A STUDY OF THE METRIC SKILLS OF GRADE SEVEN STUDENTS IN A SELECTION OF NEWFOUNDLAND SCHOOLS

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By

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Abstract

This study was designed to investigate the overall metric achievement of grade seven students in a selection of Newfoundland schools. In an attempt to identify various factors which may affect student achievement in metric, the study also examined the relationship of student metric achievement with sex of student, mathematical achievement, exposure to metric instruction, size of school, teacher's mathematical and science qualifications, teacher's metric inservice training, years of teaching experience, as well as exposure of teacher to the metric system during preservice training.

Data for the study were gathered from eighteen schools randomly selected from the total population of schools on the Avalon Peninsula. The subjects consisted of 380 grade seven students and 29 mathematics teachers who volunteered to participate in the study by completing a short questionnaire.

Williams' Test of Metric Skills (WTMS), which was identified as the most suitable evaluation instrument, was administered to the sample. Using correlation coefficients and stepwise multiple regression, analysis of the data collected led to the following conclusions:

1. Grade seven students are not proficient in their use of units and symbols, estimation skills, measurement skills, and conversion skills as measured by WTMS.

2. Grade seven students are not proficient in their understanding of length, mass, volume, and temperature as measured by WTMS.

Statistically significant differences were found in student metric achievement when students were grouped by mathematical achievement, size of school, completion of the metric chapter, and teacher's science qualifications.

Statistically significant differences were not found in student metric achievement when students were grouped by sex, their teacher's mathematical qualifications, the amount of inservice metric training received by teacher, the number of years of teaching experience of the teacher, nor the exposure of the teacher to the metric system during preservice training.

Table of Contents

List of Tables

CHAPTER I

BACKGROUND OF THE STUDY

The International System of Units (SI), commonly referred to as the metric system, has been in existence in European communities since 1795. This system of measurement, commissioned after the French Revolution, has been surrounded by much controversy from the time of its inception. The conversion of Canadians to an understanding and common usage of the metric system has progressed slowly. However, the conversion will continue, for the system has distinct advantages. Shrigley's (1982: 311) study of mathematics educators depicts these advantages:

> ... math educators support metric measurement because: (1) it is consistent with our monetary system; (2) the conversion of units is easier into metric than English; (3) it is easier to teach and easier to learn than English measurement; there is less need of common fractions; (4) most nations use metric measurement; scientists have used it for decades; (5) American industry has begun to use it; (6) metric measurement will facilitate world trade and communication; and (7) American children will need it, as adults; educational agencies are mandating it.

Metric measurements are simple and logical. The traditional system has many units for length (inch, foot, yard, mile) whereas, there is only one metric unit of length, namely, the metre. Furthermore, there is no logical relationship among the traditional units, whereas, larger and smaller units within SI are established by a logical system of prefixes based on tens. Because the metric system is a decimal system, it is easier to compute and convert measurements in metric than it is in the traditional system. Conversion simply involves moving the decimal point either to the right or left, that is, multiplying or dividing by multiples or submultiples of ten. This also implies that mixed units can be readily computed. For example, kilometres, metres, and millimetres can be easily added together. This is not so for inches, feet, yards, and miles. Also, within the metric system there is a direct relationship between units of length, capacity, and mass. For example, a one cubic centimetre container has a capacity of one millilitre and the mass of water at 4° C held by this container is one gram. Another plus for the metric system over the traditional system is that it does not rely heavily on fractions which young children often have problems understanding and computing.

Besides being a simpler and more uniform system of measurement, the conversion to SI also has major economic advantages, especially in the area of production and international trade, because all major countries of the world, with the exception of the United States, use SI as their measurement system.

The major drawback of SI in Canadian society is that the general population view it as an unfamiliar system of measurement. As with any innovative idea, it requires time for people to adjust to and become familiar with the new measurement system.

It has been recognized that education has a primary role to play in the metrication process. Hovey and Hovey (1983: 120) allude to this in the following statement: "Much of the responsibility, and many of the problems will fall to the education system, particularly to teachers." If future generations are to use SI exclusively, it is necessary to educate the generation now in school in SI. Efforts in this direction have been taken and metric units have been introduced into the curriculum. For the past eight years, students have been exposed exclusively to the metric system.

As metric education proceeds, there develops a need to evaluate the relative effectiveness of the various metric programs and materials used in the classroom. Metric conversion of the elementary curriculum is not simply a matter of substituting one set of measurement units for another. Hanson (1981: 585) stated that:

> metrication like other innovations is a complex phenomena [sic]. The challenge for mathematics curriculum workers in the next few years involves more than the integration of metrics in the measurement strand of the mathematics curriculum. ...metric conversion has several implications for the mathematics curriculum beyond the unit on measurement.

Students must be taught to "think metric" and research indicates that the best way to accomplish this is through a "hands-on" approach. The Metric Implementation Committee of the National Council of Teachers of Mathematics (1974: 366) emphasized the importance of teaching metric through an activities approach.

> Too often the study of measurement has consisted only of written exercises on worksheets or pages from textbooks, with major emphasis on conversions between units and on operations with so-called "denominate numbers". The lack of attention to activities that encourage thinking and estimating in a measurement system has meant that measurement has been viewed as dry and dull by pupils and that our instruction is not adequate for the students' real needs.

After eight years of schooling in SI, many grade seven students still do not "think metric". Children tend to convert from the metric system to the imperial system, especially in the areas of mass and capacity. As Hanson (1981: 586) points out:

> It is one thing to recognize the ramifications that metric conversion has for changing the elementary mathematics curriculum; it is another to determine whether such changes are being made.

The Purpose of the Study

The major purpose of this study was to examine the overall metric achievement of junior high school students in a selection of Newfoundland schools. More specifically, the present study investigated among other things: (a) the degree to which grade seven students were proficient in their use of units and symbols, estimation, measurement, and conversion skills as measured by Williams' Test of Metric Skills, (b) the degree to which grade seven students were proficient in their understanding of length, volume, mass, and temperature as measured by Williams' Test of Metric Skills, (c) the relationship between level of metric achievement and sex of students, student math achievement scores, exposure to metric instruction, and size of school, and (d) the relationship between level of student metric achievement and their respective teacher's mathematical qualifications, metric inservice training, years of teaching experience, and exposure to the metric system during preservice teacher education.

