to a metric tomorrow. Maybe at some point in our enlightenment we will set up a "Miss Metric" to even outdo industry's "Miss Buffy"--then drape her (slightly rotated, I do think) in the logo of the symbol of Canada's metric commitment. Finding her might be a challenge to that advertising agency. I do think she would catch the eye.

There has been real inertia to overcome. It has been largely overcome in our sector. Momentum should carry us forth into a metric tomorrow.

Teaching Metric Measurement



David F. Robitaille
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Many teachers are apprehensive about teaching the metric system of measurement. Such worries are due, in large part, to two underlying causes: an unfamiliarity with the metric system, and a feeling that a whole new set of teaching techniques is required for teaching the metric system.

Eight recommendations for teaching the metric system are discussed in this article. Teachers will recognize that most, if not all, of these recommendations apply to the teaching of any system of measurement - not just the metric system. In other words, good methodology in the teaching of metric measurement is very similar to good methodology in the teaching of any system of measurement.

RECOMMENDATION 1: Let the Students Measure

The topic of measurement is unique among the various strands of the school mathematics curriculum. When teaching measurement, you have no choice but to make use of real objects from the real world. Most of us believe that we should utilize concrete examples whenever possible in our teaching and this decision is inescapable in the case of measurement. You cannot discuss measurement unless there is something to measure.

The classroom is filled with objects to be measured: doors, desks, tables, books, windows, chalkboards, pencils, paper clips, chalk, floor tiles and, of course, people. Students, particularly in the elementary grades, enjoy collecting data about themselves. Therefore, measurement activities might include finding one's height, weight (mass), armspan, volume, area of a foot, and so on. The important point in all of this is that the pupils are actively involved in measurement activities, and are thereby gaining familiarity with the units.

RECOMMENDATION 2: Use the Word "About"

A measurement is an approximation. Anyone who has ever built a cabinet, cut out a pattern, or baked a cake knows this. Companies that manufacture various types of moldings do a thriving business covering over the gaps in corners and edges that result from our best efforts to obtain an exact measurement. There is no such thing as an exact measurement. A measurement may be more or less accurate, or more or less precise. However, no measurement is ever exact.

So, John Doe is not 150 cm tall, nor is his mass 65 kg. John is 150 cm tall to the nearest centimetre. That means his true height may be anywhere between 149.5 cm and 150.5 cm. Similarly, his mass may be anywhere between 64.5 and 65.5 kg. In other words, John is *about* 150 cm tall and his mass is *about* 65 kg.

Teachers at all levels should discuss measurement as an approximation with their students. At the primary level, where students use rulers with centimetre markings but with no millimetre markings, children should learn to describe the length of objects in terms of intervals. For example, "The length of my comb is between 9 and 10 cm. It is closer to 10, so my comb is about 10 cm long." Textbooks at this level should show illustrations of objects whose lengths are not whole numbers of units.

At the intermediate grade level, teachers can show how measurements of area and volume are approximations. For example, students can be asked to find the area of one of their feet in cm^2. By drawing the outline of a foot on cm^2 paper, the pupils can obtain an approximation of the area. The smaller the squares on the paper, the better the approximation.

At the high school level, teachers can discuss measurement as approximation in the context of accuracy and precision. The precision of a measurement depends upon the unit of measure -- the smaller the unit, the more precise the measure. Thus, a measurement of 20 mm is more precise than a measurement of 2 cm. The accuracy of a measurement depends upon the number of significant digits used in expressing the measurement.

RECOMMENDATION 3: Have the Students "Guess-timate"

Many of your students will have had little or no previous exposure to the British system. Your objective is to have them "think metric." That is, when they look at an object they should think about it in terms of metres, kilograms, litres, and so on, rather than in terms of feet, pounds, and gallons. A very effective means toward attaining that objective is to have the students estimate a measurement before actually measuring.

Suppose that students are working at a station dealing with the lengths of several objects. Each student's worksheet should include three columns, headed: Object, My Guess, Length (see Figure 1). The student looks at an object, for example, the table top, and "guess-timates" that it is 85 cm long. He writes down this guess in column 2 and then uses a tape measure to find the length of the table top is 143 cm. He enters this number in column 3. For students in the intermediate grades, you might decide to include a fourth column entitled "Difference." Under this heading, they would enter the size of their error and perhaps indicate whether their guess was too high or too low.

Figure 1

Object	*My Guess*	*Length*
table	85 cm	143 cm

RECOMMENDATION 4: Comparison - YES!

"A litre is about the same as a quart." (Actually, a litre is a little less than an imperial quart and a little more than an American quart.)

"A metre is about the same as a yard." (A metre is approximately 39 inches long.)

"21^0 Celsius is about the same as 70^0 Fahrenheit."

For older students and adults, comparisons such as these should be helpful in developing familiarity with the metric units. The students and ourselves have spent considerable time becoming adept at seeing the world in terms of feet, pounds, and quarts. We can make good use of this adeptness during the transitional period as we switch from the British to the metric system of measurement.

As the various units of the metric system are introduced, students should see examples of the use of each unit. Where possible, the new metric unit may be compared to the corresponding British unit which is familiar. Such an approach should assist students in learning the new units.

Most of the foregoing does not apply, in any great degree, to children in the primary grades. Children in the first two or three years of school have little or no grasp of techniques of measurement or systems of measurement. For that reason, any comparison of metric and British units with primary level children will likely result in confusion rather than in enhanced understanding.

RECOMMENDATION 5: Conversion - NO!

Most mathematics and science textbooks contain conversion tables such as the following:

1 cm = 0.4 in.
1 m = 39.37 in.
1 km = 0.6 mi.

These tables are intended to be used in solving exercises such as, "How many decimetres are there in 14.2 yards?".

There is no need whatsoever for teaching conversion between systems of measurement to our students. The metric system, including the interrelationships among the units of that system, should be learned as a system complete in itself. Our students, if they are to "think metric," must be capable of working in that system without recourse to the old. Analagously, bilingual persons can speak their second language fluently without having to translate back and forth between their second language and their mother tongue.

The distinction between comparison on the one hand and conversion on the other is an important one. Comparison of units should facilitate mastery of the new units and their interrelationships, whereas conversion of units from one system to the other serves no useful purpose in learning the new system.

RECOMMENDATION 6: Stress Place Value Concepts

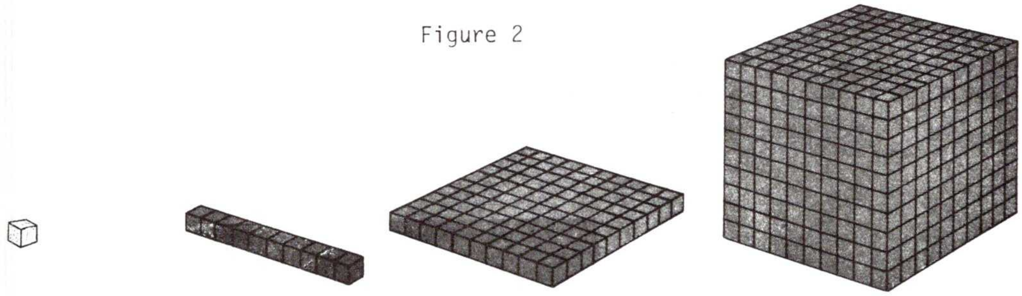
A surprisingly large proportion of students' difficulties with the fundamental operations of arithmetic are traceable to a lack of understanding of place value in our base ten system of numeration. For example, the majority of students' errors in addition and subtraction involve regrouping or renaming, which requires an understanding of place value concepts.

With the introduction of the metric system, decimal fractions and operations with decimals will be used more frequently than the corresponding operations with common fractions. For that reason, our students will need an even better understanding of place value concepts. Teachers, particularly in the intermediate grades, should not assume that their students have an adequate understanding of place value concepts such as regrouping, renaming, and recognizing "places." For many students, these ideas need to be taught, re-taught, and reviewed year after year.

Good teaching of place value requires extensive use of manipulative materials. Primary grade teachers can utilize counters, pocket charts, and various forms of the abacus, among others. Teachers of the intermediate grades cannot make too much use of counters because of the size of the numbers dealt with in those grades.

Perhaps the best teaching aid available for place value ideas with whole numbers is a set of blocks of various shapes and sizes called multi-base blocks

Figure 2



unit 1 | long 10 x 1 | flat 10 x 10 | cube 10 x 10 x 10 or Dienes' blocks. The base-10 set of blocks comes with four types of blocks: units, longs, flats, and cubes (see Figure 2). The blocks can be used to give a simple and explicit representation of whole numbers and, simultaneously, to highlight place value concepts.

RECOMMENDATION 7: Teach Measurement as a 3-step Process

The process of measurement involves three discrete steps:

1. selecting the unit of measure,
2. matching the unit against the object,
3. counting the number of units used in step 2.

As each new unit of measure is introduced we should have students work through these three steps first with arbitrary, non-standard units and then with the standard metric units. Brief descriptions of two examples of this approach follow.

In the primary grades, an introduction to length might involve having students measure the width of their desktops in paper clips. Other non-standard units of length such as pencil lengths, pieces of chalk, edges of blocks, and so on could be used. In each case the 3 steps of the measurement process are made explicit. The non-standard units of length should be phased out gradually and replaced by a unit such as the centimetre. The children can make "centimetre trains" by placing a series of centimetre cubes end to end in order to find the length of an object.

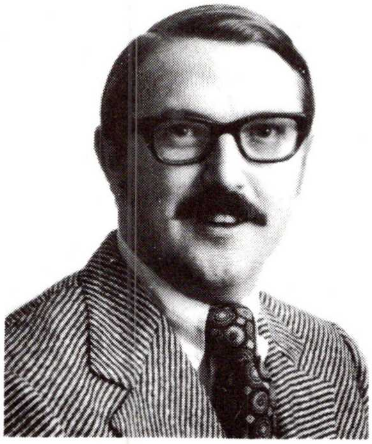
An introduction to area concepts in the intermediate grades might involve the use of geo-boards. Using this aid students learn in a concrete way that area is a measure of the space enclosed by a plane figure. After experimenting with the geo-board and finding areas of various polygons on the geo-board, standard units of area, such as the centimetre square, may be introduced.

Only at the end of this 3-step procedure should formulas be introduced. We tend to introduce formulas for area, volume and the like too soon, before students have adequately grasped the meanings of the underlying concepts. Formulas provide unthinking, automatic responses. Until we are sure our students understand a new procedure or concept, we should avoid teaching them formulas.

RECOMMENDATION 8: Relax!

This eighth recommendation may well be the most important one of all. Hopefully, a reading of this paper has helped convince you that teaching the metric system will not be an onerous task. If anything, it should be easier to teach the metric system than the British system.

28 g of Prevention is Worth 0.454 kg of Cure



by *James M. Sherrill*
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In January, 1970, Ottawa published the White Paper on Metric Conversion in Canada. Most people are aware of the conversion, but not that Canada is in its sixth year of metric conversion. It is usually the fifth, sixth or even the seventh year before the general public becomes consciously aware of a country converting to the metric system.

The Metric Commission of Canada (S.M. Gossage, chairman) is the official arm of the government for metric conversion. Metric conversion has already begun in the following areas -

- the pharmaceutical industry is almost completely metric; for example, toothpaste is available in 25, 50, 75, 100, and 150 ml tubes,

- approximately 75 percent of all Canadian hospitals use metric measurements in their internal procedures,

- highways signs (especially in Ontario) state distances in kilometres and speed limits in kilometres per hour (expected to be complete by 1979),

- the metric system of measurement is being presented in a large number of schools across Canada and will eventually be taught in all Canadian schools,

- public weather forecasts and temperatures are given in degrees Celsius,

- in intervals, rainfall amounts are given in millimetres and snowfall in metres,

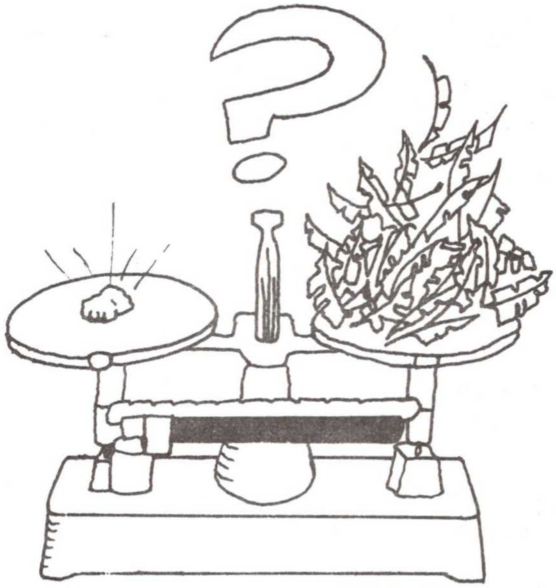
- The Canadian Grains Council has set a target date of August, 1976 for all shipments from seaboard to be in tonnes (metric ton/1 000 kg).

The metric conversion momentum should peak in 1976-78.

Canada is not inching its way down the road to metric conversion to be an isolationist. In fact, so much of the world is already committed to the metric system that it is possible to list all the countries in the world that are NOT: Barbados, Burma, Gambia, Ghana, Jamaica, Liberia, Muscat and Oman, Naura, Tonga, Sierra Leone, Southern Yemen, Trinidad, and the United States. Of these, the U.S., Jamaica, Trinidad, and the Barbados will not likely be far behind.

At this point you should use a piece of paper to cover up the rest of this page. Now uncover each line of print one at a time. I am about to ask you a question you probably have heard before, but may have thought that it was a trick question. It is a question that people from metric countries love to ask people who still use the English (or common, or British, or imperial) system of measurement.

Question Which weighs more, a pound of gold or a pound of feathers? (No peeking at the answer!)



Answer Feathers!

Feathers are weighed using the avoirdupois pound which contains 7000 grains. Gold is weighed using the troy pound which contains only 5760 of those same grains.

Question Which weighs more, an ounce of gold or an ounce of feathers?

Answer Gold!

There are 12 ounces in the troy pound, so each ounce weighs 480 grains. There are 16 ounces in the avoirdupois pound, so each ounce weighs only 437.5 grains.

Discussion could continue about the two different units called the "foot," used today in North America, or the seventeen different tons, but let's turn our attention to the variety of units in the English system of measurement. (Continue to uncover the lines of print one at a time. Also, you will need a pen or pencil.)

Final Exam

This test is called a final exam since I hope it is the last test you will ever give or take over the English units of measurement.

1. How many cubic inches are there in a gallon? ____________________
2. What is the difference between a liquid quart and a dry quart? __________ ("One is wet and one is dry" is not acceptable.)
3. How many square feet are in an acre? ______________
4. A common aspirin tablet is 5 grains. How many scruples does that represent? ______________
5. How many pennyweight are there in a troy ounce? ______________
6. How many firkins are there in a hogshead? ______________

Answers to the Odd Numbered Questions

1. About 277
3. About 43 560
5. About 20

After the results of the tests are compiled it will be time to turn our attention to a very close look at some of the units of the English system. If one wants to find out what a particular word means, he goes to the dictionary. I wanted to know what a "quart" was, so I looked in the dictionary.

Definition - Quart (pronounced kŵort) is a liquid and also a dry measure of capacity equal to one-fourth of a gallon or one-eighth of a peck, respectively (of varying content in different systems, places and times).

Now *there* is a definition that nails it right down. Everyone knows what a quart is now! The definition of a "quart" didn't slow me down though. I next looked up the definition of a "foot."

Definition - Foot (pronounced fo͝ot) is a unit of length derived from the length of the human foot. In English-speaking countries it is divided into 12 inches and equal to 30.48 cm.

Let's look at the above definition. First, I assume that the human foot the unit is derived from was the king's foot, since he was the "ruler." Secondly in North America units of length have been defined in terms of metric units for almost a century. But, for now, leave off the metric part of the definition and what we have is that the "foot" is derived from the length of the human foot and divided into 12 inches. In the same dictionary I found the following definition of an "inch."

Definition - Inch (pronounced ĭnch) is a unit of length, 1/12 of a foot, equivalent to 2.54 cm.

What really happens in class? You don't define a foot or an inch, you let your class measure objects, using the units and point out that one foot is the same length as 12 inches. The same is true in the metric system. You don't have to worry about *defining* metric units, just *using* them. Make sure your class gets ample opportunity to use the metre, don't worry about defining it.

The metric system which we will use in Canada is called the International System of Units (Système International d'Unités) (SI). The "metre" was originally defined as one ten millionth of the distance from the north pole to the equator passing along a specified meridian. As the north pole shifts position, the length of the metre changes. SI revised most of the definitions of metric units so that the unit would never change and the unit could be replicated in any scientific laboratory in the world. Following is the scientific definition of "metre."

Definition - Metre (pronounced mē′tər) is 1 650 763.73 wave lengths in vacuum of the orange-red line of the spectrum of krypton 86.

That is quite a definition!! Again, remember, you never have to use the above definition. All you have to do is feel warm all over knowing that SI has fixed up the old definitions in such a way that they are standard throughout the world.

O.K., now let's go metric.

There are basically three levels of going metric. The first level, denoted L_0, is when a country is strictly English in its measuring. All packages are labelled in English units. Canada has not been at this level for almost a century.

The second level, denoted $L_{\frac{1}{2}}$, is when a country is using the metric equivalents to the English units. Canada is in $L_{\frac{1}{2}}$. Many packages are now labelled in metric units but are exactly the same size as they always were. For example, cereal comes in 453.6 g boxes. You think the packagers count out the flakes until they get that extra 0.6 g? Or could it be by coincidence that 453.6 g is the metric equivalent of one pound? There are salad dressing bottles that say they have a capacity of 227.3 ml. A litre is smaller than a quart, a millilitre (ml) is 0.001 of a litre. The companies are simply converting mathematically from the English unit to the metric unit without changing the size of the package. The third level, denoted L_T, is when a country uses both metric sizes and labels. This is the level for which Canada is striving. Some items are already at L_T: toothpaste (mentioned earlier), wine bottles are seen in 500 ml, 1 ℓ(litre) and 1.5 ℓ sizes, medicine has come in packages labelled in cubic centimetres for a long time. Cereal will probably come in 200 g and 400 g packages.

A lot of confusion goes along with the trip from $L_{\frac{1}{2}}$ to L_T. The speed limit in front of schools will be 32 km/h. (A speed of 32 km/h just happens to be the equivalent of 20 mph when applying English unit thinking to the metric system--which is $L_{\frac{1}{2}}$.) Just as we don't have speed limits of 32 mph we won't have speed limits of 32 km/h; it will probably be 30 km/h in front of our schools.