The study attempted to answer the following questions concerning metric education:

1. How proficient are grade seven students in their use of units and symbols, estimation, measurement, and conversion skills as measured by Williams' Test of Metric Skills (WTMS)?

2. How proficient are grade seven students in their understanding of length, mass, volume, and temperature as measured by WTMS?

3. Is there a significant difference in metric achievement between boys and girls in the various subsections and content areas of WTMS?

4. Is there a correlation between student mathematical achievement as measured by the Canadian Test of Basic Skills and student metric achievement?

5. Is there a relationship between student metric achievement and completion of the metric chapter in Math Is I, the mathematics textbook used in grade seven?

6. Is there a relationship between size of school and student metric achievement as measured by WTMS?

7. Is there a relationship between teachers' mathematical and science qualifications and their respective students' metric achievement?

8. Is there a relationship between the amount of inservice metric training received by teachers and their respective students' metric achievement?

9. Is there a relationship between students' metric achievement and number of years of teaching experience of their teachers?

10. Is there a relationship between students' metric achievement and the exposure of their teacher to the metric system during their preservice training?

Rationale for the Study

To be an effective educational leader, a school administrator is required to assume a number of specific roles. He must be an effective business manager, an influential leader of people, a knowledgeable curriculum developer, as well as an agent of organizational change and movement. Although the duties and responsibilities of administrators encompass a number of roles, one of their main areas of focus should be the improvement and supervision of the instructional program. Since the curriculum is at the heart of the school system, administrators must display leadership in developing and maintaining effective programs of instruction which enhance student learning. Administrators must be aware of the different approaches to the curriculum and keep abreast of new developments and their success or failure within the schools.

This task of instructional improvement can best be achieved by providing strong curriculum leadership. Administrators can demonstrate curriculum leadership by establishing achievement as a school priority and by participating actively in curriculum development. Active participation on the part of administrators may involve selection and review of instructional materials, planning program development and curriculum modifications, identifying learning objectives, or reviewing and exploring instructional strategies for more effective teaching.

At the elementary school level, curriculum modifications are quite frequent. One of the many recent curriculum changes has been in the area of measurement, where imperial measures have been replaced by metric ones. The basic elements of the metric system are well entrenched in the curriculum. However, administrators and teachers must assume the responsibility of providing meaningful learning experiences to ensure that the quality of instruction in this area is enhanced.

This study will provide an evaluation of the current status of metric achievement among a sample of students. That assessment will provide the basis for curriculum and instructional changes and improvements in the future.

Significance of the Study

In 1970, the White Paper on Metrication was presented to Parliament outlining reasons for going metric and recommending procedures for doing so. As a result, the Metric Commission was established and a plan to convert to SI was established. The actual implementation of metric in Canada began in 1975.

In the fall of the same year, the Ontario Ministry of Education issued a policy statement on metrication (1975: 36), proposing conversion to the metric system in elementary and secondary schools in the Province. One section of the statement reads as follows:

> It is the policy of the Ontario Ministry of Education that: 1) the metric system become the principal system of measures...; 2) metric conversion be implemented in the schools... by June 1978; 3) metrication be applicable to all areas of the curriculum...; 4) the units and symbols... conform to those of the international System of Units...

Although no official policy was set forth by the Government of Newfoundland and Labrador, its basic objectives for metric implementation were quite similar to those of Ontario. If such a policy is to be implemented into the curriculum of elementary and secondary schools, it is essential that administrators and teachers be familiar with common metric units of measure. Yet, this has not always been found to be the case.

In the spring of 1982, Richmond conducted a study to determine the metric achievement of sixth grade students and the attitude of their teachers toward metric instruction. His findings indicated that teachers felt poorly trained to teach metric although they generally had a positive attitude toward the topic. Richmond's study also indicated that only a little more than half of the grade six students were able to apply metric to daily life situations, and less than half were competent in simple mathematical applications dealing with metric prefixes.

In a follow-up article written by Clark and Richmond (1983:600) the authors noted that:

> ... Less than half of the teachers ... reported participating in any kind of inservice metrics program, nor had they read any materials about the teaching of metrics. Three-fourths of the teachers stated their preservice education did not prepare them to teach metrics ... we are not making as much progress in educating children and teachers in metrics as was hoped by those who paved the way ...

Although the above comments are directed to educators in the United States, the situation in Canada is probably very similar.

In Newfoundland, as in the other provinces of Canada, money was channeled into educational agencies for metric development and there was a high expectation that metric was about to come "alive" in the classroom.

Statement Two of the Ontario Metrication Policy (1975: 36), previously cited, indicated that by 1978 students should be "predominantly metric"; that is, students should be knowledgeable about and use the common metric units. Thus, if a student were asked his mass he should not answer in pounds but rather in kilograms.

An examination of related literature has indicated that very little research has been undertaken in this Province in the area of metrication. Two early studies were conducted. In 1975, Williams examined the implications of and a plan for implementation of the metric system into the Newfoundland school system, while in 1976, Hackett conducted a study to determine the effectiveness of a teaching unit on length in the metric system.

Children who were in kindergarten in 1977 and are presently in grade seven have now completed eight years of instruction in SI. It seems appropriate to investigate how successful we have been in teaching metric measurement to students. Students should be continually adding to their knowledge of metric as they progress through the grades. The present curriculum should be ensuring a growth in metric knowledge. This is essential if future generations are expected to use this system exclusively.

Delimitations of the Study

1. This study focused on the overall metric achievement of grade seven students only. It dealt with what students understood and had retained about the metric system either from classroom teaching or personal experiences. This study did not involve any special instructional treatment.

2. This study was delimited to schools located on the Avalon Peninsula. This was done so that the researcher could administer "Williams' Test of Metric Skills". It was hoped that this would erase any teacher bias that may have resulted if individual classroom teachers administered the test.

3. This study was delimited to specific topics within the metric system, namely, length, volume, mass, and temperature. The topics of area, surface area, capacity, and the relationship between length, capacity, and mass were not investigated in detail, although some items within Williams' Test of Metric Skills did explore these topics.

4. The aspect of this study that examined the relationship between student metric achievement and mathematical achievement was limited to students who attended schools which were under the Avalon Consolidated School Board for St. John's. These were the only grade seven students who had completed the Canadian Test of Basic Skills. This proportion of the sample was further restricted, for only the scores of students whose parents consented to the release of their child's mathematics achievement score could be used.

Limitations of the Study

The attainment of knowledge in the metric system, as in other subject areas, is affected by a number of factors, each of which in turn has a limiting effect on this study. The school setting, the financial resources available, the administrative structure, and metric instruction as a part of the entire school program affect achievement in the classroom.

Although the relationship between metric achievement and the factors of sex, professional preparation of teachers, and size of school were investigated, no attempt was made to analyse the results for the various intellectual levels of the students involved.

The study did not include the investigation of such factors as teachers' experience in teaching metric, teacher knowledge of the metric system, parental attitude toward metric, nor the use of metric in the home. Undoubtedly, these are major factors in metric achievement which serve as limiting factors for this study.

Explanation of Terms

1. Conversion is the act of changing from one unit in a given system of weights and measures to another unit in the same system.

2. Metrication is the act or process of converting from an existent system of units into the metric system.

3. Metric achievement refers to the measure of one's general knowledge and skill in using the metric system.

4. Metric System is a decimal system based on the metre as a standard unit of measurement. It is also known as SI.

5. Proficiency for each subsection of WTMS was determined by a panel of ten grade seven teachers who indicated the approximate percentage of students who should answer correctly each item in the test. The proficiency level was obtained by averaging the individual teacher percentages.

6. SI (Systeme International d' Units) is the International System of Units. It is a decimal system of

weights and measures commonly referred to as the metric system.

7. Size of School: the indicator used for size of school was the total number of students enrolled in grade seven in each school.

8. Traditional system is a term used to refer to the system of weights and measures previously used in Canada. It is also known as the British Imperial System or Imperial System.

9. WTMS refers to Williams' Test of Metric Skills which was devised by Dr. Richard Lee Williams in his dissertation entitled "A Comparative Study of Metric Skills of Intermediate Students in Calgary, Alberta, and Spokane, Washington".

Summary

Students in Newfoundland schools have been exposed exclusively to the metric system of weights and measures since 1978. This study examines the overall metric achievement of junior high school students in a selection of Newfoundland schools in an attempt to determine how successful we have been in training young students to think metric. More specifically, this study investigates: (a) the degree to which grade seven students are proficient in their use of units and symbols, estimation, measurement, and conversion skills as measured by

Williams' Test of Metric Skills; (b) the degree to which grade seven students are proficient in their understanding of length, volume, mass, and temperature as measured by Williams' Test of Metric Skills; (c) the relationship between level of metric achievement and sex of students, student math achievement scores, exposure to metric instruction and size of school; and (d) the relationship between level of student metric achievement and their respective teacher's mathematical and science qualifications, metric inservice training, years of teaching experience, and exposure of teachers to the metric system during their preservice teacher education.

The following chapter, Chapter 2, presents a review of the literature and related studies. Chapter 3 sets forth the research methodology employed in this study. This is followed by a report of the statistical treatment of the data in Chapter 4. Chapter 5 contains the conclusions, discussion of the findings, and recommendations.

CHAPTER 2

REVIEW OF THE LITERATURE

A comprehensive search of the literature concerning metric education revealed that the bulk of research, reports, and articles written on the metric system was printed between 1972 and 1980. Although a fair number of articles pertaining to the metric system have been written in Canada, actual empirical research on the topic has been quite limited. In the United States, on the other hand, more in-depth studies of this topic have been undertaken. Both American and Canadian studies, therefore, have been reported in this review.

While the present study examines the overall metric achievement of intermediate students, studies related to other aspects of metric will be reviewed in this chapter. After a brief statement of the historical development of the system, individual sections will focus on the following: Teaching the Metric System to Elementary Students; Teaching the Metric System to Preservice and Inservice Teachers; Teacher Attitude Toward the Metric System; Student Achievement in Mathematics and Selected Variables; and Metric Achievement and Selected Variables. The chapter will conclude with a brief summary of major findings directly related to the present study.

The Historical Background of the Metric System

In the late eighteenth century, after the French Revolution, the National Assembly of France appointed a measurement committee whose mandate was to devise a single, logical, universal, yet scientific system of measurement. As noted by Leffin (1975: 4), the Academy's study was based on three basic principles:

1. The standard unit for length should be derived from some universally accessible, invariant physical standard.
2. The basic unit for volume and mass should be derived from the basic unit for length, so that all basic units are directly related to each other.
3. The specified units for each measure should be based on decimal ratios.

The French Academy of Science decided that their standard for measurement would be accurate for all time and agreed that the basic unit of length, the metre, would be based on one ten-millionth of the distance from the North Pole to the equator. Using multiples and sub-multiples of ten, the Academy expanded upon the newly defined metre which was then used to derive other units of the metric system.

In 1795, the French Government officially adopted the metric system and passed laws that made the system compulsory. However, it was not until the mid-nineteenth century that the new system was in general use in France and other European countries.

The need for an improved international standard of measurement led to the signing of the Treaty of the Metre in 1875. This, in turn, saw the establishment of an International Bureau of Weights and Measures whose main task was to extend and refine the metric system which would eventually be recognized as the international system of measurement.

In 1960, the Eleventh General Conference on Weights and Measures adopted the metric system as the International System of Units (Systeme International d'Unites), commonly referred to as SI. This action acknowledged the wide acceptance of the metric system and encouraged unanimous acceptance of the system by all industrial nations of the world.

In Canada, the use of the metric system of weights and measures was officially permitted in 1871 when the Parliament of Canada passed an act which rendered "permissive the use of the metric or of the decimal system of weights and measures". Two years later, in 1873, the use of the metric system for commerce and trade was legalized by the Weights and Measures Act.

The decision for Canada to abandon the imperial system and convert to the metric system in all aspects of Canadian measurement was not an easy one. Although Canada had close cultural and historical ties with Britain, a country which had adopted the metric system in 1965, its economy was more dependent on the United States, a country which did not opt for metric conversion. Canada had to decide whether to wait for the United States to convert to metric or to lead the way in the metric conversion of North America.

In 1970, the Canadian Parliament decided unanimously that Canada should adopt the metric system of measurement. In January, the White Paper on Metric Conversion in Canada (1970:5) was presented to Parliament outlining general policy concerning metric conversion. It stated that:

> The Government believes that adoption of the metric system of measurement is ultimately inevitable -- and desirable -- for Canada. It would view with concern North America remaining as an inch-pound island in an otherwise metric world -- a position which would be in conflict with Canadian industrial and trade interests and commercial policy objectives.