But what *will* it be like in metric Canada? Following is a story about what a typical day in the life of a school teacher will be like in metric Canada:

> Get up at 06.30 (this is no different - how many of you get up at 6:30 a.m. and say, "Oooh, 6:30!"), have 200 ml of coffee, two 20 g slices of bacon, and one 40 g egg for breakfast.
>
> The radio announcer says it is already 20°C so you know you won't need a coat. You hop into your car and you're off to school. You make the 10 km drive in 20 minutes since you had to creep along at 30 km/h in the heavy traffic.
>
> Classes start at 09:00. You spend your day helping others inch their way down the road to metric conversion.
>
> At 15:00 you go home to start grading the 2 kg of papers you have to grade. First, you slip out of your petite size 38 dress and slip into your slim, size 61 pants and comfortable size 40 shoes. (For the men, you might wear size 85 slacks, size 45 shoe, size 23 socks, and size 70 hat. For comparison's sake, the "petite" size 38 dress is a size 10 by our current standards.)
>
> The temperature has risen to 28°C so you have a drink out on the patio before starting to work.

Now prepare yourself for a very short course on the metric system of measurement. We will hold our discussion to seven areas of measurement: length, area, volume, capacity, mass, temperature, and time.

LENGTH - In the SI, certain units are singled out for special attention and are called *SI preferred units*. The SI preferred units are: the base units; 1 000 times the base units; 0.001 times the base units. The base unit for length is the metre. One thousand times the metre is the kilometre and 0.001 times the metre is the millimetre. Following is a list of the different prefixes.

<u>Metric Prefixes</u> (*SI preferred units)

*kilo	unit times 1 000
hecto	unit times 100
deca	unit times 10
*----	unit times 1
deci	unit times 0.1
centi	unit times 0.01
*milli	unit times 0.001

kilogram (kg)	means 1 000 grams
kilometre (km)	means 1 000 metres
kilolitre (kl)	means 1 000 litres

milligram (mg) means 0.001 g
millimetre (mm) means 0.001 m
millilitre (ml) means 0.001 ℓ

In everyday practice there is one exception to the SI preferred unit rule--the centimetre. Since the millimetre is such a short unit of length (a dime is about a millimetre thick), the centimetre is also used very frequently. The mile, yard, foot, inch, will be replaced by the metre, kilometre, centimetre and, more rarely in everyday usage, the millimetre.

Some examples are -

I am about 177 cm tall.
It is about 300 km from Edmonton to Calgary.
She ran the 100 m dash in 11.3 seconds.
The tubing was 2.5 mm in diameter.

AREA - As in the English system, area is a direct derivative of length. We measure length in feet, inches, yards, etc. and area in square feet, square inches, square yards etc. We will soon measure area in square centimetres (or centimetre squares), square metres (or metre squares), etc. The symbol is a bit different, cm^2 is the symbol for square centimetres and m^2, mm^2 respectively for square metres and square millimetres. When one gets to very large areas, such as acres, the unit used is the hectare (ha) which is equivalent to 10 000 m^2.

Some examples are -

The room had an area of 12 m^2.
The farm has an area of 8 ha.
The postcard's area was 96 cm^2.
The microdot's area was only 2 mm^2.

VOLUME - For volume we simply use one more dimension. Technically speaking, volume is the amount of space filled by an object. It is becoming quite common to use the units of volume to measure dry capacity and the units of capacity for liquid measurement. The commonly used units of volume are cubic centimetres (or centimetre cubes), metre cubes, or millimetre cubes. The symbols should be no surprise: cm^3, m^3, mm^3.

Some examples are -

The adult dosage is 30 cm^3.
The truck can only carry 2 m^3 of dirt.
There are one billion (1 000 000 000) mm^3 in 1 m^3.

CAPACITY - Capacity is the measurement of how much something will hold. Practically speaking, as mentioned above, the units of capacity are used to measure liquid quantities. In the metric system the distinction between volume and capacity and the units to use is less important since a container with an inside volume of 1 cm^3 will hold 1 ml of water. The present units of gallon, quart, pint, cup, tablespoon, and teaspoon will all be replaced with the litre and its division, the millilitre--just two units, the second being derived from the first. The other preferred unit is the kilolitre which, of course, is 1 000 ℓ and not used in everyday practice.

If a container with an inside volume of 1 cm^3 will hold 1 ml of water, then a container with an inside volume of 1 dm^3 (1 dm=10 cm so 1 dm^3=1 000 cm^3) will hold 1 000 ml of water,or 1 ℓ. So the litre is derived from volume units.

Some examples are -

The baby's formula calls for 100 ml of water.
The wine bottle holds 1.5 ℓ
The swimming pool has 1.7 kl of water in it.

MASS - A lot of confusion has been generated by this area of measurement for reasons that should not be of too much concern in everyday life.

Yes, mass and weight are different! The most common example is the moon story. If you weigh 120 pounds on earth, then you will weigh about 20 pounds on the moon and 0 pounds in a vacuum. If you have a mass of about 50 kg on the earth, then you have a mass of about 50 kg on the moon and in a vacuum.

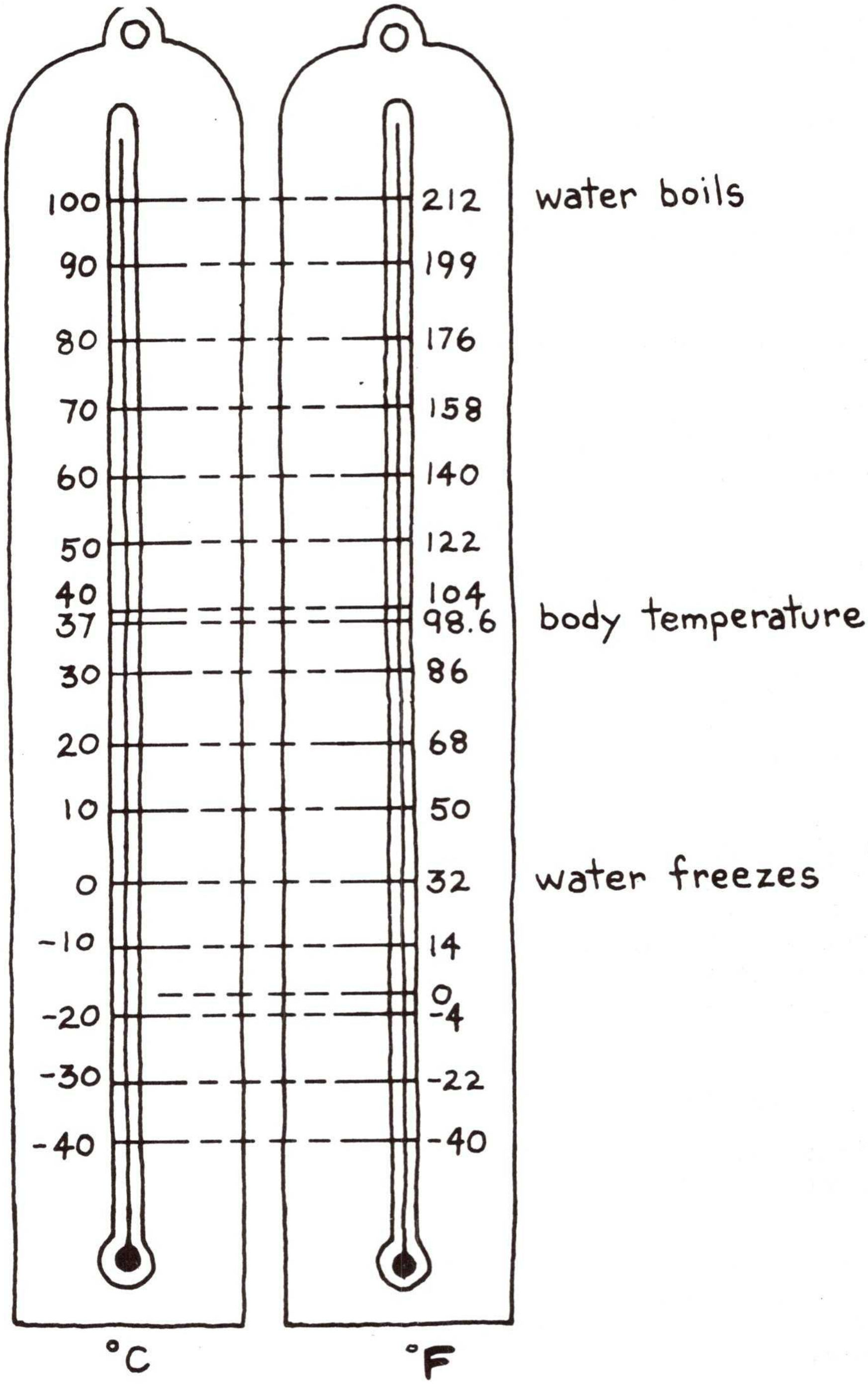
In the metric system the units of mass are being used when you use the gram, kilogram (the only two used in everyday life). If you want to say that you "weigh" 50 kg, then go ahead. The world will not crumble beneath your feet. To be correct you should say that you have a mass of 50 kg. The U.S. National Bureau of Standards has ruled that one may use the words "weight" and "mass" synonymously. While you are on the face of the earth, mass and weight are the same for all practical purposes.

Some examples are -

The standard paper clip has a mass of 1 gram.
My mass is about 77 kilograms.

TEMPERATURE - This is the most troublesome area of metric measurement during the period of conversion. There is no physical model for the degree Celsius (^{0}C) and it is in the area of weather forecasts that the public is generally shocked into the awareness that we are going metric.

The Celsius scale and the centigrade scale are the same. In parts of Europe the centigrade is the name of a unit used for an angular measurement, so another name was needed and the SI chose Celsius, after Anders Celsius who developed the centigrade scale. It is *much* simpler than the old Fahrenheit scale. Water boils at 100^{0}C and freezes at 0^{0}C, two very easy numbers to remember. Normal body temperature is 37^{0}C instead of 98.6^{0}F. Normal room temperature is about 20^{0}C.



TIME - The change that will occur in writing hours and minutes has nothing to do with the metric system of measurement. It was decided that, since so much change would be taking place, why not bring Canada in line with most of the rest of the world and introduce the universal clock. Following are some examples in both the sun clock notation and the universal clock notation.

Time

Sun Clock	Universal Clock
12:30 a.m.	00:30
1:15 a.m.	01:15
10:45 a.m.	10:45
1:05 p.m.	13:05
4:00 p.m.	16:00
8:30 p.m.	20:30
12:00 p.m.	00:00

The final section of this article must be addressed to the problem of notation --- actually writing numerals and results of measurements in the metric system. There has been (and will continue to be, for a short while) some confusion about the proper symbols and notational devices in the metric system. So many people have tried to jump the gun and use any symbols they want. So many people have again applied English system thinking to the metric system and used abbreviations when they shouldn't. My favorite example was on the front of a truck which stated that it could carry 4 000 KG and on the back of the truck it read that it could carry 4 000 Kg. Neither KG nor Kg is the proper symbol for kilogram.

There is one very simple rule to remember - symbols are just that -- symbols, *not* abbreviations! In the English system we use abbreviations, in the metric system we use symbols. The use of symbols means that there are *NO* periods, *NO* plurals, and *NO* capital letters, unless the symbol is a capital letter such as C for Celsius. Some of the many incorrect ways of symbolizing eight centimetres and the one correct way are -

Correct	Incorrect
8 cm	8 cms
	8 cms.
	8 Cm
	8 Cm.
	8 Cms.
	8 cm.

A hint for remembering the proper symbol is that it is always (would you believe *almost* always) the first letter in the prefix and the first letter in the root word.

Several examples are -

Metric Symbols

millimetre	mm
centimetre	cm
metre	m
kilometre	km
gram	g
kilogram	kg

milliliitre ml
litre 1 or ℓ*
degree Celsius °C**

Some of you may have already noticed in some of the new textbooks that even the numerals are written differently. As with the change in writing the time of day, the change in writing numerals has nothing to do with the metric system except as it is part of the scheme to have everyone in the world write the numerals the same way. Eventually the numerals in all textbooks will be written in the following manner - *Example* Old way: 1,230,456. New way: 1 230 456.

If a numeral has 5 or more digits, there is a space (NOT a comma) to set off each group of three digits starting from the decimal point.

The following change I have not seen in textbooks yet, but I do know it will occur very soon. Any decimal fraction between 1 and -1 will have a zero (0) to the left of the decimal point. *Example* Old way: .604. New way: 0.604.

Some of the changes that have been mentioned probably seem very strange to you, especially notation, but remember -- the changes are being made so that we will be in line with the rest of the world. In a few years when all the benefits of the metric system start becoming very evident to the general public, people will wonder why we waited so long to go metric.

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*The script (or cursive) ℓ is used when the printed 1 might cause confusion. For example, does 141 1 mean 1411 or 141 litres? To avoid the confusion you should write it 141 ℓ.

**The symbol for degrees Celsius, °C, is the exception to the rule that the symbol is the first letter in the prefix and the first letter in the root word (in everyday units).

The Bulletin Board, an Aid to Thinking Metric

Irvin K. Burbank
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Measurement is a process of comparing two objects with a common attribute. For example, a pencil and the edge of a desk have "length" as a common attribute. Hence, by using the pencil to measure the desk we compare the length of the pencil with the length of the desk. Similarly, in measuring area we compare the attribute of the surface of one object with the surface of another. As students experience activities in comparing objects, they should be encouraged to develop units of measurement from a choice of objects. This will introduce arbitrary units, which leads to the need for standardized units. It is at the point of standardization of units that metrication appears. If measurement is understood and taught in the above approach, then one of the major jobs for the teacher in giving instruction is to provide models that can help a student develop a frame of reference which will give the standard metric units meaning.

Many students have an idea of how far 100 yards is because they have run that distance at a track meet or in a football game. Similarly, 100 lbs is a big bag of spuds; 100°F is a very hot summer day; 1 yard is from chin to tip of fingers on outstretched hand; 1 gallon is a large jug of A & W root beer. In a similar manner there is a need to provide models and experiences which will help in developing a "feeling" for metric units.

The purpose of this article is to share ideas on how the bulletin board can be used to display models that will help the student develop a "feel" for the metric units of measurement.

The following is a list of models for comparing the various metric measures. The models are not exact measurements. They are meant to serve as a reference only so that students may know *about* how big the unit is.

Length *Model*

Metre - height of kitchen counter
- little more than yardstick
- length of walking cane
- little more than long pace
- width of front door of a house

Centimetre - width of fingernail of Dad's little finger
- width of fingernail of 10-year-old's index finger
- width of a front tooth
- 2 cm, width of a nickle
- 10 cm, width of Dad's hand
- 10 cm, width of forehead
- 5 cm, length of the ear

Millimetre - little less than thickness of a dime
- width of a pencil mark
- thickness of 8 sheets of paper
- 2 mm, thickness of a quarter

Temperature

180^0C - temperature for baking a cake
100^0C - boiling water
40^0C - very very hot summer day
37^0C - body temperature
30^0C - beautiful summer day
19^0 - 21^0C - comfortable room temperature
10^0C - beautiful spring/fall day
4^0 - 6^0C - refrigerator temperature
0^0C - freezing water
-5^0C - cold winter day
-8^0C - deep freezer temperature

Capacity

Litre - little less than a quart (Canadian)
- large size milkshake
- jumbo A & W root beer

Mass

Gram - paper clip
- 2 grams - dime
- a small bean
- a pea

Kilogram - 2 lbs of butter plus a little bit more
- a cantaloupe
- 5 good sized apples
- 45 cm trout
- 12 large eggs

Area

Square Millimetre - pin head

Square Centimetre - fingernail of Dad's little finger
- fingernail of 10-year-old's index finger

Square Metre - large bath towel
- crokinole game board
- card table top

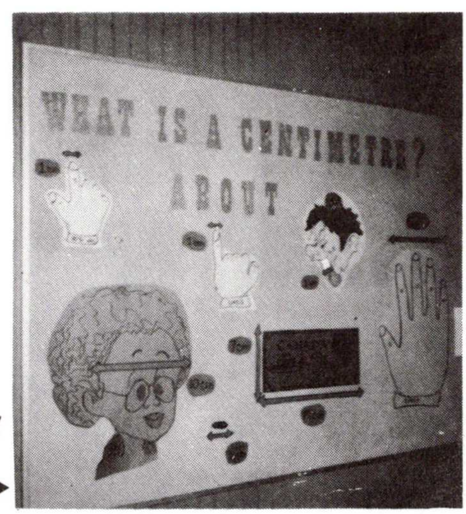
Volume

Cubic Centimetre - tip of Dad's little finger
- tip of 10-year-old's index finger
- chicklet gum

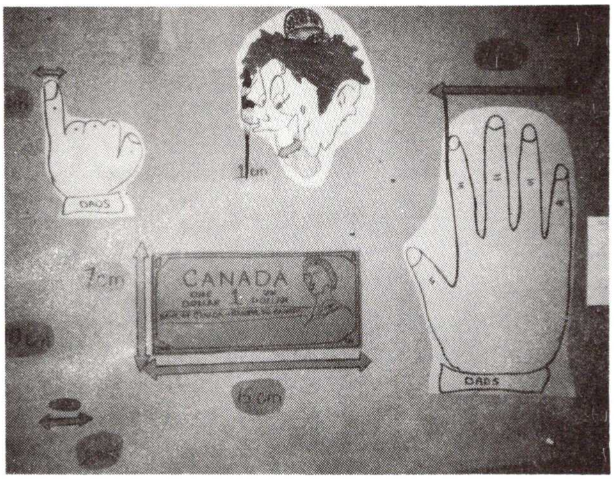
Cubic Metre - large toilet tissue carton
- large corn flakes carton
- space occupied by a card table with legs extended
- 2 cubic metre - large deepfreeze outside measure

This is only a sample of the many bulletin board models that can be used in developing a metric frame of reference that will assist students in the elementary grades to "Think Metric."