In order to initiate the process of metric conversion in Canada, the document (p. 22) proposed that:

> (i) A full-time Preparatory Commission will be appointed to advise upon and coordinate overall planning of the conversion process.
>
> (ii) The projected Standards Council of Canada will be given responsibility to develop and coordinate planning and preparation for conversion in industry, including change to metric standards.

In June of 1971, an Order-in-Council established a Metric Commission that eventually proposed a plan for metric conversion. The plan consisted of four phases: (1) Investigation (1974); (2) Planning (1974-75); (3) Scheduling (1975-76); and (4) Implementation (1975-80).

Canada has now progressed through all four phases of the metric conversion plan. How successful we have been in converting the general population to SI has yet to be determined.

Teaching the Metric System To Elementary Students

Since the late 1960's, many studies have been conducted to determine the most effective way of teaching the metric system of measurement. Studies by McFee (1968), Hervey (1980), and Marburger (1976) addressed the question of how best to teach the metric system to students who had prior knowledge of the imperial system. These investigators researched the effects of total immersion in the metric system as compared with relating the metric system to the imperial system of measurement. Although the three independent studies differed in research design, all three concluded that both methods were equally effective in improving the metric ability of intermediate students whose previous knowledge of measurement was that of the imperial system.

Today, in Canada, the method of teaching metric measures by relating them to imperial measures is no longer relevant. The Canadian school environment as it relates to measurement is such that knowledge of the imperial system is no longer taught. Thus, in Canada, total immersion in the metric system is considered the only practical method of teaching the measurement system to today's children.

Over the past decade, researchers have been turning their attention to the most appropriate immersion method for teaching metric so that students will have a better understanding of the measurement system. Rees (1975), working with a group of grade four students, investigated the effects of four different teaching strategies for presenting the metric system. Her four modalities consisted of: (1) a visual presentation; (2) an auditory presentation; (3) a kinesthetic-tactile presentation; and (4) VAK-T (a combination of activities selected from the first three presentations). Rees found that metric results following the auditory presentation were significantly lower than those for visual, kinesthetic-tactile, and VAK-T. These latter three methods resulted in equivalent results.

Smith (1980) studied the effects of teaching linear measurement skills to grade one and two students through manipulative, graphic, and abstract instruction. Manipulative instruction involved the use of concrete materials; graphic instruction made use of pictures, filmstrips, and charts; while abstract instruction provided verbal explanation of skills. The researcher concluded that manipulative and abstract methods of instruction produced similar results which were significantly better than graphic instruction.

Hildreth (1981) studied the effects of estimation strategies on the metric achievement of intermediate students. Half of the sample population were taught to use appropriate estimation strategies, while the remaining students were taught to use a guess-and-check approach. Hildreth discovered that students who were taught appropriate estimation strategies exhibited a greater degree of strategy use than the subjects taught by the guess-and-check method.

In an attempt to identify the appropriate grade levels at which various aspects of the metric system should be taught, Bergmann (1973) developed a teaching unit and proceeded to teach the various metric skills to students in grades three through six. Analysis of his test results suggested the following grade placement of metric skills:

1. Grade three - meaning of length, volume, and mass, the organization of the metric system by multiples of ten, as well as simple conversion skills.

2. Grade four - concepts of area and cubic volume.

3. Grade five - conversions between metric units and decimals.

4. Grade six - all metric units and conversion skills.

The above findings seem to support the assertion made by curriculum developers that children learn and understand concepts much better when they are exposed to concrete, manipulative methods of instruction.

Teaching the Metric System To Preservice and Inservice Teachers

Since the responsibility for educating children in the area of metric knowledge lies heavily on educators, it is essential that teachers think metric. For this to become a reality, teachers must be thoroughly familiar with the metric system of measurement and be prepared to teach it in such a manner that they encourage their students, also, to think metric.

A number of studies have examined preservice and inservice education in the metric system. Tate (1977) concluded that, with respect to general metric knowledge, lecture/demonstration, lecture/laboratory, and mediated instructional strategies were all equally effective for teaching the metric system to preservice elementary teachers. Wright (1979) compared the metric skills of four groups of elementary teachers who were taught metric either by video-lecture, video-no lecture, no video-lecture, or no video-no lecture method. Wright's findings indicated that each teaching method produced a significant gain in knowledge about the metric system. However, the results of a retest ten months later indicated that the video-lecture group was the only group that did not have a significant loss of metric knowledge.

Attivo (1979) working with prospective teachers investigated how various metric estimation skill instruction affected a teacher's ability to estimate metric units. The three instructional strategies employed were (1) a personal reference unit, (2) a cut or drawn unit of reference which was not visible during estimation and (3) estimation without using an explicit strategy. Attivo (1979) found that a personal reference unit was significantly more effective in teaching the metric system to prospective teachers than was either a cut or drawn unit of reference or no explicit reference.

In an attempt to determine the present knowledge of preservice and inservice teachers as well as their gain in knowledge after metric instruction, Esham (1975) developed a self-instructional metric booklet. The pretest scores revealed that the knowledge level of preservice and inservice teachers was below those of general science teachers reported in other studies. Posttest scores, on the other hand, indicated that there was no significant difference in level of knowledge between the subjects of this study and general science teachers of other studies.

Rose (1976) evaluated the level of metric knowledge of preservice teachers taught by the traditional method and a similar group taught by a self-instructional method. He found no significant difference in teacher metric achievement under the two methods. He did find, however, that teachers with prior metric training performed better than teachers receiving metric instruction for the first time.

McGill (1974) conducted a comprehensive study in an attempt to identify the needs of teachers involved in teaching the metric system of measurement. His conclusions and recommendations were as follows:

1. Teachers are in need of metric inservice programs.
2. A study which identifies the factors which affect a teacher's metric knowledge is needed.
3. A study which examines teachers in parochial schools should be conducted.
4. Studies into the elementary teacher's understanding of measurement and the decimal system should be conducted.

Although some methods of instruction are more effective than others, these studies indicate that both preservice and inservice teachers do experience a gain in metric knowledge after a given period of instruction.

Teacher Attitude Toward the Metric System

The successful teaching of the metric system or any other content area often hinges on the attitude of teachers toward the topic. If teachers have acquired a positive attitude toward metric, then it is highly probable that this same attitude will be reflected in their students. Devies (1977) pointed to this association when his study concluded that there was a positive relationship between student achievement and retention on a metric unit and student perception of teacher attitude toward the metric system.

Scott (1977) concluded that administrators, as well as elementary and secondary teachers, exhibited a favorable attitude toward the metric system, were in favor of implementing the measurement system into the school curriculum, and possessed a general knowledge of the metric system. He also found that subjects with a prior knowledge of the metric system displayed a more positive attitude than those subjects exposed to the system for the first time. McGill (1974) also noted that a teacher's level of metric knowledge was directly related to the teacher's attitude toward the system. McGill determined that teacher-related variables such as age, sex, level of education, grade taught, and years of teaching experience had little if any influence on a teacher's attitude toward the metric system.

Hess and Shrigley (1981) reported the effect of three modes of teaching the metric system to preservice elementary teachers on teacher attitude toward the metric system. The researchers acknowledged that gaming, modular, and expository approaches to teaching the metric system produced similar results in metric attitude. Tate (1977) pointed out that regardless of instructional strategies used to teach the metric system, preservice teachers who were moderately favorable toward the system displayed no significant attitude change toward metric after the instructional period.

Esham (1975) observed that exposure of preservice and inservice teachers to measuring activities in the metric system strengthened their attitude toward the metric system and its use.

In conclusion, research tends to indicate that the more knowledgeable a teacher is of the metric system the more positive his/her attitude toward the system will be. This, in turn, leads to a more positive attitude of his/her students toward the topic. If students possess a favorable attitude, then it is more likely that they will readily understand, learn, and apply the metric system in their daily lives.

Student Achievement in Mathematics and Selected Variables

This review of the related literature in the areas of student achievement and sex of students, size of school, teacher experience, and teacher courses in mathematics and science will focus primarily on mathematics achievement and not metric achievement, for metric research in these areas has been extremely limited.

Sex of Students

Randhawa and Hunt (1984) analyzed the results on the Canadian Test of Basic Skills for a group of grade four, seven, and ten students in Western Canada. Data analysis examined sex differences as well as urban/rural differences.

Amongst the grade seven sample, the researchers found that while females performed significantly better than males on the Reading, Spelling, Capitalization, Punctuation, and Usage subtests, males outperformed females on the mathematics problems and concepts subtests. Subskills analysis of both mathematics problems and mathematics concepts indicated that males were superior to females in four out of the six subskills. Similar findings were reported for grade ten students, while grade four students displayed no significant gender difference in mathematics problems sections of the test.

Randhawa and Hunt thus concluded that there appears to be a significant male superiority in mathematics at the grade seven and grade ten level and that the differences appear to be developmental.

Marshall (1982), while studying sex differences in solving story problems among sixth grade students, found that although there was a general weakness in students' ability to solve story problems, boys did perform better than girls. However, girls outperformed boys on computation skills.

Lloyd (1983) examined sex differences in six math topics for a sample of students from grades three to six. Analysis of the data revealed that there was a significant gender effect in three of the six context areas. These were Numeration and Number System; Decimals, Currency and Percent; and Geometry and Measurement. For Equations and Inequalities; Whole Numbers; and Fractions the gender difference was not significant. For the three areas where statistical difference was displayed, males performed better.

The difference in males' and females' achievement in mathematics is a topic that has received much attention over the years. Research findings into the relationship between sex and mathematics performance, have not always been consistent. However, research does seem to indicate that there is a change in mathematics performance with age, and that the change tends to favour the male section of the population. Whether these differences are related to gender or whether other variables account for the differences between the sexes has yet to be determined.

Size of School

It has long been recognized that larger schools which offer better facilities, more specialized instruction, and more qualified teachers graduate students whose achievement is superior to that of students graduating from smaller schools where the work load of the teacher often prevents an in-depth study of various subjects. This weakness of small schools is addressed by Warren (1967) and Kitchen (1967) who independently studied factors which affected the educational output of Newfoundland children.

Kimble (1976) investigated the degree to which various factors affected student achievement. The size of the school the students attended was one of the variables studied. At the senior level in high school, Kimble found that no significant difference existed between achievement based on the size of the school. However, at the sophomore level, students from larger high schools performed better than students from smaller schools.

Teacher Experience

In an effort to analyze the effects of teacher qualifications on grade ten mathematics achievement in Alberta, Lindstedt (1960) found that teacher experience significantly affected student results. More specifically, he found that teachers with ten or more years of experience produced better student results than teachers with less experience and when years of training were combined with years of experience, teacher competence was noticeably increased.

Teacher Courses in Mathematics and Science

The preservice education of a teacher often influences the educational output of his/her students. In an effort to analyze the effects of teacher qualifications on grade nine mathematics achievement in Alberta, Lindstedt (1960) reported that teachers with a stronger mathematics-science background had pupils whose final mathematics results were superior to those pupils whose teachers were not as widely versed in mathematics and science.

From the above, it may be concluded that the present school system favors males in larger school environments taught by more experienced teachers who have strong mathematics-science backgrounds.

Metric Achievement and Selected Variables

The variables relating to metric achievement reviewed in this section are: sex of students; teacher courses in mathematics and science; exposure to the metric system; and mathematical achievement.

Sex of Students

One of the first comprehensive studies of metric education conducted in Canada was that by Williams (1978). Williams conducted a comparative study of the metric skills of intermediate students in Calgary, Alberta, and Spokane, Washington. The major purpose of Williams' study was to determine if differing federal policies concerning the metrication process in Canada and the United States affected the metric achievement of intermediate students. Williams' study consisted of two major functions. The first was to establish a test of metric achievement that was suitable for fifth and sixth grade students. The second was to use this evaluation instrument to conduct the comparative study. During the course of this study Williams investigated the effect of sex on overall metric achievement. His findings indicated that there was no significant difference between the metric achievement of boys and girls.

Teacher Courses in Mathematics and Science

Esham (1975) attempted to determine the present knowledge of preservice and inservice teachers as well as their gain in knowledge after metric instruction. After examining preservice and inservice teacher results on the McFee Metric Test (MMT), Esham realized that the more mathematics and science courses a teacher had completed, the better his/her results on the MMT. Esham concluded that the best predictors of metric achievement in descending order were the number of semester hours of mathematics and the number of semester hours of science completed by each teacher.