◄ *Temperature on the Celsius scale is pictorially associated with each season of the year. For example, a warm summer day would be 25°C, and an average winter day would be -5°C*

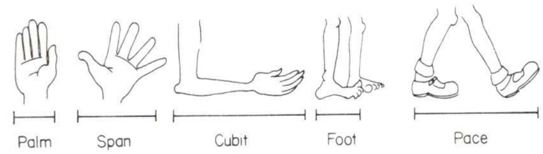


"What is a centimetre?" This display shows approximate body measurements in centimetres ►



A centimetre is "about" the width of the nail on the index finger of a ten-year-old or the little finger of Dad, or the width of a front tooth. Also, 10 cm is "about" the width of the forehead or the width of Dad's hand ◂

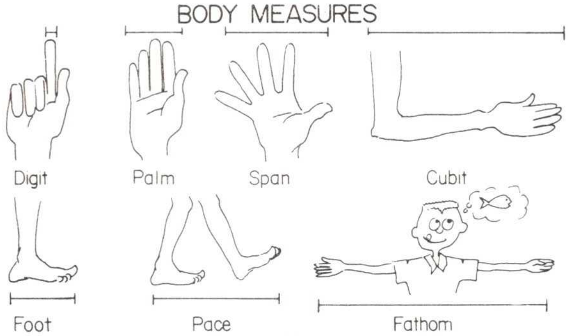
ME AS A MEASURE



What to Measure	Guess	Measurement
Door		
Desk top		
Desk height		
Chalkboard		
Book		

"Me as a Measure" displays the use of the palm, span, cubit, etc. in measuring objects in the classroom ▸

BODY MEASURES



__ digits make a palm
__ digits make a span
__ digits make a foot
__ palms make a cubit
__ palms make a pace
__ palms make a fathom
__ feet make a pace
__ feet make a fathom
__ span make a cubit
__ span make a fathom

Which is bigger, a foot or a palm?
Which is bigger, a foot or a span?

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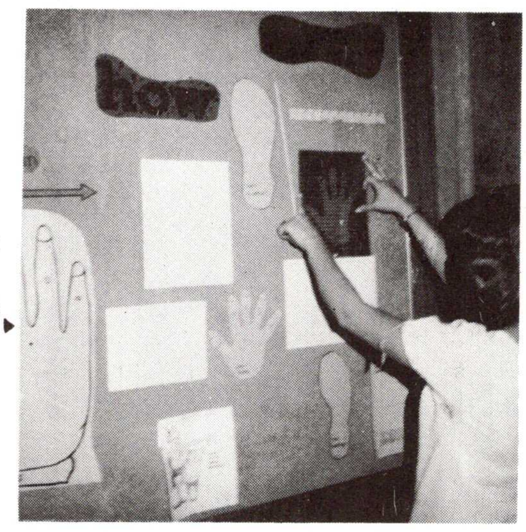
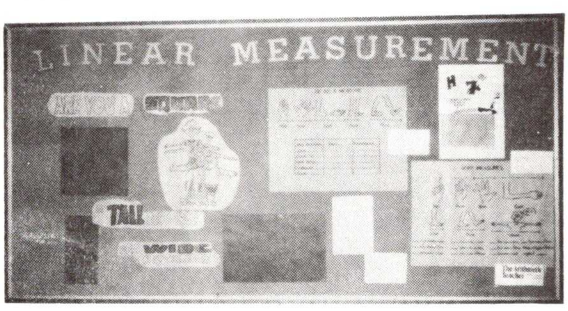
"Body Measures" shows how the digit, palm, span, cubit, etc. can be compared; i.e. 9 digits make 1 palm, or 3 spans make 1 cubit ◂

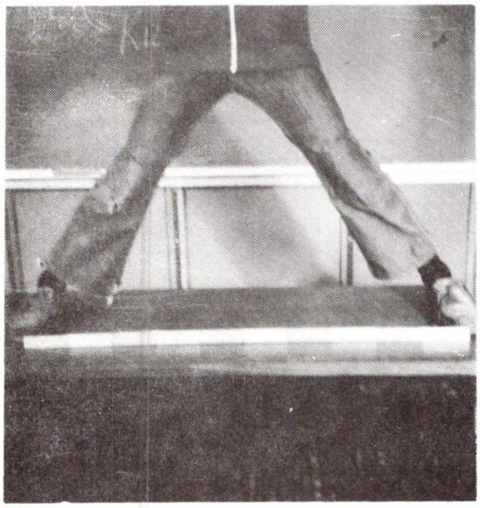


"How many" square units are needed to cover the hand print, or the foot print, etc? Here a clear plastic 1 cm^2 grid is used to approximate area ▸



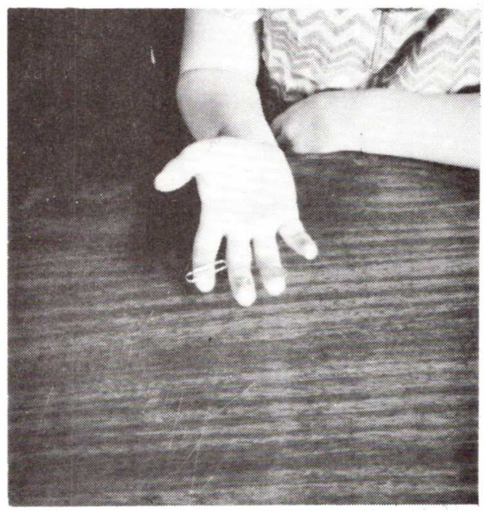
"Linear Measurement" displays how length can be measured with parts of the body ◂

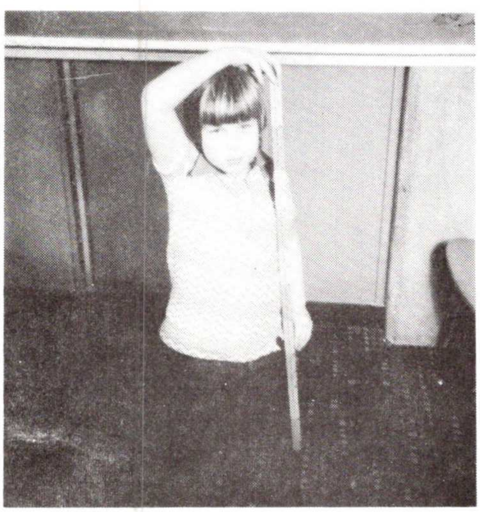
1 000 little one-centimetre cubes are the same size as this litre cup ▸



One metre - about the foot span of an 11-year-old boy ◂

One gram - about the same mass as a paper clip; a dime is about two grams ▸





◂ One metre - about the height of the chalkboard ledge or the height of kneeling 10-year-old boy

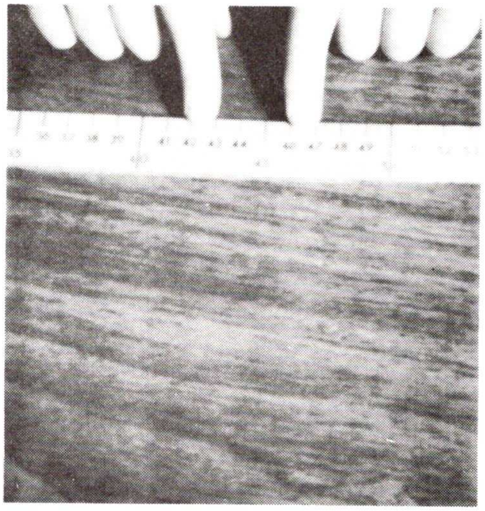
One metre comes about up to here on me ▸

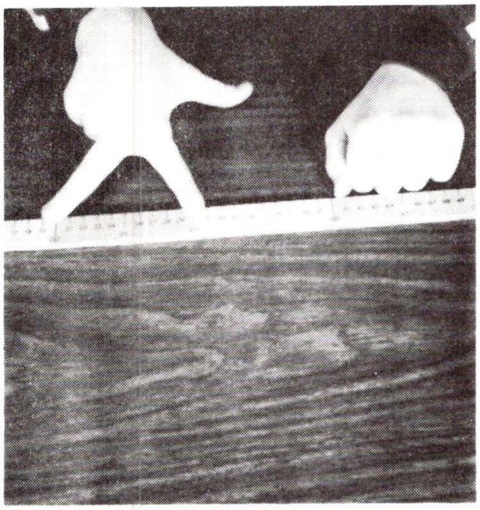
A pile of 1 cubic centimetres which is ten long, ten wide and ten high, makes a block 1 000 cubic centimetres ◂

It looks like a litre is a little more than twice the size of the soup tin ▸

◂ A cubic centimetre is about the size of my fingertip

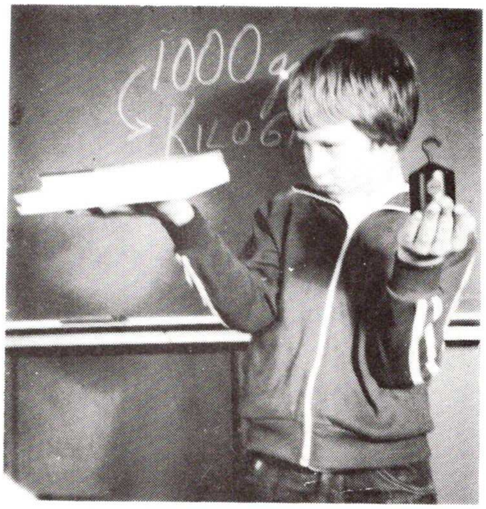
A centimetre is about as wide as my fingernail ▶





10 centimetres is about as far as I can span two fingers, or about as long as my fist
◀

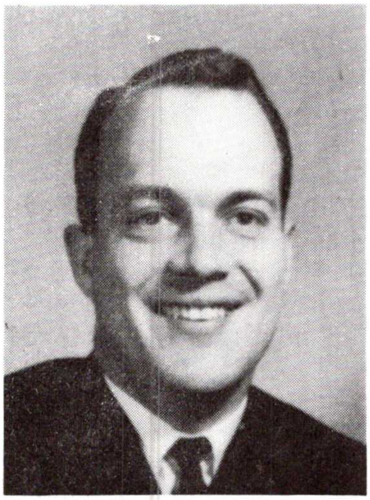
A kilogram is about the same weight as two medium sized books
▶



PART TWO
Specific Units

Part II

Linear Measurement in the Early Grades



by *Werner Liedtke*
University of Victoria

THE CHILD

Perhaps the greatest quantity of work in the field of intellectual development and concept formation has been conducted by the Swiss psychologist, Jean Piaget. He has concerned himself not only with the learner, but also with the substance to be learned and its structure or logical organization. Piaget set himself the task of investigating empirically the basis for man's conception of the real external world. With his ingenuous methods and experiments he has probed into the growth of children's concepts in a variety of areas.

Since Piaget's description of intellectual development is a significant contribution to the understanding of how a child thinks and learns, his name is frequently cited by educators developing curricula for the pre- and elementary school child. Although Piaget has not written extensively on the educational value of his developmental theory, other authors have attempted to state the important educational implications of his work. Sullivan, for example, shows how Piaget's description of development could be used as an assessment of intellectual capacity and as an aid in assessment of learning outcomes in a curriculum. Further, he describes how Piaget's stage observations could be used as an aid in the structuring and sequencing of subject matter in a curriculum, and how these observations are suggestive of certain types of learning atmospheres. Harrison in his article showed how Piaget's theory is applicable to secondary school situations and particularly to mathematics teaching and learning. Copeland presents most of Piaget's experiments that are related to mathematics instruction in the early grades. He describes how notions of number, operations with numbers, geometry and measurement arise in children and points out the developmental limitations that might be expected from children at certain age levels. Implications for the classroom teacher are discussed and illustrations show the teacher how to use laboratory or manipulative materials which help the child to learn mathematical concepts at the concrete operational level. Lovell claims that Piaget's work provides the best conceptual framework we yet have, inside which we can discuss the growth of children's understanding of mathematics. His book deals essentially with children's understanding of mathematical concepts and he includes a variety of activities which foster this comprehension of mathematics in the early grades.

In this part of the article, some of Piaget's experiments pertaining to length and linear measurement will be described, and some of his findings will be stated.

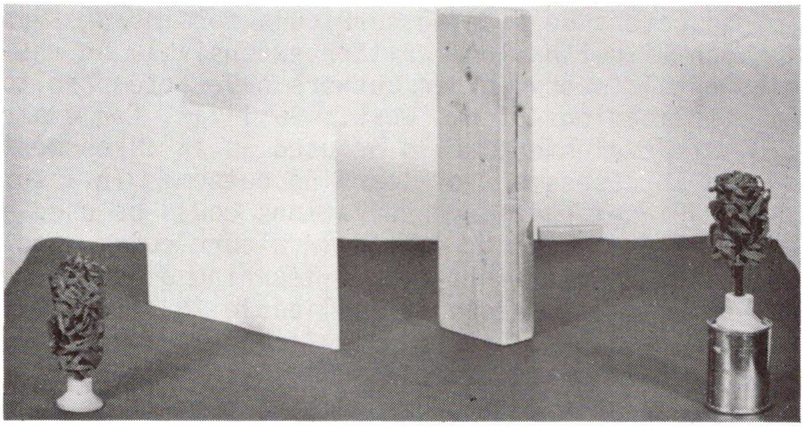
Children come to school with certain conceptions about length. They have had many experiences with it and some of its related concepts. Taller than, shorter than, smaller than, or bigger than are just some of the concepts that many children have at their command. However, it can be shown that a child's understanding of length and measurement is very different from an adult's understanding of these concepts.

To demonstrate how children come to understand the concepts of length and measurement in conventional terms, Piaget (1960) has outlined some interesting little experiments. The experiments consist of simple tests that are described under four separate subheadings.

RECONSTRUCTING RELATIONS OF DISTANCE

Usually no sharp distinction is made between the concepts of distance and length. Psychologically they point to quite different situations. "Length" denotes a measure (linear) of an object. "Distance" refers to linear separations of objects or empty space. The notion of distance is essential to both the development of measuring and viewing spatial relations between objects. Interpreting relations in terms of distance heralds the construction of a coordinate system.

To find out how children judge distances, Piaget and his experimenters use two trees or lead figures [picture #1].



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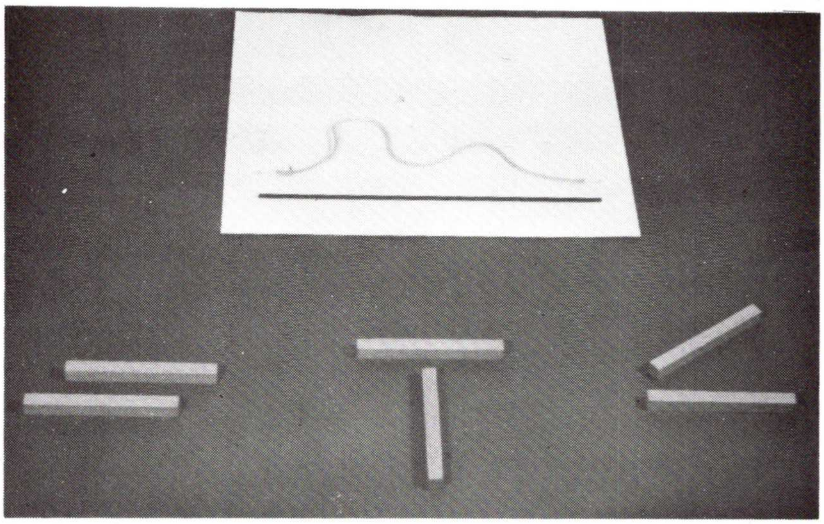
These are placed about fifty centimetres apart. The child is asked whether they are "near one another" or "far apart." The setting is then changed. For example, one tree is raised, screens (with and without doors) or a cube are placed between the trees. In each case the child is asked if the trees are still as "near" or as "far apart," depending on his previous reply. Responses from children of different ages show three distinct developmental stages: the concept of distance as defined above is not present and the distance in one direction is greater or less than the distance in the opposite direction; overall distance is recognized but not when an object is placed between the trees; children realize that distance between two stationary objects remains invariant and the same in either direction, no matter what is placed between them.

CHANGE OF POSITION AND CONSERVATION OF LENGTH

In describing the child's development of operational structures, Piaget distinguishes four distinct stages: the sensory-motor stage (up to 18 months), the pre-operational stage (18 months to 7 years), the concrete-operational stage (7 to 11 or 12 years), and finally, the stage of formal operations. One of the most important components of the transition from pre-operational to concrete-operational thought is the acquisition of various conservations, that is, the cognition that certain properties (in this case, length) remain invariant under certain transformations. According to Piaget (1952), conservation is an important step in the development of logical thinking. It represents intellectual potential and is necessary for all rational activity.

The subjects are faced with different arrangements [picture #2] and the questions are designed to determine whether they are conservers or not.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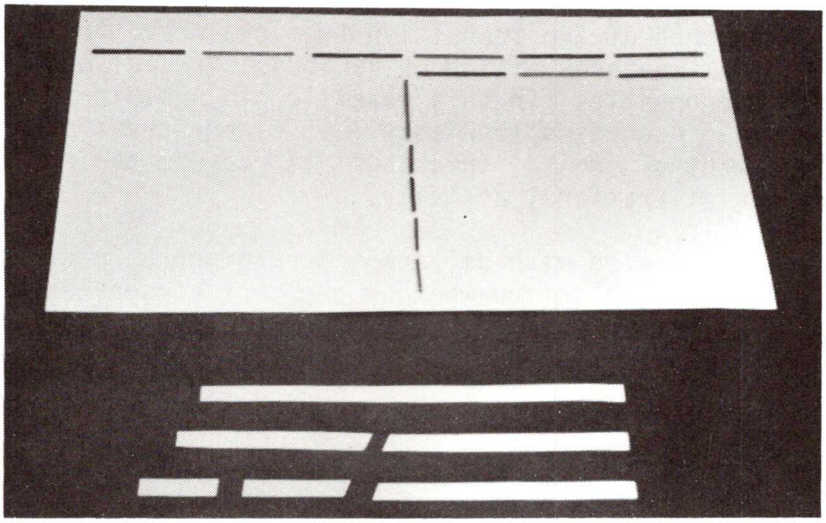
For one part of the experiment the children are faced with a stick and an undulating thread of plasticine (string), their endpoints coinciding. They are asked, "Which of the two is longer, or are they both the same length?" If the children identify the two objects to be the same length, the string is extended and the question repeated. Then the string is twisted once more to make it coterminous with the stick and the same question is asked again.

For another part the subjects are shown two sticks with their extremities facing each other. One of the sticks is then moved forward one or two centimetres or into different positions [picture 2]. For each position the quesion is asked, "Are the sticks the same length, or is one longer than the other?" Only when the children reach the age of seven are they able to relate the objects, any of their parts and the empty sites, and therefore show an understanding of conservation of length.

CONSERVATION AND MEASUREMENT OF LENGTH

Two of the experiments involve distortion of shape. Twelve to sixteen matches (sticks) are placed end to end in two parallel rows so that their equality is obvious. One row is modified by the introduction of angles, zigzags, or some of the matches are broken. Also, two 30 centimetre strips of paper are used. One of the strips is cut, cut again, and arranged in a variety of ways [picture 3]. The question is always whether the two rows or strips are still the same length.