Exposure to the Metric System

Williams (1978) also attempted to determine the effects of inservice training on teacher metric achievement. He found that teachers with more inservice training in metric performed significantly better on the Williams' Test of Metric Skills than teachers with less inservice training.

Further evidence which supports previous exposure to the metric system as a positive indicator of metric achievement can be found in a study conducted by Rose

(1976). Rose found that students who had prior knowledge of the metric system performed significantly better on the intuitive section of the MMT than students receiving instruction for the first time. Scott (1977) found that prior knowledge of the metric system positively affected the attitudes of his subjects toward the topic.

It can be concluded that the greater the exposure to the metric system, the better is one's knowledge of the system and the more positive is one's attitude toward the topic.

Mathematical Achievement

McFee (1967) and Slobojan (1974) compared two strategies for teaching metric to elementary school students. Although these independent studies varied in research design, both suggested that the best predictor of metric achievement was mathematical ability. Houser (1975), studying the metric achievement of preservice elementary teachers, found results supporting those of Slobojan and McFee.

Hess and Shrigley (1981), on the other hand, did not support these findings. Their study of preservice elementary teachers indicated that there was no significant difference in metric knowledge between low and high mathematics achievers.

On balance, it might be concluded from the above discussion that the best predictor of metric achievement will be the general mathematical ability of the student.

Summary

It is clear from the review of the literature that over the past decade much emphasis has been placed upon various methods of teaching the metric system, as well as on attitudes toward this system of measurement. Very few studies have attempted to investigate the results of converting from the imperial measurement system to the metric system.

This study attempts to determine how successful students have been in adjusting to the metric system of measurement. Research indicates that in the present school system males in larger school settings taught by more experienced teachers who have a strong mathematics-science background will perform best in metric.

CHAPTER 3

THE RESEARCH METHODOLOGY

The major purpose of this study was to examine the overall metric achievement of a sample of students in a selection of Newfoundland schools. Before proceeding with the initial study it was necessary to identify and modify a metric achievement test suitable for Newfoundland students. Furthermore, an appropriate grade level had to be chosen so that selected variables would be significant at that particular level.

Selection of a Metric Evaluation Instrument

A problem which confronted the present researcher was the lack of availability of a standardized metric achievement test for students. At the time of this study, there did not exist a standardized metric achievement test in Canada or the United States. However, various researchers had constructed evaluation instruments to collect and analyze data on the topic of metrication.

One of the first to do so was McFee (1968), who investigated the results of teaching the metric system simultaneously with imperial measures and teaching the metric system without reference to imperial measures. To conduct his study, McFee found it necessary to develop an instrument that would measure metric achievement. With seventh grade general science students as his subjects, McFee devised an instrument which consisted of three components: (a) A general Proficiency section, (b) A Manipulative section, and (c) An Intuitive section. Both content validity and reliability were determined for the instrument.

Since 1968 a number of investigators have used McFee's Metric Test, while others such as Pigford (1975), have developed their own instruments to serve differing program objectives. The purpose of Pigford's study was to investigate the effects of teaching measurement and estimation in metric units to preservice elementary teachers, using two different methods. Pigford's evaluation instrument was divided into four general skills: (a) Select-Units, (b) Reading Measurement Instruments, (c) Converting Units, and (d) Estimating Quantities.

Another test of metric achievement was constructed by Richmond (1982). In an attempt to measure the metric achievement of sixth graders, Richmond designed a test which contained the major metric concepts presented in elementary school mathematics textbooks used in the United States in 1982.

The Williams' Test of Metric Achievement was devised by Williams (1978), who undertook a comparative study of the metric skills of grade five and grade six students in

Calgary, Alberta, and Spokane, Washington. Williams divided his instrument into four components: (a) Use of Units and Symbols, (b) Estimation, (c) Measurement, and (d) Conversion Skills. Both content validity and reliability were determined for Williams' Test of Metric Skills.

The present researcher chose Williams' Test of Metric Skills as the most appropriate evaluation instrument. This was done for a number of reasons:

1) Williams' test of metric achievement was devised for intermediate students, with Canadian students as part of the sample, and
2) The present mathematics program taught in Newfoundland schools is <u>Math Is I</u>. In this course, students are exposed to a measurement strand on metric which explores the concepts of length, mass, volume, temperature, conversion, measurement, estimation, as well as the use of units and symbols. These are the components of Williams' Test of Metric Skills.

<u>Williams' Instrument</u>

In developing his test, Williams commenced by establishing a list of performance objectives. These objectives were obtained, using the hierarchy of measurement skills deduced from an analysis of the measuring sequence in an elementary science program, more specifically identified as Science - A Process Approach (SAPA).

After completion of the hierarchy of measuring skills, Williams began the task of coding the hierarchy using metric as the measurement unit. For this he used a three-unit sequence: number, letter, number.

Williams' test items were based on four general skills. These skills consisted of conversion within and between systems, familiarity with metric units and estimation, direct and indirect measurements, as well as the selection of units and use of symbols. Thus the first number designated one of these four general skills. The first letter identified the assigned hierarchal level, or degree of difficulty within the general skill:

A. Identifies the highest expected level of competence

B. The next subordinate level

C. The next lower level

D. The lowest expected level.

The second number identified a specific skill within the general skill.

Using this three unit sequence, Williams coded the hierarchy of metric skills under the headings of:

1. Conversion within and between systems. For example, $1B_3$ - Identify a metric measurement as a given ratio of a stated metric measurement.
2. Familiarity with units and estimation. For example, $2C_1$ - Relate a specified object to any metric or British unit.
3. Direct and indirect measurement. For example, $3A_1$ - Make indirect measurements in the metric system for regular and irregular figures or objects.
4. Selection of units and use of symbols. For example, $4A_1$ - Select the most accurate and/or the most convenient unit for a given measurement task.

Williams compiled a large number of items specifically designed to cover the implied objectives of the hierarchy. The content of the test items dealt with length, volume, mass, and temperature. All test items were multiple choice items and the five choice format was employed.

Using a panel of six experts knowledgeable in both test construction and the metric system, the test items were coded for validation. Only those items that were coded similarly by five of the six experts were used to develop the initial test instrument.

The initial instrument was then pilot tested to further refine it. The students who completed the Williams' test also completed the McFee Metric Test, with a correlation coefficient of 0.70. Williams concluded that "this value is sufficiently high to conclude that the two tests do measure approximately the same criteria."

The pilot test was also correlated with the mathematics achievement scores of the participating students. Upon application of the Spearman-Brown Prophecy Formula, it was found that Williams' instrument has a reliability coefficient of 0.85.

As a result of the pilot study, Williams made minor changes in the wording of some items, and in the format of some of the items in the measurement section of the test. Williams thus finalized his test of metric skills.

Procedure Employed to Modify the Williams' Instrument

Before the present researcher administered Williams' Test of Metric Skills, it was necessary to establish the content validity of the test as it pertained to the students of Newfoundland and the objectives of the curriculum of the school system for the Province. The researcher undertook a three-fold procedure to ensure content validity. First, the Williams' Test of Metric Skills was pilot tested with a sample group of grade seven students. Any test item that was answered incorrectly by

100 percent of the students was changed, as was any item that was answered correctly by the same percentage of students. After completion of the test by the pilot group, the researcher chatted informally with the students about the test to obtain feedback on any particular items or word groupings within the test which may have presented difficulty. Second, Williams' Test was presented to a panel of six persons: a mathematics consultant, a science consultant, two mathematics professors at Memorial University of Newfoundland, and two mathematics teachers. Each member was asked to verify each answer on the test, note any ambiguous items or items that may not pertain to the Newfoundland setting, and to comment on any item within the test that may cause problems for Newfoundland students. Further comments and suggestions were invited. Third, the test was evaluated by a panel of ten grade seven teachers who had taught the measurement strand in Math IS I. Each teacher was asked to indicate whether each item in the test measured simply knowledge or both knowledge and understanding. They were also invited to comment on the suitability of each item for Newfoundland students who had completed grade seven. To help determine proficiency, the panel of teachers was asked to indicate the approximate percentage of students who should answer correctly each item.

Modification of Williams' Instrument

As a result of the information obtained from the pilot study and the professional analysis, the following alterations were made to WTMS:

1. Since fractions are not used in teaching metric measurement, all fractions were deleted and replaced by decimal numerals. (The fractional numerals used were not a correct response in any of the three test items in which they appeared.)

2. One item which was not appropriate for the Newfoundland environment was replaced by a similar item more relevant to the Newfoundland setting. (Part B-Estimation, Number 6.)

3. Since the time of Williams' study, the symbol for litre has changed from a lower case l to an upper case L. Thus the correct response to question four under Part A of WTMS was changed from ml to mL.

4. Conversion Skills, Part D of WTMS, contained only eight items which were solely metric related. The remaining four items investigated the relationship between the imperial system and the metric system. To retain the balance in all four sections of the metric test, four items pertaining solely to the metric system were added. Two of the items added related to mass, while the topics of length and volume each received one item. No item

relating to temperature was included since metric conversion does not apply to temperature.

5. The four items relating to the relationship between the imperial system and the metric system were included under a fifth section entitled "Part E - Relating Imperial and Metric Measures".

Table of Specifications

In order to determine student proficiency in the various areas of metric measurement, a table of specifications was established for WTMS. The modified format of Williams' test consisted of 52 items, four of which are not contained in the table of specifications. These four items related the imperial system to the metric system and since students are not taught the relationship between these two systems, they are not included in determining student proficiency.

WTMS consisted of 48 items, divided equally under: (a) Use of Units and Symbols; (b) Estimation Skills; (c) Measurement Skills; and (d) Conversion Skills. The content criteria covered in the test items were length, volume, mass, and temperature. Table 1 outlines the complete table of specifications for the test used in this study.

Table 1

Table of Specifications for Williams' Test of Metric Skills

Content	Units and Symbols	Estimation Skills	Measurement Skills	Conversion Skills	Totals
Length	6	4	4	3	17
Volume	3	3	4	5	15
Mass	3	2	2	4	11
Temperature	0	3	2	0	5
TOTAL	12	12	12	12	48

<u>Table of Proficiency Levels</u>

The proficiency levels for each subsection and the various content areas of Williams' Test of Metric Skills were determined by a panel of ten grade seven teachers. The teachers on the panel were selected from those who had taught the metric strand in <u>Math Is I</u> in the 1984-85 school year, the first year the new math program which focused in detail on the metric system was implemented in Newfoundland schools. These ten teachers, who represented six different schools, indicated the approximate percentage of students who should answer correctly each item in the test.

The expected mean percentage score for the four subsections of Williams' test was calculated, as was the expected mean score for the content criteria areas of length, volume, mass, and temperature. Table 2 depicts the proficiency levels expected by the grade seven teachers for the various topics covered in Williams' Test of Metric Skills.

Table 2

Proficiency Levels Expected for Williams' Test of Metric Skills

Subsection	Percentage	Content	Percentage
Units/Symbols	90	Length	86
Estimation	78	Volume	75
Measurement	81	Mass	82
Conversion	78	Temperature	84
Mean for WTMS	81.75	Mean for WTMS	81.75

The Selection of a Population

The sample for this study was chosen from the population of grade seven students on the Avalon Peninsula. Grade seven students were chosen for a number of reasons:

1) In the new Math Is I program presently taught in Newfoundland schools, grade seven students are exposed to a measurement strand on metric. This strand explores length, mass, volume, temperature, conversion skills, measurement, estimation, as well as the use of units and symbols. These are the components of Williams' Test of Metric Skills.

2) When students complete grade seven, their understanding of the metric system should be well established as the following grades require an application of metric knowledge.

3) Since the grade seven math program reviews and extends previously-taught metric knowledge in detail, the teacher-related variables toward student metric knowledge would tend to be more significant at this level than any other.

4) Williams' Test of Metric Skills was designed for intermediate students from grades five and six. Thus, the test should be appropriate for a group of grade seven students. In fact, Williams suggests that his test is suitable for use with ages intermediate through adult.

Sample Selection

The sample for this study was chosen from the population of grade seven students on the Avalon Peninsula. The information for selecting the participating schools was obtained from the Directory of Schools: Newfoundland and Labrador, 1984-85.