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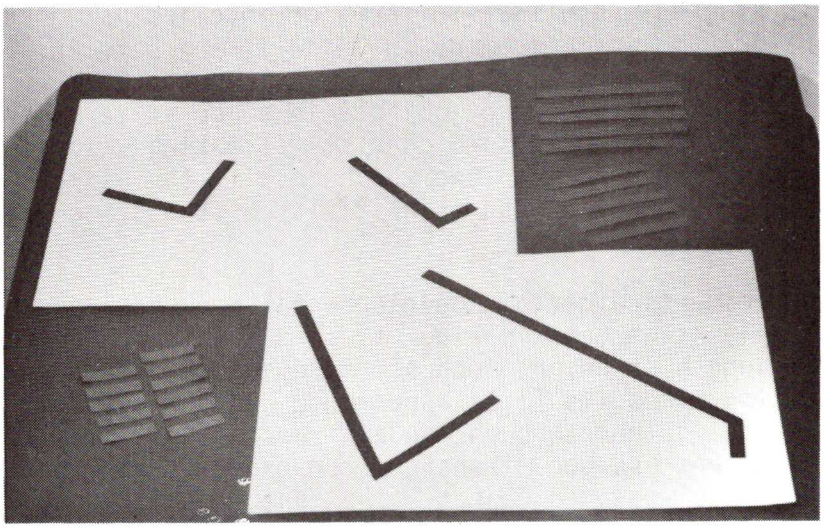
In order to answer the question correctly, both subdivision and order or change of position must be considered. Coordination between these two comes after the age of seven, for most subjects.

Another experiment involves measurement of length. Strips of paper are pasted on cardboard in a variety of linear arrangements: right, acute and obtuse angles [picture 4]. The child is asked to compare two of these at a time, state whether he thinks one is longer than the other or the same length, and then verify his answer. Strips of cardboard are available to serve as "unstandardized" units.

Most young children fail to see the necessity for using unit measures. While many seven-year-olds conserve length, the insightful operational fusion between subdivision and change of position is achieved only by eight-year-olds.



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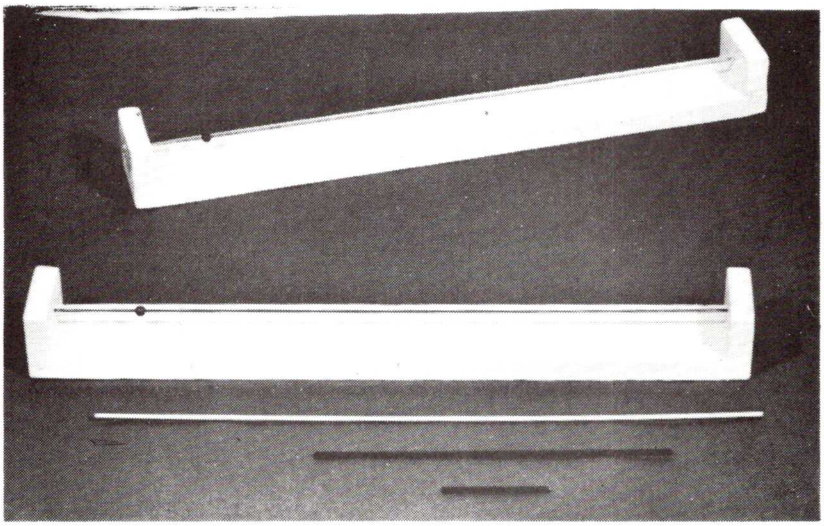
SUBDIVIDING A STRAIGHT LINE

In this experiment the children are asked to locate a segment on a straight line equal to a segment given on another straight line. Beads on strings are used. The setting is changed by staggering the strings (wires), [picture 5] beginning at opposite ends, using strings of different length, or having the strings neither parallel nor in alignment. A blank ruler, two sticks, strips of



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paper, a pencil, or threads are available for measurement purposes. Young children fail the task because they neglect to take into account the points of arrival and departure. They see no need for accurate subdivision. Their measurements are merely visual or manual estimates. Measurement beyond trial and error is not achieved until the age of eight.

The results of the experiments by Piaget (and other researchers who have replicated his studies) show that in terms of intellectual or cognitive development, most children in Grade I, many in Grade II and some in Grade III are not ready for the concepts of length and linear measurement. They lack a reference system and they can only interpret objects in space in terms of their own perspective. Their ability to measure consists of making visual comparisons between endpoints. They fail to see the necessity for using a unit and exact subdivision; unit interaction and transitivity of the common term (unit) are meaningless.

From experiments a certain developmental sequence appears evident. Measuring at an early stage means making visual comparison, and objects are judged to be equal in length or height because "my eyes are good" or "I have good eyes." Change of position makes its first appearance when children attempt to bring perceptual fields together through manual transfer. At a later stage they discover the "middle term" and use body transfer; for example, part of an arm, or finger spans to imitate the measured object. The last stage is reached when the children see the need for using a unit and accurate subdivision, and when they are able to consider the point of departure as well as that of arrival.

The responses young children will make to the questions stated above indicate that they are not "miniature adults" and that they structure the world around them in quite a different way. Their replies imply that many pupils in the primary grades may be able to verbalize measurement terms, but they do not comprehend the underlying concepts, in fact, they are not ready to deal with these. Thus Piaget's methods of observation and inquiry present an excellent way to assess whether a child is ready to be taught certain concepts and understands what has been presented, or is just parroting the teacher. Knowledge of the developmental stage of the pupils is also an invaluable aid in appraising texts or other material that is presented to children in their day work in the classroom. While it might be impossible to test each pupil individually, some insight might be gained by probing the children who have difficulties with some particular concept. This new insight could then be used to provide activities related to the pupil's level of development.

Copeland suggests that a teacher cannot tell children how to measure. Pupils should be provided with materials similar to those described and be allowed to experiment and try to solve measurement problems for themselves. He states -

> . . . if systematic measurement is to be "taught" it should not be presented before the latter part of what is usually the third grade. Even then, for most children it will have to be an experimental or trial-and-error readiness-type experience. . . . The necessary concepts will develop (1) when the child is old enough (eight to eight-and-a-half, according to Piaget) and (2) when he is allowed to operate on (experiment with, manipulate) objects used in measurement. Both conditions are necessary to perform measurement.

Only one particular example has been discussed here. Similar experiments for other geometrical concepts are presented in the same book by Piaget (1960). Also of special interest to the elementary teacher would be Piaget's observation of the child's conception of number (1952), space (1963) and time (1955).

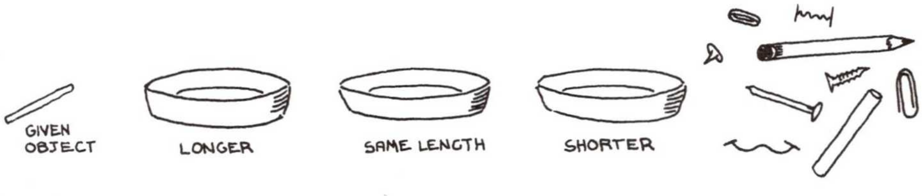
THE TEACHER

The experiments and results from the previous section indicate that, for the young child, linear measurement is a highly contrived process. A certain level of development or understanding is required before young children can attempt systematic and meaningful measurement. Since some children may not reach this level of understanding before they are eight years old, the early part of an instructional sequence should be based on problems and activities which allow the young child to experiment and manipulate in a setting which could be labelled as "trial and error."

In the paragraphs that follow, suggestions for an instructional sequence will be made, some of the important learning outcomes will be stated and sample activities and problems will be described. In terms of most pupil texts or curriculum guides (objectives), the suggested sequence includes activities for the first three years in school. During the first year, emphasis would be on the first part of the sequence. Children in the second year would be taken through the initial parts of the sequence, but then the emphasis would be on the activities suggested in the middle part. Third year children would, after having discussed the initial problems, spend most of their time on the learning outcomes suggested in the last part.

The first task involves the definition of the characteristic to be measured, which in this case is length. To accomplish this a group of objects is presented. One of the objects, such as a paper clip, is put aside or placed upon a plate. The child is asked to sort the given objects into two groups - those that are 'just as long' and those that are 'not as long' as the paper clip. To justify his solution the child is asked to respond to the questions: "How do you know these are as long as the paper clip?" and, "How do you know these are longer?"

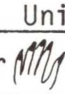
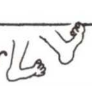
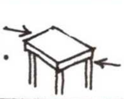
Again objects are presented. One of them is selected and this time the child is asked to separate these objects into three groups: those 'just as long as,' those 'longer than,' and those 'shorter than' the given object. The follow-up discussion would be as for the previous problem.



Five or six children are selected. They are arranged from shortest to tallest.

The remaining members of the class are asked to describe similarities, differences and reasons for the assigned positions. Problems are presented that involve adding to either end of the ordered sequence or inserting into the sequence. The children are then asked to solve similar problems with dowels, pieces of string, pieces of paper, or other objects. These classifying or sorting and ordering problems give the young child the opportunity to make all kinds of relative comparisons and, as a result, will lead him to understand the meaning of length.

Now the problem of describing the characteristic called length without making a comparison to a given object is presented. It is suggested to the children that they use a part of their body or a "body unit" (hand, thumb, arm, etc.) to guess and measure the lengths of various objects. In order to measure correctly, the children will have to be shown the need for, and taught the skill of, accurate subdivision. To accomplish this, the initial measurement problems should be solved by using as many children or "body units" as it takes to completely cover the object to be measured. After having solved a few problems in this fashion, the children are challenged to simulate the action involving many units by using just one of them. Correct and incorrect procedures are illustrated for them and by them. By providing activity sheets that require the child to guess and measure and to record both of these results, the teacher can gain some insight into how familiar the child has become with the "unit" he is using. At this stage guessing should be encouraged. However, in the next part of the sequence, an attempt should be made to teach the child something about the logic of estimation, or the difference between guessing and estimating. During this part of the instructional sequence the activities involve guessing, measuring, recording, comparing, and discussing. The children could also be given a chance to make a decision as to which "body unit" is most appropriate for the measurement tasks under consideration before proceeding with the tasks listed in the previous sentence. The results are recorded in a table.

Object	Unit	Guess	Result
	A or  or 		
1. 			
2. 			

The possible learning outcomes for this part of the instructional sequence include knowing how to accurately subdivide the object to be measured, selecting an appropriate unit, and attempting to have the child become familiar with certain units. The final problems or tasks should consist of assigning a measurement task, soliciting results which differ (including the teacher's answer) and displaying these on the blackboard. Reasons for the differences are discussed and the children are asked to make suggestions as to how these differences could be overcome or corrected. The aim is to have the children see the need for a "standard" unit.

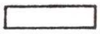
For the next series of estimation (guessing) and measurement problems, the following are examples of "standard" units which could be adopted: new erasers, pencils, crayons, paper clips, pennies, sticks, or pieces of string. To reinforce the necessity for accurate subdivision, the initial problems are solved by supplying the children with a sufficient number of units for covering the object to be measured. Most children may be ready to simulate this action with just one of the units. However, some children may need to use both procedures for awhile or use one method to check the result for the other.

To teach the child something about the logic of estimation, a game setting can be used (Mathex, 1970). For the game of MEST (Measure - Estimate), the children are assigned to groups. A "standard unit," such as a piece of chalk, is shown. A path consisting of two or more parts ( or  or ) is drawn on the blackboard (behind a map) or on an overhead projector. After the children have had a chance to look at the path for five or ten seconds, they are asked to record on a piece of paper how many "units" (pieces of chalk) they think will fit onto the path. One child is chosen from each group and asked to record his/her estimate in a table on the blackboard.

	Estimates					
Problem	Group 1	Group 2	Group 3	Group 4	Group 5	Results
1.						

The path is measured and it is decided which child (group) gave the best estimate. Then the child is given a chance to tell how the estimate was arrived at. To determine a winner, points could be given for each estimate; for example, five points for the closest estimate, four for the next closest, etc. Another table on the blackboard could show the standings. One simple but interesting variation to the setting consists of having each member in a group record the estimate, but the results are compared and discussed within each group before an agreed upon value is reported or recorded on the blackboard. For another possible setting, each child (group) is given a piece of paper, the "standard unit" (eraser) is shown, and the problem of drawing a path three (six, etc.) erasers long is presented. Rules and scoring procedure may have to be revised or decided upon to make this into a game. The responses provide two types of information: how familiar a child (group) has become with a particular unit, and how well a child (group) is able to use the information from previous problems to solve the estimation task on hand.

The follow-up session for activities with "standard units" should include a discussion on how the length of an object can be communicated to someone in a different classroom or town (or country). As a result of this discussion, the children see the need for a "standardized" unit.

A piece of cardboard () is presented to the children and they could be told that when people hear or see the word "centimetre," that is the length they think of or refer to. Assuming that most children have learned how to accurately subdivide and know the difference between guessing and estimating, the main task now is to have them become familiar with this unit. "Thinking metric" or in this case "thinking centimetre" will mean solving various estimation and measurement problems and playing the game MEST (or variations thereof) with this new unit. As activity sheets are prepared for the children, an occasional problem is presented which would make the use of the centimetre rather awkward. As a result, the children may inquire about, or see the need for other "standardized units" and the decimetre and/or metre are introduced to them. Hopefully, they will be given a chance to make their own cardboard ruler or metre stick by drawing or placing onto these marks or numerals the children think appropriate. (For some of them, the first attempt will likely result in the discovery that there are 99 cm in one metre; a valuable lesson in terms of accurate subdivision or using a sharp pencil.)

The main part of the suggested instructional sequence is introducing or defining the characteristic to be measured, using "body units," "standard units" and "standarized units." This sequence and the learning outcomes stated can easily be adapted to other areas of measurement, such as capacity, area, volume, or even time. [See other articles in this monograph, or Liedtke (1974).]

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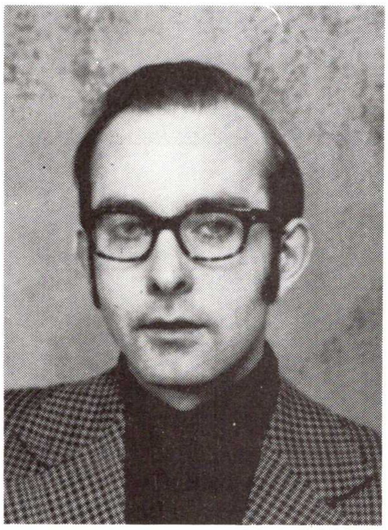
Area Measurement



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The metric system is a simple, logical way of expressing measures, and less instructional time will be required for teaching the common units of area and for computation and conversion involving these units than was needed under the British system. Thus, more time will be available for developing the major ideas of measurement as they relate to area, and for activities designed to allow students to gain a feeling for the everyday units in real situations.

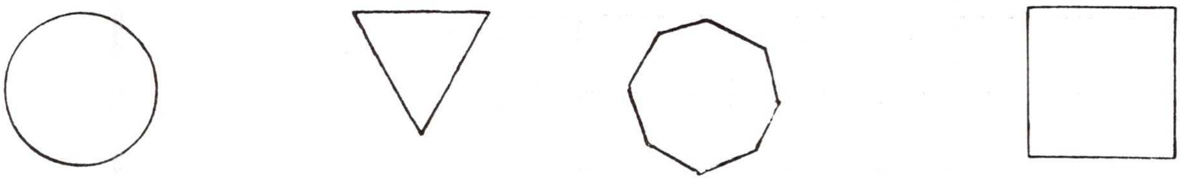
CONCEPT OF AREA

Area is the amount of surface bounded by a closed curve or covered by a plane region. The adoption of the metric system will have little effect on the procedures and activities used in the early development of the concept of area and how it is measured. The measurement process first encountered in the study of linear measurement is applied to area. A suitable unit is selected and the object to be measured is compared to it. When the question of a standard unit arises, metric measures are introduced rather than the square inch and square foot.

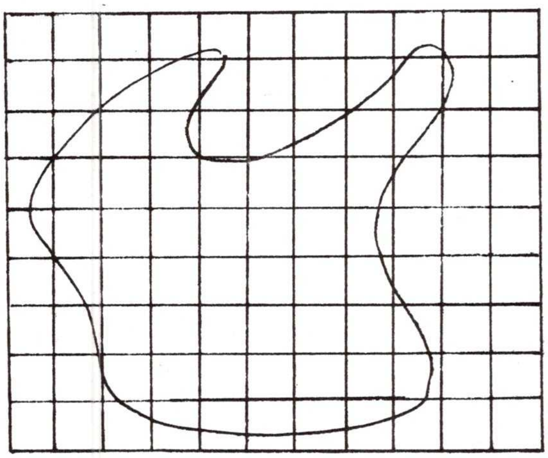
Following are some suggested activities for developing the area concept.

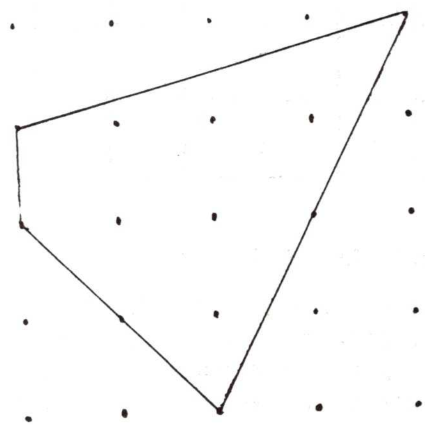
Arbitrary units - Students find the number of hands, textbooks, etc. needed to completely cover the top of a desk or table.

Tiling - To determine which shapes are suitable for use as a unit of area, students try to completely cover (without overlapping) a notebook using various regular and irregular shapes.



Counting unit squares - Using an arbitrary square unit, students determine the approximate area of non-rectangular shapes by counting the number of squares needed to cover each shape. This can be accomplished by placing squares on the shape, placing a transparent grid over the shape, or drawing the shape on grid paper. Some shapes can also be made on the geoboard. Other tasks would involve using a given number of unit squares to form different shapes with the same area.



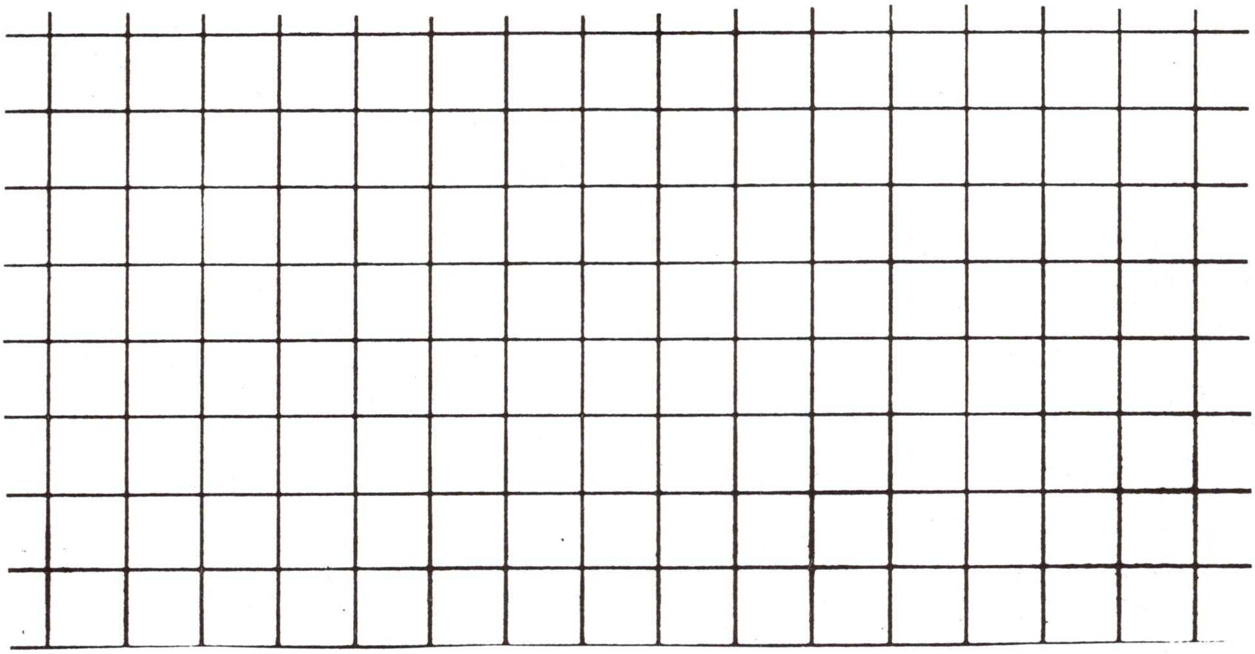


The square centimetre (cm^2)[1] - is introduced as a standard metric unit for expressing the area of small objects. Students should have many opportunities to estimate and then determine the approximate area of a variety of familiar items. A good supply of centimetre grid paper and/or a transparent centimetre grid should be available for these activities.

Trace each object on grid paper and find its approximate area in square centimetres. Estimate first.

	Estimate	Measured Area
Your hand	________	________
A dollar bill	________	________
A stamp	________	________
An envelope	________	________

[1]The symbol for square centimetre, cm^2, should be introduced as just that - a symbol. No reference to exponents is needed at first. In later grades it can be pointed out that the symbol refers to $(cm)^2$, not $c(m)^2$.



DEVELOPING AREA FORMULAS

Formulas and procedures for finding the area of a rectangle, parallelogram, triangle, circle, and the surface area of various solid figures are developed in the usual way. Although the activities leading to the formulas normally would be carried out using an arbitrary unit, the square centimetre might be used to provide added exposure to this metric unit.

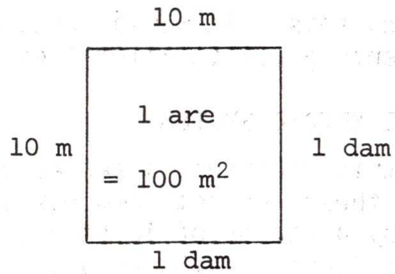
THE SQUARE METRE (m^2)

Once standard procedures for determining the area of a rectangle have been developed, problems requiring students to find the area (in square metres) of surfaces in their immediate environment can be posed. Note that, if linear measurements are made to the nearest tenth or hundredth of a metre, multiplication of decimals will be needed. Students should be reminded to estimate before measuring and computing.

1. How many square metres of carpet are needed to cover the classroom floor (or a room in your home)?
2. Find the amount of glass needed to replace all the windows in the classroom (your home).
3. How much paint would be required to paint the four walls of a room (given the number of square metres covered by a litre)?

LAND MEASURE

The square metre is small for practical purposes of land measure. A square 10 metres by 10 metres (a square decametre) is easy to visualize and was adopted as a metric unit suitable for describing the area of gardens, etc. This unit was called the <u>are</u> (a).

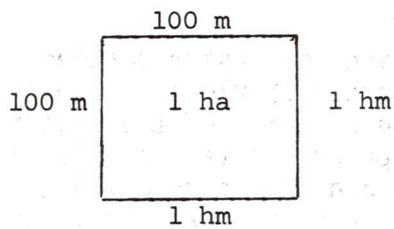


The "are" is not an official SI unit, however, and although it may continue to be used in certain countries, it is not recommended for use in Canada.

The size of the are makes it an appropriate unit for outdoor activities. Rather than learn the term are, students can be asked to estimate and determine area in hundreds of square metres.

1. On the playground, mark off a square 10 m by 10 m. Think of the area contained by this square when you think of 100 m^2.
2. Find the area of the athletic field (or a nearby lot, your back-yard, etc.). Make linear measurements to the nearest metre.

The hectare (ha) is equal to 100 ares, as the name suggests, and is the area of a square 100 m by 100 m (a square hectometre). Thus 1 ha = 10 000 m^2.



Like the are, the hectare is a non-SI unit which may continue to be used for a limited period of time. Because of the need for a unit similar to the acre, the hectare will be recognized in Canada for use in surveying and agriculture.

Keeping in mind that the playing field in Canadian football is approximately 100 m by 60 m, the area of two fields side by side would measure a little more than a hectare (about 1.2 ha).

A typical word problem might be as follows:

A rectangular plot of land measures 400 m by 350 m. Find the area in hectares.

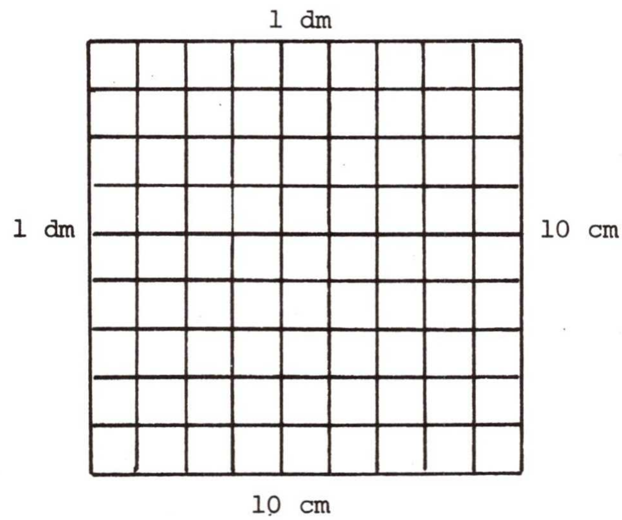
Solution: Using metres, Area = $(400 \times 350)m^2$ = 140 000 m^2 = 14 ha
Changing to hectometres first, Area = $(4 \times 3.5)hm^2$ = 14 hm^2 = 14 ha.

The square kilometre (km^2) is used to describe the area of large tracts of land. The province of Alberta, for example, has a total area of 661 188 km^2.

Student activities involving this unit would consist of paper and pencil exercises with linear measurements given in kilometres.

AREA EQUIVALENTS WITHIN THE METRIC SYSTEM

Using the set of metric prefixes, a series of metric units for area are named. (Note that some of these are not commonly used.) A basic idea is that, where linear units differ by a factor of 10 [e.g., 1 dm - 10 cm] the corresponding area units will differ by a factor of 100 [e.g., 1 dm^2 = 100 cm^2].



Many exercises requiring conversion between metric units of area can be formulated. However, the teacher should be aware of the objectives of such exercises. While they do provide a review of the system of prefixes and practice in multiplying and dividing by powers of ten, such activities are not essential to developing the understanding and skills relating to area measure at a practical level. Several exercises of this type are now illustrated.

1. How many square centimetres are there in a square metre?

   Solution: 1 m = 100 cm
   therefore 1 m^2 = (100 x 100) cm^2 = 10 000 cm^2.

2. What is the relationship between a hectare and a square kilometre?

   Solution A:

   1 km^2 = 1 000 000 m^2
   1 ha = 1 hm^2 = 10 000 m^2
   therefore: 1 km^2 = 100 ha

   Solution B:

   1 km = 10 hm
   therefore: 1 km^2 = 100 hm^2 = 100 ha.

3. 470 dm^2 = __________ mm^2 = ___________ dam^2.

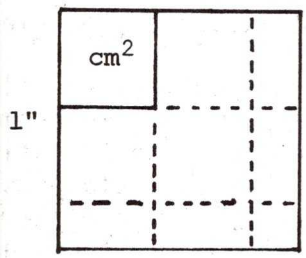
COMPARING METRIC AND BRITISH UNITS

One does not learn to "think metric" by converting between the British and metric systems. However, for students who are already familiar with conventional units of area, comparisons provide useful reference measures. For example:

- There are more than 6 square centimetres to a square inch.
- A square metre is a little larger than a square yard.
- A hectare is about 2.5 acres.
- A square kilometre is less than four-tenths of a square mile.

Students should understand how area conversion factors can be obtained from the corresponding linear equivalents.

For example, what is the relationship between a square centimetre and a square inch?

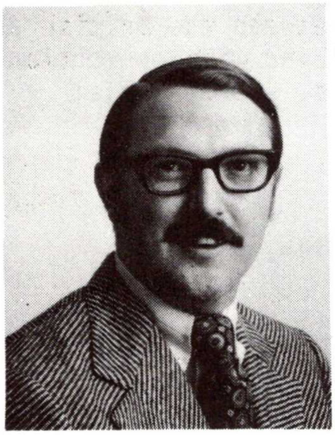


From the diagram, it appears that there are between 6 and 7 square centimetres in a square inch. Computing,

$$1 \text{ in.} = 2.54 \text{ cm}$$

$$\text{therefore } 1 \text{ sq. in.} = 2.54^2 \text{ cm}^2 = 6.45 \text{ cm}^2$$

(to two decimal places)



Temperature Measurement

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In April of 1975, Canada started using the degree Celsius (°C) as the everyday unit of temperature. The general public is being made vividly aware of the fact that Canada has been "inching" its way to metric conversion since 1970.

The Celsius temperature scale is identical to the centigrade scale. In Europe the centigrade is used as a unit of angular measurement. To avoid confusion, the centigrade scale was renamed after Anders Celsius, the scientist who developed the centigrade scale. It is very important that your students NOT have a special unit on the Celsius scale. Your class (and you) must use the degrees Celsius as a unit of temperature *throughout the year!* The first three activities are designed to be repeated many times.

ACTIVITY ONE

Every day of the school year the temperature both inside and outside the classroom should be measured and recorded. If a Celsius thermometer is placed inside the classroom and another just outside one of the exterior windows, the entire exercise could be completed in one or two minutes each day. Preferably, the readings would be made at the same time each day. After each reading, record the data on a graph (Figure 1).

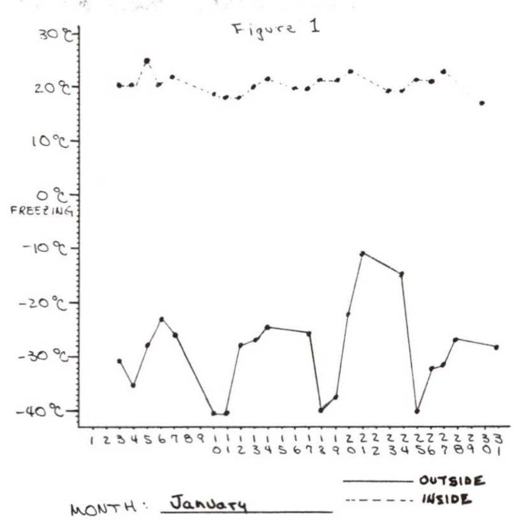


Figure 1

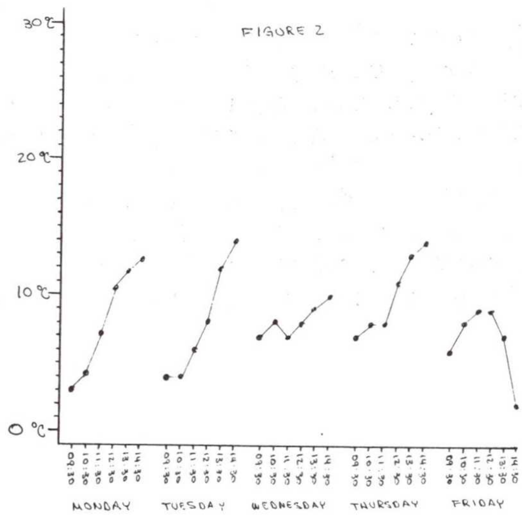
You can run the grids off on dittos. In the example in Figure 1, the blank was filled with the particular month and the data started with the first Monday (or first school day) in the month, which happened to be January 3. Saturdays and Sundays are not recorded and the points are connected for aesthetic reasons only.

According to the grade level, you may want to label the scale "40^{0}C below freezing" instead of -40^{0}C or read -40^{0}C as "Forty degrees Celsius below freezing."

Activity One is an easy activity to implement. It gives the class lots of experience using the degree Celsius and it keeps the terminology (and symbols) in front of them for the whole year. This type of activity also serves to have students thinking about the new system every day and not as some special mathematics project.

ACTIVITY TWO

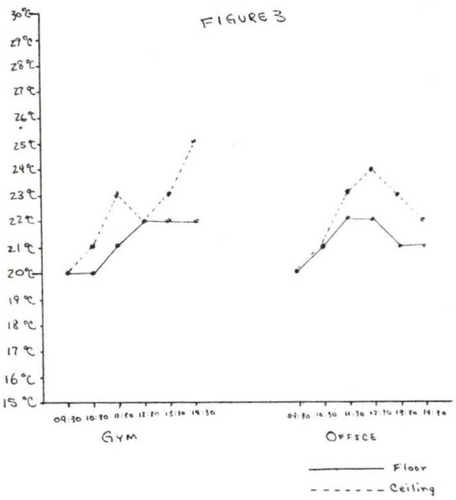
Early in the school year (say the second or third week) of the third grade, or later grade, one should take time to measure and record the outside temperature in degrees Celsius every hour of the school day for a week. This activity gives the students at least 30 measurements in one week. (I wouldn't start quite so early in the school year in Grades I and II since the numbers might give the students some difficulty.) Figure 2 graphs an entire week's measurements. One can compare measurements taken at any particular hour by connecting all the 09:30 dots, then all the 10:30 dots, etc. to see the pattern the temperatures form through the day.



As with Activity One, the key is to let the students make many measurements using metric units.

ACTIVITY THREE

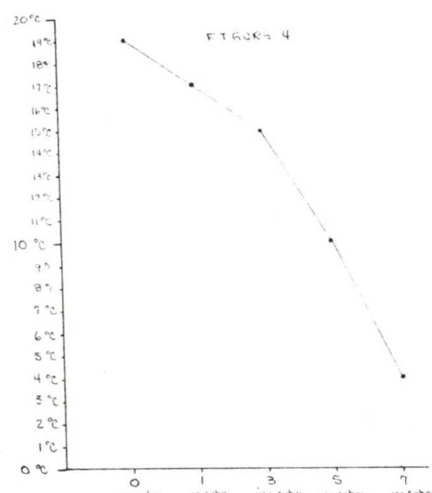
Each hour of the school day the students (in teams and with an adult) measure the temperature at a point on the floor and on the ceiling of, say, the gym, the classroom, hallway, office, etc. The teams then return to the classroom to record the results on the graph(s). Figure 3 is an example of this activity.



Activities One, Two and Three are not "one-shot" affairs to be done and forgotten. *Use* these activities to give the students continual practice in using the degree Celsius as the unit of temperature. Also, as you and your class progress through the year, use the Fahrenheit as little as possible. You may want to have an activity where you record both the Fahrenheit and the degree Celsius on the same graph for the sake of comparison.

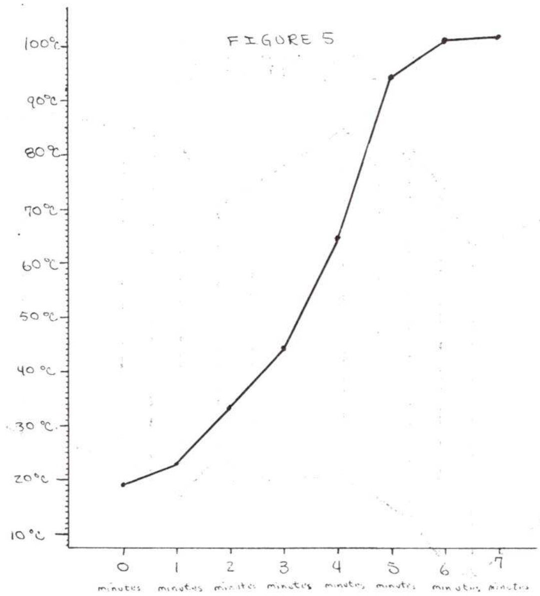
ACTIVITY FOUR

For this activity you will need a source of ice cubes. If no fridge is available in the school, you probably will want to skip this activity. Divide the class into as many teams as you have equipment for. The students pour one litre of regular water from the faucet into a pan and put the Celsius thermometer in it. The students then place one ice cube in the pan, wait two minutes, read the scale, and graph the data. Next the students put two more ice cubes in the pan, wait two minutes, read the scale, and graph the data. Repeat the lab for five, seven etc. ice cubes. Use as many ice cubes as the pan will hold or as many as you have, whichever is fewer. The graphing can be done on a graph similar to the one given in Figure 4.



ACTIVITY FIVE

This activity is similar to Activity Four, except you are warming the water instead of cooling it. You will need an electric kettle if a stove-top heating element is not available. The activity is better done with a pan of water being boiled on a stove-top. Fill the bottle with water and place the Celsius thermometer in the water so that you can still read the scale. Record the temperature after each minute for five minutes. See Figure 5.



ACTIVITY SIX

This activity is concerned with body temperatures. Normal body temperature is 37^{0}C. If you have a class set of Celsius thermometers, have each student do this lab individually, otherwise in teams. The students put their thumbs over the "bulb" of the thermometer, wait two minutes, then record the result. The thermometer is left to "cool off" after each measurement. Then the students place it between the palms of their hands, wait two minutes, and record the results. Finally the students place the bulb of the thermometer up against their cheeks, wait two minutes, and record the results.

ACTIVITY SEVEN

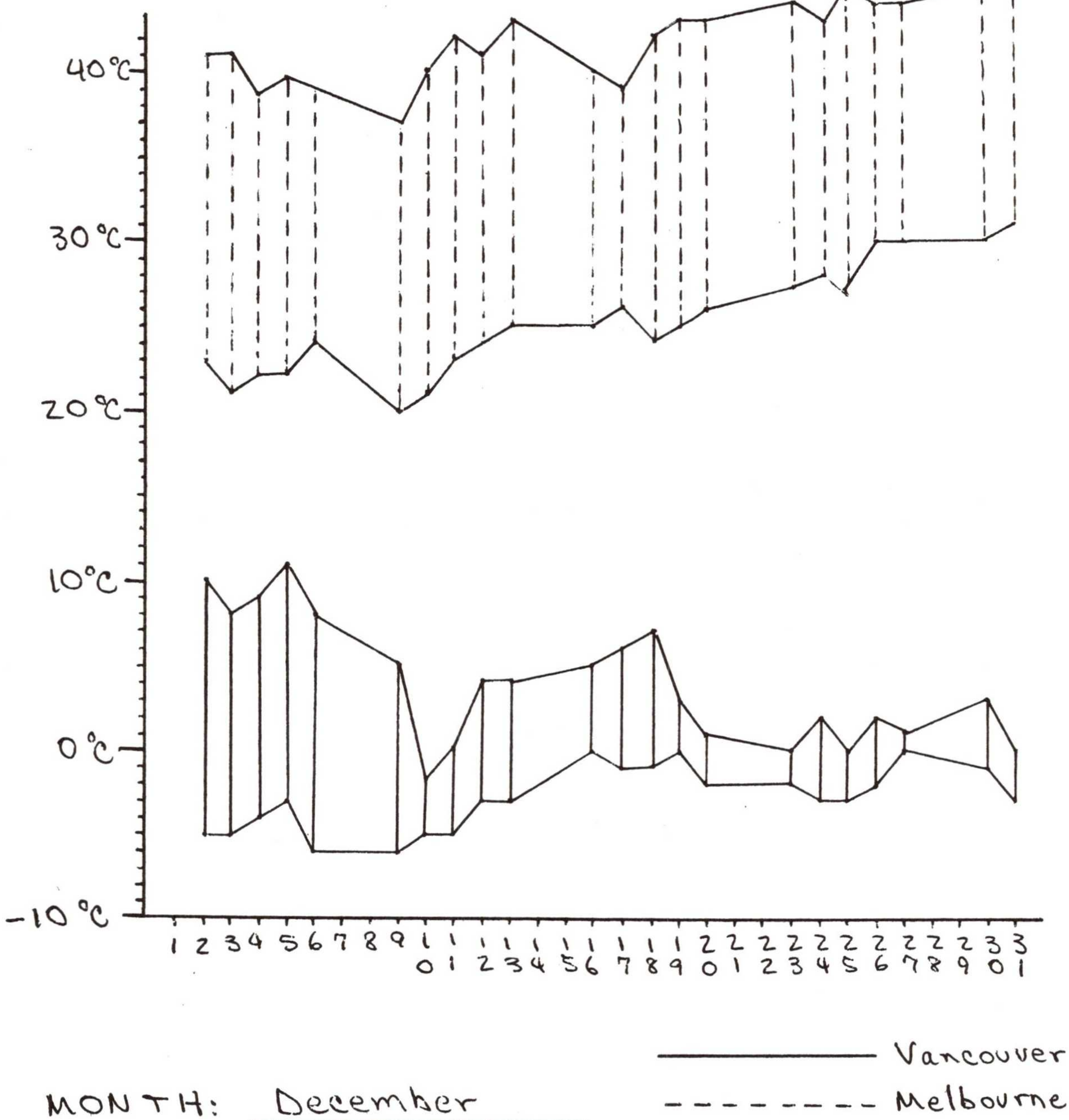
You will need a bright sunny day for this activity. Have the students take their Celsius thermometers outside and measure the temperature in several different places. Measure the temperature outside on the ground in the sun, on the ground in the shade, on a car hood in the sun, holding the thermometer in the air in the shade, holding the thermometer in the air in the sun, on asphalt or cement, etc. After they record the different measurements, then ask them, "What is the temperature outside?" You may want to lead into a discussion or field trip to a weather bureau to see what they mean when they say "It is 15^{0}C today."

ACTIVITY EIGHT

The last two "activities" are not activities in the true sense of the word.

Activity Eight consists of each student picking a city in Canada and a city outside of North America and keeping a graph of the high and low temperatures of the two cities over a period of one month in the fall and for one month in the spring. The vertical line segments on the graph in Figure 6 connect the low and high temperatures for each day to show the entire temperature range. Notice that December is an early summer month for Melbourne.

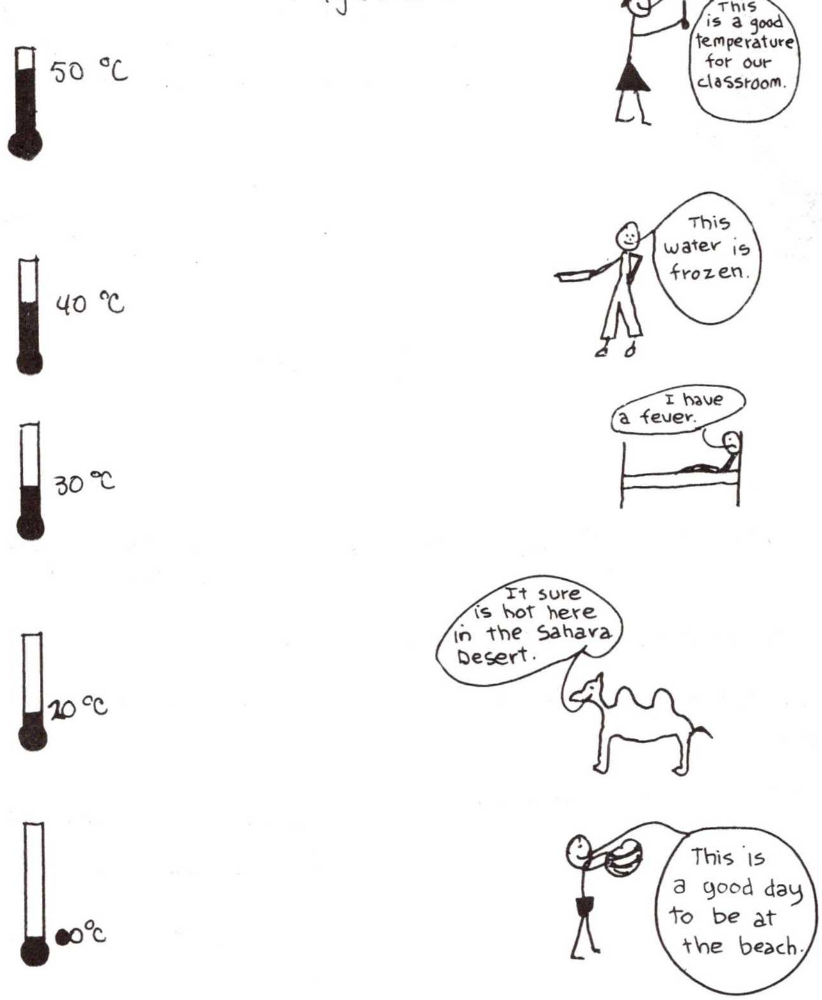
FIGURE 6



ACTIVITY NINE

This "activity" is strictly a worksheet, but a very necessary item in teaching metric measurement. After the students have had a chance to use the degree Celsius as the unit of temperature, it is a good idea if they can think in terms of temperatures being given in metric terms. Figure 7 gives some examples to use with your class. The idea is to match the picture with the thermometer that best reflects the temperature.

Figure 7



As you can tell, the main emphasis in this article is for you and your class to go out and *measure temperatures in degrees Celsius!* There is no need to learn the conversion formulas between Fahrenheit and Celsius and/or between Celsius and Fahrenheit. If the students (and you) use the degree Celsius as the unit of temperature throughout the year, by year's end you will be thinking in metric terms. You won't feel the urge to bundle up when going outside into 20°C weather.

Hands-on Workshop Activities

Reprinted from *Think Metric - A Workshop on the Metric System of Measurement,* a publication of the Alberta Department of Education

Sidney A. Lindstedt
Government of Alberta

VOLUME AND CAPACITY

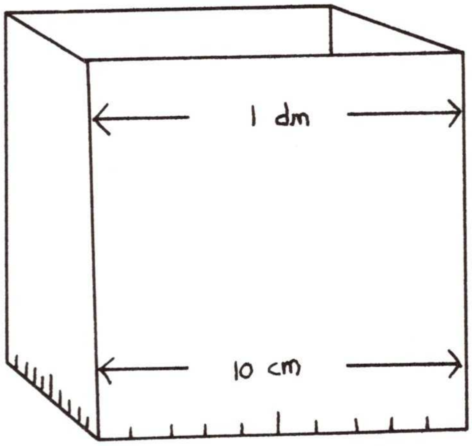
The Cubic Decimetre

1. (a) Using the sheet of cardboard supplied, construct on open rectangular box with each edge 1 dm long. Use plastic tape to secure the edges.

   (b) Compare your container to the milk carton.

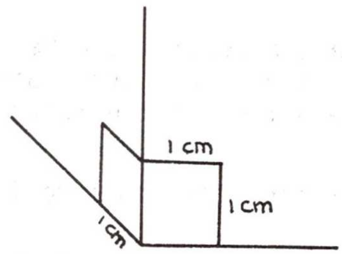
   (c) Select one bottom corner and mark in centimetre scales along each dimension.

   (d) Label 3 adjacent edges as 1 dm.



(scale drawing)

2. (a) Select another bottom corner and draw in the lines to show the size 1 cm^3.



(b) How many centimetre cubes would fit along <u>one</u> row of the bottom? __________

(c) How many such rows would fit into the bottom? __________

(d) How many cm^3 would there be in this bottom layer? __________

(e) How many layers would fit into the whole box? __________

(f) How many centimetre cubes would fit into the whole box? __________

__________ cm^3 = ____1____ dm^3

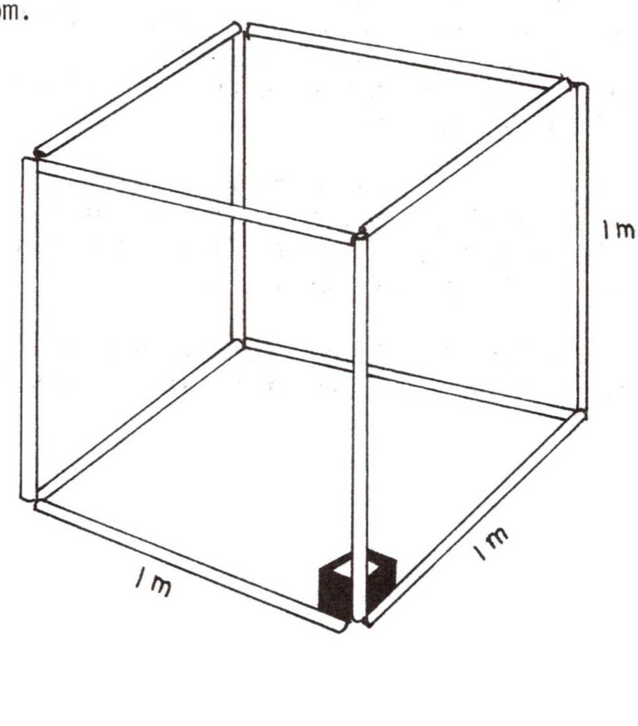
3. (a) The capacity of this box is 1 litre (1 ℓ). What is the capacity of 1 cm^3? __________

4.

Container	*Your Estimate of Capacity in mℓ*	*Actual Capacity by Calculation*	*Error*
Shopping bag	__________	__________	__________

The Cubic Metre

1. (a) Please contribute 12 "newspaper" metre measures and your assistance to construct the skeleton of a metre cube, in the corner of the room.



(b) Place a decimetre cube within the metre cube in one corner. How many decimetre cubes (litres) would fit into one row along the bottom of the metre cube? __________

(c) How many such rows would fit in the bottom? __________

(d) How many decimetre cubes (litres) would there be in this layer? __________

(e) How many layers would fit into the whole metre cube? __________

(f) How many litres have the same capacity as 1 m^3? __________

(g) The capacity of 1 m^3 is __________.

Additional Notes

The cubic centimetre (cm^3) may be used to express the volume of small rectangular boxes, blocks, cylinders, spheres, cones, and other solids whose volumes can be determined by mathematical formulae.

The cubic metre (m^3) will be used to state the volume of a building, the hold of a ship, the amount of concrete in a dam, the earth moved in an excavation, and the gravel, sand or loam delivered by a truck.

The millilitre (ml) will occur when stating volumes of milk, drinks, oils, paraffin, fluid medicines, shampoos, toothpaste, lotions, solvents, paints, and similar fluids in containers generally holding less than one litre. The millilitre will appear on measuring spoons and in recipe books. Medicinal doses will often be administered by the 5 ml teaspoonful.

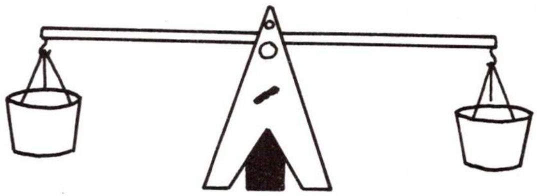
The litre (ℓ) will be used to express a measure of gasoline, antifreeze, paint, solvents, milk and various drinks, and household liquids having volumes generally of one litre or more. The capacity of car radiators and gas tanks, of refrigerators and wheelbarrows will likely be given in litres.

The kilolitre (kl) may help describe large fluid volumes such as water consumption shown on hydro metres or the capacity of a swimming pool, reservoir, gasoline truck or oil tank.

MASS

Mass Comparisons

1. (a) Assemble the balance provided.



   (b) Adjust balance by adding paper clips to pans, as needed.

2. Using sand in plastic bags, prepare a set of mass units consisting of:
   (i) A 50 g mass (0.05 kg)
   (ii) A 100 g mass (0.1 kg)
   (iii) A 200 g mass (0.2 kg)
   (iv) A 200 g mass (0.2 kg)
   (v) A 500 g mass (0.5 kg)
   (vi) A 1 000 g mass (1.0 kg)

3. Complete the following -

	Mass	*Your Estimate (To nearest 100 g)*	*Actual Mass*	*Error*
(a)	Of your shoe	____ . ____ kg	____	____
(b)	Of this booklet	____ . ____ kg	____	____
(c)	Of a pair of scissors	____ . ____ kg	____	____
(d)	Of a math book	____ . ____ kg	____	____

4. Using a sheet of light plastic, provide a water-tight lining for a litre container (1 dm^3).

   Fill the container to the top edge with water. Because the sides are flexible, the box will bulge a little. Avoid this by having two colleagues hold the sides vertical with their hands.

   Empty the water (good luck!) into one of the plastic containers of the balance. Use your sets of units to find the mass of the water. Measure to the nearer 100 g.

   Mass of 1 litre of water is ________.

5. If 1 ℓ of water has a mass of _______kg
then 1 kl of water has a mass of _______kg
which is equal to _______Mg.
1 kl is the capacity of _______ m^3
therefore _______ m^3 of water has a mass of _______Mg.

This unit of mass, the Mg, is called a tonne (t).

Additional Notes

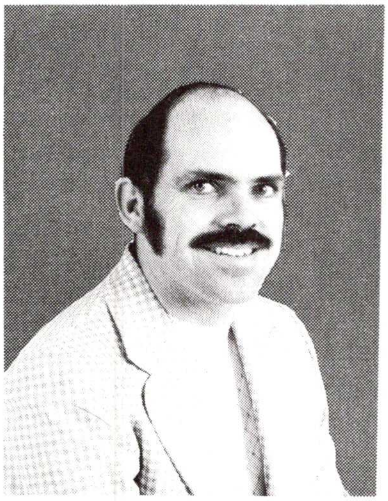
As Canada goes metric, many small goods will have specifications in grams (g). Among these there will be butter, cheese, packaged meat, jams, jellies, spices, canned fruit, nuts, loose candies, nails, putty and paste fillers. Knitting wool will be shown in grams. Perhaps kitchen scales in grams and kilograms will become popular.

The kilogram (kg) will be used in buying meat, vegetables, fruit, sugar, flour, fertilizer, lawn seed, cement. Baggage limits when travelling by air are stated now as 20 kg for economy and 30 kg for first class. The kilogram will also be used to express a person's own mass which we have so often called our weight.

The tonne (t) will be useful in expressing the annual yield in grain crops, in specifying the mass of very large loads, such as a truckload of bricks, or almost any type of massive cargo which may be shipped or transported from one place to another.

The milligram (mg) is a very small mass and therefore not too common in daily life except in pharmaceutical quantities where the contents of drugs may be shown in milligrams.

Metric Interest Centres in Secondary Mathematics



Thomas E. Kieren
University of Alberta

Canada is in the process of officially converting to the metric system of units known as the International System of Units (Système International d'Unités), or SI. While this has many implications for all sectors of our country, it has special implications for mathematics teachers. It has direct implications as we teach measurement in the junior high school. It has indirect implications as other teachers look to us to educate students who can discuss and apply this new system in their classes and courses. It has vivid implications for our secondary school students. They are persons who are already naturally familiar with the "imperial" system of measures. Yet, as they reach adulthood in a few years, they will have to function in a metric society.

The Metric Commission of Canada is providing a great deal of literature on the change. Our provincial Department of Education is providing both in-service leadership and organization as are other educational agencies in the province and indeed across Canada. Our professional organizations, the MCATA and the NCTM are providing ideas and guidelines. Last, but certainly not least, commercial publishers and school equipment suppliers are providing a vast array of material and devices to help us "go metric" and "think metric" in our mathematics classrooms.

Thinking seriously about the learning problem facing secondary school students, we can see that learning the "SI" is not a short term proposition meant to satisfy the requirements of a school examination. Students must have sufficient time and experience to grow in personal familiarity with -

- the basic units of SI, what they look and feel like,
- the derived units of area, volume and capacity so useful in our junior high school curriculum,
- the system itself based on 10,
- the nominal system of prefixes,
- the symbolic system tied up in the numerous correct abbreviations.

How can we, as teachers, best use the growing myriad of metric materials and metric ideas to provide the range of experiences needed by our students in meeting the objectives stated above? It is the purpose of what follows to describe what I have termed a Metric Interest Centre which is an instructional plan to allow a mathematics teacher to provide the needed time and metric experiences for our students.

What is a Metric Interest Centre (MIC)? Physically, a MIC is a collection of materials, most of which can be made or collected by your students, appropriate SI measuring devices, and a large number of projects involving their use. These projects are the heart of the centre and should be designed so that students can work on them individually, in small groups, or as classes.

The pedagogical basis for using a MIC has been alluded to above. It is based on the premise that learning, especially that which is to be lastingly useful, takes *time*. It is also based upon a second premise which has two components. The first is that secondary students, particularly those at the junior high school level (perhaps ages 12-14), need *personal experiences* upon which to base the many generalizations necessary in gaining personal mastery over SI ideas. By personal experience is meant being faced with a situation, interpreting it for yourself and then working successfully within it. The second component of this premise is that secondary students need to be faced with situations which are *motivating*. Combining these three notions, it can be said that the pedagogical aim of an MIC is to provide *motivating personal experiences* with metric measuring situations over an extended period of *time*. Hopefully these will constitute the *practice* so necessary for learning which lasts.

Professionally the MIC allows a mathematics teacher the opportunity to interpret both the curriculum and the SI learning objectives noted above in a way that is most relevant to the students. The teacher can make use of the environment in which the school exists, the occupations of the parents, and the stores in the areas in making up projects on which students can work. Students can and should be expected to provide extensions to the MIC and indeed to come up with projects on their own.

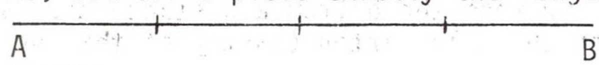
The Metric Interest Centre examples which follow will include measures of length, area, volume, mass, and capacity. In addition, they will focus on comparative problems and all of the aspects of SI. The teacher must be sensitive to the mathematical prerequisites and corequisites of the various projects. These mainly involve the notions of ratio and proportion, as well as measurement concepts. However, the following projects attempt to develop a situation in as open a way as possible, allowing any student to try any project.

PROJECT I

Materials: Twine, marking pens, half-gallon milk cartons, material to put in cartons. In a convenient location in your classroom, mark 2 points (A and B), 4 metres apart on the floor of your classroom.

Card A

From the ball of twine, cut off a piece exactly the length from A to B.



Find and mark with a pen the exact middle of your twine. (How can you do this?) Find and mark the exact middle of the other two segments of your twine. (What is an easy way to do this?) You now have a measuring instrument with 4 parts of equal length. How tall are you? More than 1 unit? __________ More than 2 units? __________ Take a metre stick and measure the segments and total length of your twine: Segment __________, Total __________ . With another person, use your measuring twine to find the approximate perimeter of your classroom, or room at home, in metres.

Card B

Cut another piece of twine exactly as long as one segment of your measuring twine. Without using a metre stick or any other kind of standard measure, figure out a way of dividing this piece of twine into 10 equal parts. (Hint - you will have to use something with parallel lines on it, for example, boards on a floor.)

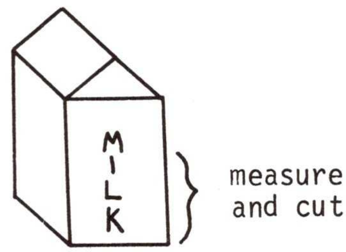
Each of these small segments represents a tenth of a metre (0.1 m) and is called a decimetre (dm).

Using your measuring twines, work with another person to find the following in decimetres and metres.

	decimetres dm	*metres* m
height		
length of arm		
length of foot		

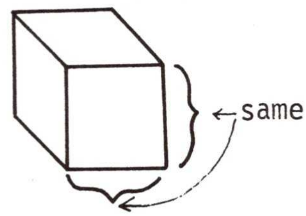
Card C

Take a half-gallon milk carton. Use your twine to measure the length of the side of its bottom in decimetres.



How long? __________

Carefully measure up from the bottom a distance the same as the length of the bottom side. Cut off the milk carton exactly at this height.



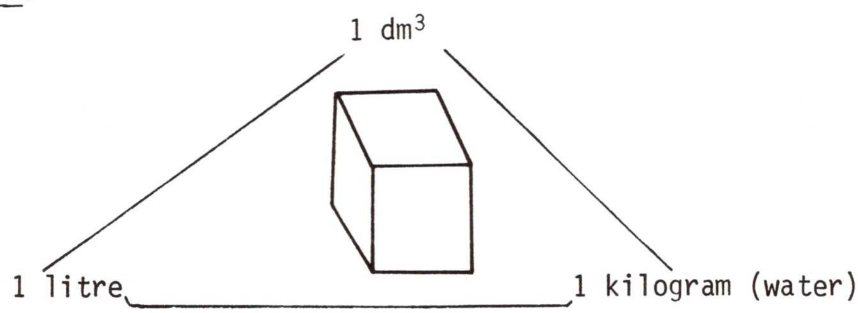
What shape is your container? ____________

What are its dimensions? ____________by ___________by _____________.

Its volume is found by multiplying its length, width and height (which are the same).

Volume = __________dm x ___________dm x ____________ dm = ____________dm^3.

Fill your container with rice or sand or other material. You now have a litre of material.
Empty your container and exactly fill it with water. The mass of this water is about 1 kilogram.



You might think of your container as showing the "magic metric triangle."
Use your container to estimate capacity of these containers in litres.

10 oz. pop bottle ____________ *litres*
26 oz. pop bottle ____________ ℓ
40 oz. pop bottle ____________ ℓ
soup can ____________ ℓ
48 oz. juice can ____________ ℓ
half-gallon milk carton ______ ℓ

Card D

In Canada's change to metric units, new measures of common objects will likely be adopted. For example, a chair seat measuring 42.3 centimetres high, in the future may be set at 40 or 45 or 42 centimetres; a pencil now 14.3 cm long, set at 14 cm. Put your mind to work and see if you can think up good dimensions for these and other objects. Filling in the table following should help. To help you learn to "think metric," make an estimate of the distance in centimetres (cm) or metres (m) before you measure. See how close your guesstimate can be! Use a metre stick marked off in centimetres in your measuring.

	Guesstimate dimensions (centimetres or metres)	*Actual measure dimensions*	*Your proposed metric measure for the object*
Mathematics book			
Ball point length			
Writing paper dimensions			
Chair seat height			
Book shelf width			
Wall panelling panel			
Doorway width and height			

PROJECT II

Materials: A variety of commercial and homemade measuring devices.

Card E

One of the facilities for the Commonwealth Games in Edmonton will be a pool for swimming competitions. Make an accurate drawing of such a pool and find the following information about it in metric units: length, width, depth, volume, water in pool, width of lanes.

List the Commonwealth records for the various events and then calculate them in kilometres per hour. Visit a swimming pool in your neighborhood. Find out, or, better yet, measure and calculate the above measures for your pool.

Card F

Visit your community hockey rink. Find the following measures in metric units: length, width, distance from end boards to blue line, distance between blue lines, distance from back of net to boards, diameter of face-off circle, number of litres of water needed to originally flood ice, number of litres used in maintaining ice, volume of ice on rink.

Card G

Get a score-card from a nearby golf course. Rewrite the card using metric units. Extra for experts: How many square metres of grass are there on the largest green? Write a report on how you figured this out.

Card H

Look over cards E, F and G. Find the relevant measures or change the wording of the rules of other games which interest you so that they use SI.

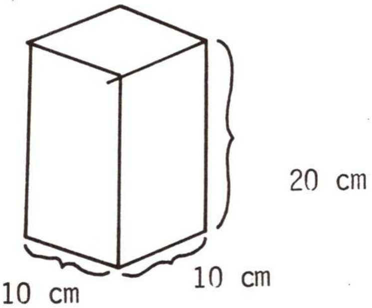
Card I

Organize a metric sports day for your school. Set up all the events in metric units. The day could involve various running, jumping, throwing, and target events. It could also involve some "fun and think" events such as a relay race carrying pails of water to fill a larger container where each contestant would have to calculate the amount he or she adds in litres. Think up your own events which will help all the kids in your school to "think metric." Have your classmates and teacher help you organize and carry out the sports day.

PROJECT III

Materials: Metric measurement devices, tagboard, tape.

Card J



This carton can contain up to two litres. What is its volume? ________
Can you find other shaped cartons which would hold 2 litres? Sketch them and give their dimensions. Build them out of tagboard.

Card K

Get a half-pint milk carton. On it you will find its metric capacity 227.8 millilitres (ml). As we change to SI, the contents of milk cartons will likely change to 250 or 200 ml. What portion of a litre would each of these measures be?

250 ml = ________ ℓ

200 ml = ________ ℓ

Design various milk cartons which would hold 200 ml. You may wish to get your teacher, the industrial arts teacher, or a carpenter to help you with this. Sketch and build cartons you think will work. What shapes do you think would be most practical? Why?

Extra for a smart shopper:

What is the price of milk now (½ pint)? What would be fair prices for 250 ml cartons? __________, 200 ml cartons? __________. Why? What do you think milk machine prices would be for these cartons: 250 ml? ____________, 200 ml? _____. Why?

Card L

Collect containers for various products and complete the table following.

	Current measure in grams	*Better SI measure*
Soap		
Soup		
Soda Biscuits		
Ice Cream		
Bread		

Measure the containers used above. What would be the metric measures for your new container?

PROJECT IV

Materials: A road map of Alberta, topographical maps of various parts of Alberta, map of Canada, rulers marked in centimetres.

Card M

Find the shortest road distances in kilometres (km) between your home and the following cities: Calgary, Peace River, High Level, Fort McMurray, Banff, Pincher Creek, Coronation, Lloydminster, Vegreville, Edson, Grande Cache, Medicine Hat, Red Deer, Brooks, Grande Prairie, Rocky Mountain House. Check the laws of Alberta and convert the following signs to appropriate or equivalent metric measures: speed limit signs (on highways, in towns and cities), load limit, clearance signs, junction signs.

Card N

Find a lake on a map of Alberta. Give its approximate measurements in metres: length, width. Make the smallest rectangle you can around the lake. What is its area in square metres? __________ What is the area of the lake (approximately)? __________

Card O

On a map of Canada use metric measures to find:

- the area of the smallest rectangle in square kilometres (km^2) which will enclose the country,
- the approximate length of our none island coastline in kilometres,
- the air distance in kilometres from Edmonton to: Victoria, Regina, Winnipeg, Toronto, Quebec City, Fredericton, Halifax, St. Johns, Charlottetown, Whitehorse, Yellowknife.

PROJECT V

Card P

Metric Hunt 1

Find, using metric units, the following information (give the measure in at least two equivalent forms):

Examples -		
Dad's height	180 cm	1.8 m
Cream carton	227.8 ml	0.2278 ℓ
Your height	________	________
Amount of natural gas Alberta exports daily	________	________
Area of a page of your local newspaper	________	________
Highest elevation in Alberta	________	________
Capacity of the gasoline tank on your car	________	________
Height of your school building	________	________
Volume of your math classroom	________	________

Card Q

There are many prefixes in the metric system which are not commonly used. Find things which are usually measured using the following prefixes. Find as many things as you can for each category. If you wish, get pictures of each and, with a classmate, make a display of your findings: nanno, micro, milli, centi, deci, deca, hecta, kilo, mega.

PROJECT VI

CARD R

Obtain a copy of your local newspaper. Change all of the "ads" so that they would be appropriate in a metric society. Remember to change the prices where necessary.

Example: 3 lb. margarine -- $1.79

A convenient metric amount might be 1 kilogram or 2 kilograms so our new ad might be: 1 kg margarine -- $1.31, 2 kg margarine -- $2.62.

CARD S

In that same newspaper, go through the sports page and change it using appropriate metric values.

Example: "In Montreal, Steve Smith vaulted 18'2½." "In Montreal, Steve Smith vaulted 5.55 metres."

DEVELOPMENT AND USES OF A METRIC INTEREST CENTRE

The projects and cards are but a few of the many possible directions such a Metric Interest Centre could take. The basic units, the system and applications have been stressed; review games have not but are easy to develop.

M	E	T	R	I
100 cm	10 g	30 m	250 ml	1 dm^3
0.2 mm	2 kg	5.54 m	6 ℓ	600 cm^3
150 km	350 mg	SI FREE	3 kl	0.01 m^3
10 dam	0.3 kg	382 cm	170 ml	1 m^2
1 000 m	110 g	12 dm	0.85 ℓ	10 000 cm^2

In the game METRI, a call of "under T, 1.2 m" would be marked as shown. Games such as this are useful in stressing within unit conversions the abbreviation system and the prefix system.

In developing other projects on cards, a good source is your imagination and that of your colleagues. But, as mentioned earlier, there is a wealth of material available. A major task is to take a piece of material - for example the Metric Commission's "Metric Conversion in Agriculture," - and transform it into a project. This could be done by attaching a 5 x 8 card with student directions on it. For example -

Card Agr.

Read "Metric Conversion in Agriculture."

What is the area of your farm in hectares ? __________
How many hectares of wheat did Canada plant last year? ___________
What is the mass in kilograms of your largest beef animal? ___________

Another important source of cards and projects is the students themselves. They could be required to contribute at least two cards a year to the Centre. This would be a source of over 300 potential cards for the average junior high teacher.

There are many ways to use a MIC in your teaching. Organizing your classes into small groups and assigning them to complete a certain set of projects or cards could well form the basis for a unit on the SI. A better use would be to spread these assignments over the course of a semester or year, allowing sufficient student time to simply grow in familiarity with the system. An even more open use would simply require each student to complete a report on a contracted number of cards or projects of the student's choice over the course of a year or semester.

However you choose to use such a centre, the idea is to provide a junior high student with the time and experience base for SI learning and the motivational impetus to do something with it.

PART THREE
Charts, Chronicles and a Final Bit of Humor

Part III

Scope and Sequence

This article has been reprinted from *Think Metric - A Workshop on the Metric System of Measurement*, a publication of the Alberta Department of Education

Sidney A. Lindstedt
Government of Alberta

As the strand of metric measurement is developed into the mathematics program, teachers should have in mind a scope and sequence format upon which to build their activities, projects and exercises. There are, of course, many ways to formulate a scope and sequence organization and there are many variables, such as the nature of the class, the general organization of the whole school program. The following chart is one suggestion intended to serve as a referent for discussion on this topic. It is *not* a "prescribed" course of study.

It is fairly easy to have a consensus on what the overall content should be in the elementary school, that is, the content up to the end of Grade VI. In general, it should include the common units of length, area, volume, capacity, mass, temperature, and money. In addition to the commonly used units, it should include, for cognitive reasons, one complete example of a system of subunits from the milli- units to the kilo- units in order to have a complete understanding of the decimal structure of the metric system.

There are many ways to accomplish this overall result. For example, we could sequence the linear units from the smallest (millimetre) to the largest (kilometre). This would be a rational, logical sequence, but a millimetre is a very tiny unit to begin with so the sequence is probably not psychologically sound. Therefore, some decision must be made whether to begin with a centimetre or with a metre.

Another example is the question of *when* to introduce decimal notation. There are several possibilities. We could continue to call the length of this page 2 dm and 8 cm, or 28 cm, for an extended period of time (two or three years) without difficulty, or we could introduce the notation of 2.8 dm as another way of expressing the distance.

In the following chart no attempt has been made to designate the vertical sequence into "grades" by putting in horizontal divisions. "Continuous progress" and/or "individualized" programs suggest that such a designation would be inappropriate. However, consideration has been given to the horizontal articulation of various concepts from one measurement attribute to another, e.g. millimetre, millilitre and milligrams are included at the same horizontal level.

THE MEASUREMENT STRAND IN ELEMENTARY MATHEMATICS

SCOPE AND SEQUENCE

SEQUENCE	SCOPE
Kindergarten	1. Activities that involve making comparisons - long, short; thick, thin; tall, taller; heavy, light; warm, warmer; big, small; etc. 2. Ordering a set of objects by some measure attribute, especially by length. 3. Use of non-standard units.

LINEAR	AREA	VOLUME	CAPACITY	MASS	TEMPERATURE
1. Non-standard units - tooth picks, paper clips			1. Non-standard units- cups, cans, bottles		
2. Standard unit - The centimetre (cm) (a) Familiarization (b) Centimetre scale (ruler) (c) Measuring to nearer centimetre			2. Standard unit - The litre (ℓ) (a) Familiarization (b) Measuring with a litre		
3. Standard unit - The decimetre (dm) (a) Familiarization (b) Decimetre scale (c) Measuring using dm and cm (d) Decimal notation to one place of decimal, eg. for "1 dm and 3 cm" write "1.3 dm" and say "one point three decimetres"			3. Standard unit - The decilitre (dℓ) (a) Familiarization (b) Measuring with litres and decilitres 4. Use of 5 dℓ containers	1. Meaning (a) Examples (b) Comparisons 2. Standard units - The kilogram (kg), (large) The gram (g), (small) (a) Familiarization (b) Appropriate unit selection (c) Measuring	1. Meaning 2. Celsius scale 3. Common temperatures 4. Reading a celsius scale
4. Standard unit - The metre (m) (a) Familiarization (b) Metre scale (c) Measuring using m, dm and cm (d) Decimal notation to two places of decimal, e.g. for "7 m, 4 dm, 2 cm" write "7.42 m" and say "seven point four, two metres"	1. Meaning (a) Use of non-standard units (b) "Counting" units of area	1. Meaning (a) Rectangular prisms (b) Use of non-standard units		3. Reading a scale e.g., "2.7 kg" means "2 kilograms and 700 grams"	
5. Standard unit - The kilometre (km) (a) Familiarization (b) Road maps, etc.	2. Standard unit - The square centimetre (cm^2) (a) Familiarization (b) Measuring area of regions by "counting" square centimetres	2. Standard unit - The cubic centimetre (cm^3) (a) Familiarization (b) Measuring volume by "counting" cubes	5. Standard unit - The millilitre (mℓ) (a) Familiarization (b) Relationships to cm^3	4. Standard unit - The milligram (mg) (a) Familiarization (b) Uses	5. Computing changes in temperature

6. Standard unit - The millimetre (mm)
   (a) Familiarization
   (b) Measuring to precision of nearer millimetre
   (c) Decimal notation of three places of decimal. e.g., for "3 m, 0 dm, 6 cm, 5 mm" write "3.065 m" and say "three point zero, six, five metres"

7. Standard units - The hectametre (hm) and The decametre (dam)
   (a) Familiarization
   (b) Measuring fields, etc.
   (c) Scale drawings (road maps)
   (d) Decimal notation to three places of decimal, e.g., for "6 km, 5 dm, 0 dam, 2 m" write "6.502 km" and say "six point five, zero, two kilometres"

8. Using linear units to show metric system from "milli-" to "kilo-"
   (a) Decimalization
   (b) Conversion of units by shifting decimal point
   (c) Consideration of "ragged decimals"
   (d) Precision

3. Finding area of irregular regions by counting square centimetres

4. Area of rectangles
   (a) Length X width formula

5. Standard unit - The square metre (m^2)

6. Land areas - The hectare (ha)

7. Area of right triangles

3. Standard unit - The cubic decimetre (dm^3) (relationship to a litre)

4. Volume of rectangular prisms
   (a) Length X width X height formula

5. Standard unit - The cubic metre (m^3)

6. Relationship of a litre to a cubic decimetre

7. Standard unit - The kilolitre (kℓ)
   (a) Familiarization
   (b) Relationship to a cubic metre

5. Standard unit - The megagram (Mg) 1 tonne (t)
   (a) Uses

6. Reading a Celsius scale to one place of decimal (clinical therm)

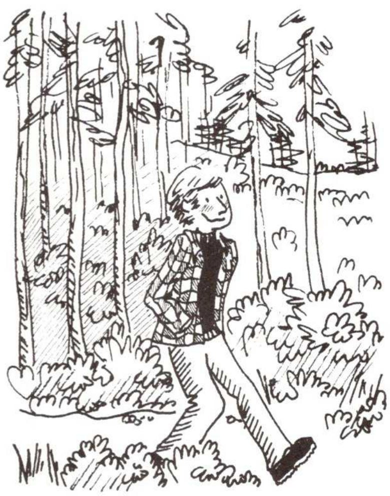
INTERRELATIONSHIPS

(Activities and problems involving interrelationships among different measurement attributes)

1 cm	⟷	1 cm^2	⟷	1 cm^3	⟷	1 mℓ	⟷	1 g (water)
10 cm	⟷	100 cm^2	⟷	1000 cm^3	⟷	1 ℓ	⟷	1 kg (water)
1 dm	⟷	1 dm^2	⟷	1 dm^3	⟷	1 ℓ	⟷	1 kg (water)
1 m	⟷	1 m^2	⟷	1 m^3	⟷	1 kℓ	⟷	1 Mg = 1 t (metric ton)
10 m (1 dam)	⟷	100 m^2 (1 dam^2) = 1 are						
100 m (1 hm)	⟷	10000 m^2 (1 hm^2) = 1 ha						

Metric Update

by *Harold Don Allen*
Nova Scotia Teachers' College

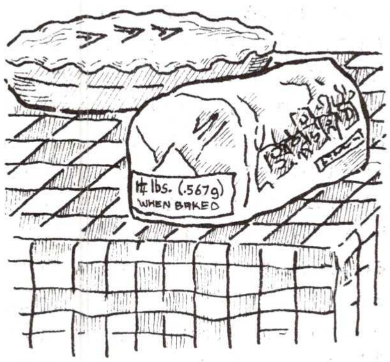


"Metric" may have been the furthest thing from my mind this summer as I roamed the Laurentian foothills of Quebec, following paths I'd known since boyhood. A leisurely hour would take me three miles or more, experience had taught. Three miles is five kilometres, more or less. So, for me, a kilometre along a country byway is roughly a ten-minute stroll. That kind of informal, intuitive relationship--as opposed to formal unit conversion--can have an important place in metric re-education. One hundred kilometres becomes equated to one hour of expressway driving, so many litres to a dollar's worth of gasoline, and so many kilograms' mass to a commonly experienced "weight." Or, in my Laurentian setting, where memorable thunderstorms punctuate every summer, count three seconds and think "a kilometre" (rather than five seconds and a mile) while awaiting the thunder and estimating the distance of the flash. Only when we identify metric measures with real occurrences rather than with old units does "metric" really become a part of our lives.

Professor Allen has written a number of these brief chronicles on metrication. They have been published in various newsletters in Canada and the United States.

"Metric means bigger numbers," one teacher claims. He expresses concern about public acceptance of this aspect of Canada's measurement change-over. Yet, *does* metric, as such, necessarily imply larger numerical values? A "Miss Canada" figure of 36-24-36 (inches) undeniably becomes, with sensible rounding, 90-60-90 (centimetres)--somewhat larger values. But let's look further. If Miss Canada "weighs in" at 106 pounds, the metric counterpart is a mass of 47 kilograms. Should her fever ever reach 102.4 on a Fahrenheit thermometer, that's 39.1 degrees Celsius. Also choosing somewhat randomly, 39 miles is 61 kilometres, 14 ounces is 4 hectograms (0.4 kilograms) and Canada's quart approximates the litre, the yard is a little less than the metre, and the hectare (for land measure) is a somewhat larger unit than either the acre or the arpent.

"Big numbers" arise artificially and needlessly when the range of metric prefixes is curtailed. Thus, if milli- and kilo- are used, omitting centi-, deci-, and deca-, and hecto-, the decigram becomes 100 milligrams (to uncertain precision) and eight decilitres is 800 millilitres or 0.8 litres. This kind of stress on the milli- and kilo- prefixes is being officially encouraged in Canada--except for body measurements (and hence clothing sizes), which are to be in centimetres. Educators could, and perhaps should, put forward good arguments for fuller use of the intermediate units.

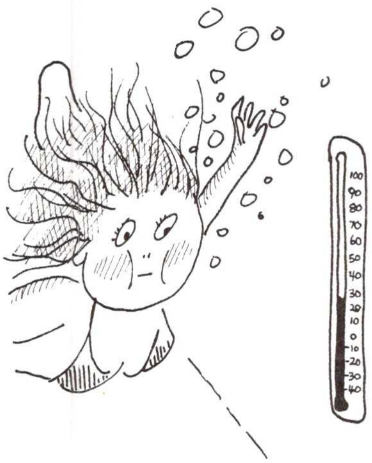


A study of dual labelling as encountered on Canadian packaging can come up with, among other things, some startling conversions. One recently encountered in a Quebec general store was a Farm House brand frozen rhubarb-strawberry pie--a net weight of 24 ounces was converted as 680.385 grams, to the milligram, while a single drop of moisture could mean a difference of 20 mg either way! More seriously, a Nova Scotia supermarket currently sells an Eastern Bakeries Limited product, Butter-nut Thin Sliced Dark Rye Bread, strikingly mislabelled, "1-1/4 lbs. (.567g) when baked." There's food here for classroom discussion--including the important areas of accuracy and precision. Incidentally, quart milk cartons (Imperial measure) are near-universally relabelled 1.14 litres, yet I am told that automatic filling machines operate with a tolerance of roughly three percent. Surely the saddest addition to Canada's metric scene, pedagogically speaking, is the new, larger bottle of Schweppes Ginger Ale. "NEW 35.2 FL. OZ." declares the new label, in bold red numerals 17 mm high. Far below, for those who read smaller print, is "1 LITRE."

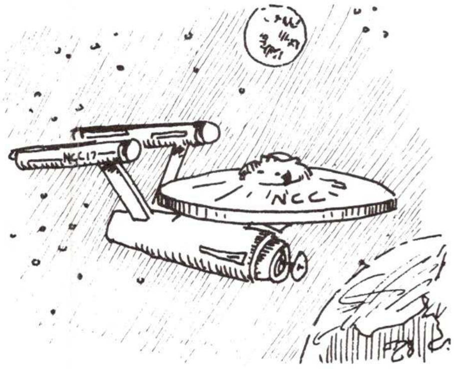
"Metric" bathroom scales have begun to make their appearance on the Canadian consumer market. The first models seem to be "dual," reading both kilograms and pounds. This arrangement may have initial consumer appeal, but adults are less likely to develop a true sense of metric measure with the "pounds" reading to fall back on. "Kilograms only" scales currently available are British imports from science supply houses. All metric calibrations seem to suggest a need to subdivide the kilogram (why, really?), and proceed to do it nondecimally (I shudder at ½ kg!) You "weigh in" to determine your mass, and a force (in newtons) is read as the corresponding kilograms mass. This may sound confusing to our generation. My metric faith was restored, however, when our Grade I daughter arrived home from school the other day and proudly -- and impeccably -- announced, "My mass is twenty kilograms."

Letterhead that is a bit longer and a bit narrower than the usual North American size is being seen increasingly in Canada. Certain federal and provincial departments and forward-looking industries are the prime users to date, and the recipient is right if he guesses that the paper somehow is metric. The A4 international letterhead size is 210 mm by 297 mm, and the dimensions themselves are interestingly derived. A0 (A-zero), the basic metric sheet, has an area of one square metre and dimensions in the ratio one to square root two. Canadians know it as the double page of Toronto's *Globe and Mail* -- and, more often than they realize, as a poster size. As a challenge, calculate its dimensions to the nearer millimetre. Halved to A1 size, its proportions remain unaltered, one to square foot two. Four such halvings give A4 letterhead size, and eight yield A8, the new calling card size for the metrically alert. Australian paper manufacturers changed completely to metric paper last year. Canada has yet to formulate official policy, but metric school supplies, including A4-size four-ring binders, currently are available.

"All the difficulties in the metric system are in translating from one system to the other, but the moment you are in the metric system alone there is no difficulty." A United States congressional committee was so informed by a scientist and inventor who had found it necessary to impose metric standards on carpenters and mechanics in his employ. "I do not anticipate any difficulty in the use of the metric system by itself; and if the government will lead the way, the change must and will come, and we will be brought into line with the progressive nations of the world, instead of lagging behind." The year was 1906, and the scientist, Alexander Graham Bell. Twelve pages of Bell's metric observations were published in the March 1906 *National Geographic* as "Our Heterogeneous System of Weights and measures." Metric Update recommends the presentation as still-timely background reading and suggests that an educational library should be able to retrieve a photocopy.



Dual markings on packages have no educational value. So reports Australia's Metric Conversion Board, and, to an educator, this should make sense. New concepts are internalized by experiencing, by immersion--not by repeated reference to old ideas. There's a lesson here for those about to buy a new thermometer. Make absolutely certain that all thermometers in your life read "Celsius only" for rapid, efficient learning . . . assuming, of course, that Ottawa has done its job of preliminary coordination and that suitable thermometers are generally available in the stores.



The rapidly emerging metric world has been, in a sense, such a blind-spot for North Americans that the urgent need for change-over has caught many by surprise. Ironically, among those most conspicuously caught have been those prophets of possible tomorrows, the science fiction writers. As a particularly horrendous example, our well-metricated youngsters have found unintended high humor in "Star Trek," the televised space opera. A pointedly cosmopolitan "starship" crew has come up with startling mouthsful of those all-but-antiquated units that at this point only Uncle Sam seems determined to preserve . . . and in the long run, of course, can't and won't. Warp factor six, Mr. Sulu!

The Case for Cold Turkey:

Willard F. Reese
University of Alberta

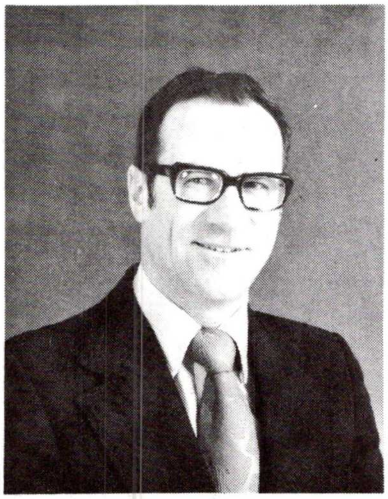
Most of us who have been concerned with metric education are convinced that the best way to get the job done is by total immersion. We believe that metric units should be used exclusively in order to facilitate the ability to "think metric." We're right, of course, but up until now there is no research evidence to back up our contention.

While preparing a metric workshop for teachers, it occurred to the authors that here was an opportunity to test the cold turkey hypothesis.

The forty teachers who participated in the workshop were all pretty much on square one, as far as knowing the metric system was concerned. As they entered the workshop room, every other teacher was asked to step on the bathroom scales to the right and read the weight (mass) in metric units. The next teacher was asked to go left and do the same thing. The scales were identical except that one had only kilogram graduations, whereas the other showed both pounds and kilograms.

An hour into the workshop, the teachers were asked, "How many of you can honestly remember your weight in kilograms?" Sixteen of 20 who weighed on the kilogram scale remembered, but only 9 of 20 who weighed on the double scale still knew their weight in kilograms.

Ala Metric Conversion



This article is a reprint from the November/December 1974 issue of *Metric News*. Permission was granted by the editor, David Mathieu.

W. George Cathcart
University of Alberta

The results of this little pilot study were so encouraging that we decided to experiment with a large class of students in their first year in the Education Faculty at the University of Alberta. Seventy-nine students participated. As they entered the large lecture hall, the first was sent to the right (blue side), the second to the left (red side) and so on. The two sides were identified by large pieces of colored cardboard. In addition to weighing on the bathroom scales, the students were asked to find their height in metric units. On the side with the dual-dial bathroom scales, we had placed two metre sticks, one on top of the other against the wall. On the side of the metric only bathroom scales, we had two more metre sticks plus two yard sticks alongside them and similarly arranged.

No explanation was offered. The students were asked to find their *metric* height and weight. When the students had weighed in and checked their height, they sat down and listened to an hour-long panel discussion on educational administration.

Following this, they were provided with paper and asked two main questions. The questions (and number of persons answering each) were as follows -

Question	*Red* (N=37)		*Blue* (N=42)	
	Yes	*No*	*Yes*	*No*
1. Do you honestly remember your weight in kilograms?	16 (43%)	21 (57%)C	35 (83%)C	7 (17%)
2. Do you honestly remember your height in centimetres?	35 (95%)	2 (5%)	19 (45%)	23 (55%)

After each question, students were also asked to tell whether or not they knew their metric weight and height prior to today. In the red group, only two said they had known their weight prior to the experiment and only one person in the blue group knew it in advance. One person said he knew his height in centimetres in advance. He was in the red group. These few individuals do not appreciably affect the proportions indicated above.

If we apply the statistical test of a difference between two independent proportions to the responses to question one, we find that the difference is highly significant ($Z=3.7$; $p>0.001$). The proportion of the subjects who could recall their weight (mass) in kilograms was significantly greater in the group who weighed on the metric only scales (83%) than in the group who weighed on the dual dial scales (43%).

Similarly, the proportion of students who could recall their height in centimetres was significantly greater in the group that measured themselves only in centimetres (95%) than in the group that took their height in both British and metric units (45%), ($Z=4.7$; $p>0.001$).

While this experiment was not as well controlled as it might have been, the results are so one-sided as to suggest that the cold turkey hypothesis is valid. The most efficient way for us to help our students to "think metric" is to immerse them in the metric system and avoid, as far as possible, any reference to the British system of measurement. This little experiment indicates that when people are faced with both systems they concentrate on the one they are familiar with and ignore the other. Conversely, when forced to measure themselves in the metric system only, they think in terms of the metric units.

Here are a few suggestions for activities which should help your pupils to "think metric." Ask them to estimate how many centimetres long their longest finger, hand span, height, pace, etc. is. Measure. Compare the estimate with the measured length. You might give your pupils exercises in the following form -

I think this <u>(object)</u> is ________ centimetres long.

The <u>(object)</u> is ________ centimetres long.

For measurement of mass (weight), ask your pupils to hold metric weights in their hand. The 200 g, 500 g, and one kilogram (kg) masses are helpful. Then ask your pupils to estimate and then find the mass of a variety of objects.

In measuring capacity, pupils should study a litre (1 000 ml) to get some idea of its capacity. Using water and various containers, have the pupils estimate and then measure the capacity of the containers.

The estimation process is important because it forces children to think about the different units and the number of units involved. Estimating measurements is one of the best processes for getting people to the point where they can, in fact, think in metric terms.

The most important principle in teaching the metric system to children - and this is supported by the experiments reported here - is to teach it independently of any other system of measurement.

Metric Proverbs

This article is a reprint from *The Science Teacher*, September, 1974. Permission was granted by the editor, Mary E. Hawkins

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Birmingham Board of Education
Birmingham, Alabama

Since the metric system is upon us, we need to begin using the metric vocabulary. Following is a "fun" way to become familiar with metric terms and to estimate equivalents. Each saying has two blanks--one for the old familiar term and another for an appropriate metric term. The metric term need not be exact, as this is more for practice in using the metric words than for exact equivalents. However, the exact conversion may be worked out if desired.

1. There was a crooked man and he walked a crooked ______ (______).
2. Peter Piper picked a ______ (______) of pickled peppers.
3. Give them an ______ (______) and they'll take a ______ (______).
4. Oh, Thumbelina, what's the difference if you're very small? When your heart is full of love you're ______ (______) tall.
5. A miss is as good as a ______ (______).
6. An ______ (______) of prevention is worth an ______ (______) of cure.
7. I wouldn't touch a skunk with a 3 ______ (______) pole.
8. It's ______ (______) in the shade.
9. He's all wool and a ______ (______) wide.
10. The Texan pulled a rabbit out of a ______ (______) hat.

11. My favorite dessert is _____ (_____) cake.

12. Don't hide your light under a _____ (_____) basket.

13. He fell for it like a _____ (_____) of bricks.

14. This is a _____ (_____) stone (post) in my life.

15. I love you a _____ (_____) and a _____ (_____).

16. Penny wise and _____ (_____) foolish.

17. _____ (_____) of diamonds.

18. _____ (_____) under the sea.

19. Ten _____ (_____) of gas.

20. A _____ (_____) of flesh.

21. _____ (_____) worm.

22. Hundred _____ (_____) dash.

23. Two _____ (_____) truck.

24. A _____ (_____) a minute.

You Can't See The Wood. . .

This article is a reprint from *Mathematics Teaching*, No.68. Permission was granted by the editor, David S. Fielker

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Maria Grey College
London, England

SCENE: A wood shop, not a hundred miles from Greenford.

DATE: Summer 1970, before decimalisation of money, but after the demise of the half-crown.

CUSTOMER: I should like a piece of that moulding please, 1 inch wide and 6 feet long.

SHOPKEEPER: We are just going metric and all our lengths have been metricated.

C: Well, I do need the moulding 1 inch wide. I'll take a piece 2½ cm wide and 2 metres long. Perhaps you would kindly saw it into two pieces 1 metre each so that it will fit more easily into my car?

S: Actually only the lengths have been metricated. We can certainly do you a bit 1 inch wide. How long did you say?

C: 2 metres altogether, in two halves.

S: We don't actually sell it by the metre. The nearest we can do is 0.9 of a metre.

C (Astonished): Well two bits, 0.9 of a metre each, will be fine, but why do you sell it in 0.9's of a metre and not whole metres?

S: It's all based on units. One unit is 30 cm, that's roughly equivalent to a foot, so 0.9 of a metre is 3 units.

C: I see. Well, give me two bits, 1 inch wide and 0.9 metre long please.

Shopkeeper goes to back of shop and presently returns with wood which appears to suit customer's requirements.

C: That looks fine. How much will that be please?

S (Inscrutable): Let me see. That'll be half-a-crown a foot ...

Customer turns pale, pays up and hurries out.

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