On the Avalon Peninsula, there were eighty-six schools which housed grade seven students. From this total number of schools, eighteen schools were randomly selected. The indicator used for size of school was the total number of students enrolled in grade seven in each school. This information was obtained from the teacher questionnaire.

For ease and efficiency, the Williams' Test of Metric Skills was administered to all students in each grade seven class within these eighteen schools. Ten individual students from each class were randomly selected. The random selection of students who attended one particular school under the jurisdiction of the Avalon Consolidated School Board for St. John's was limited to those students whose parents had consented to the use of their child's mathematics score as measured by the Canadian Test of Basic Skills (CTBS).

The mathematical results on the CTBS was used to indicate a student's mathematical achievement. The research question pertaining to the relationship between mathematical achievement and metric achievement was restricted to 83 students in the sample. This was because (a) only grade seven students with the Avalon Consolidated School Board for St. John's had been administered the CTBS and (b) parental consent was required for the release of a student's score.

The mathematics teacher of each class surveyed was invited to participate by completing a short questionnaire pertaining to their teacher preservice and inservice training.

The sample consisted of 380 pupils, 198 boys and 182 girls. This information was obtained by having students indicate their sex on the answer sheet. A total of 29 teachers completed the teacher questionnaire with six of these teachers teaching two grade seven class.

Collection of the Data

All data for the study were collected between March 7 and March 14 of 1986. It was felt that the metric strand in the grade seven mathematics program would be completed at this time.

The metric test was administered by the investigator or her research assistant. A routine set of oral instructions was developed for this purpose. Although there was no time limit for student completion of the metric test, most students were finished in less than 25 minutes.

Treatment of the Data

The data obtained from the sample were first analyzed using descriptive statistics. In this analysis, the test was divided into categories according to the four subsections of the test (Units and Symbols, Estimation, Measurement, and Conversion) and the topics of length, volume, mass, and temperature. The statistics that were applied to the subtest scores included range, mean, standard error, and standard deviation.

Student metric achievement as it related to the sex of the children and mathematical achievement scores were analyzed using correlation coefficients. Student metric achievement as it pertained to size of school, completion of the metric chapter, teacher total years of experience, teacher preservice exposure to the metric system, teacher inservice training, and the number of mathematics and science courses completed by respective teachers was analyzed using a stepwise multiple regression.

Summary

The Williams' Test of Metric Skills was selected as the most suitable metric achievement test for this study. After various preliminary analyses, a number of minor modifications were made and the modified instrument was administered to a group of grade seven students on the Avalon Peninsula. Statistical analysis of the data, presented in Chapter 4, either confirmed or disproved the questions posed.

Chapter 4

STATISTICAL ANALYSIS OF THE DATA

The data collected were analyzed using the Statistical Package for the Social Sciences (SPSSX). Both student metric test data and teacher data were submitted for computer analysis. The student metric test data included student results in the four skills and content areas of the Williams' Test of Metric Skills. The four skills areas involved the use of units and symbols, and measurement, estimation, and conversion skills. The four content areas were length, volume, mass, and temperature. The student metric test data also contained information regarding students' sex, the size of school the students attended, whether or not the metric chapter in the mathematics curriculum had been completed, and the mathematical achievement test scores of the students as measured the Canadian Test of Basic Skills.

The teacher data included information regarding years of experience, amount of inservice training, mathematical and science qualifications, and exposure to the metric system during preservice training.

The researcher established critical values of 0.05 for analysis of student metric data results with the factors of sex, and size of school, chapter completed, and mathematical achievement. Student metric data results correlated with teacher variables were also assigned critical values of 0.05.

Research Questions

As previously stated, the researcher sought to answer the following questions concerning metric education:

1. How proficient are grade seven students in their use of units and symbols, estimation, measurement, and conversion skills as measured by Williams' Test of Metric Skills (WTMS)?

2. How proficient are grade seven students in their understanding of length, mass, volume, and temperature as measured by WTMS?

3. Is there a significant difference in metric achievement between boys and girls in the various subsections and content areas of WTMS?

4. Is there a correlation between student mathematical achievement as measured by the Canadian Test of Basic Skills and student metric achievement?

5. Is there a relationship between student metric achievement and completion of the metric chapter in <u>Math Is I</u>?

6. Is there a relationship between size of school and student metric achievement as measured by WTMS?

7. Is there a relationship between teachers' mathematical and science qualifications and their respective students' metric achievement?

8. Is there a relationship between the amount of inservice metric training received by teachers and their respective students' metric achievement?

9. Is there a relationship between students' metric achievement and number of years of teaching experience of their teachers?

10. Is there a relationship between students' metric achievement and the exposure of their teachers to the metric system during their preservice training?

Descriptive Analysis of Data

The descriptive statistics of range, mean, standard error of the mean, and standard deviation for the various sections of WTMS are contained in Table 3. An examination of these statistics reveals considerable variation among grade seven students in their understanding of the various elements of the metric system of measurement.

The four subsections of WTMS, namely, units and symbols, estimation, measurement, and conversion skills each contained twelve possible correct responses. Ranking these subsections in descending order according to mean scores indicates that students performed best in the area of units and symbols followed by measurement, estimation, and finally conversion skills. A mean score of 4.076 out

Table 3

Descriptive Statistics for the Various Sections of WTMS
(N = 380)

Test Variable	Possible	Range	Mean	Standard Error	Standard Deviation
Units/Symbols	12	11	8.384	0.116	2.262
Estimation	12	9	5.289	0.097	1.889
Measurement	12	10	7.400	0.096	1.876
Conversion	12	12	4.076	0.124	2.411
Length	17	14	11.492	0.136	2.644
Volume	15	12	5.634	0.120	2.346
Mass	11	11	5.042	0.108	2.097
Temperature	5	5	2.961	0.054	1.053
Total	48	32	25.166	0.328	6.402

of a possible 12 indicates that grade seven students are lacking in the skill of converting from one metric unit to another. The conversion subsection displayed the greatest variance of the four subsections with a standard deviation of 2.411 and thus a variance of 5.813.

The items in the four content areas of WTMS, namely, length, volume, mass, and temperature were not equally distributed under the four content areas. However, comparison of mean scores with possible scores implies that grade seven students perform best in the content area of length, followed by temperature, mass, and volume. Although students performed best in the content area of length, length was also the area which displayed the greatest variation with a standard deviation of 2.644 and thus a variance of 6.990. This may be due to the fact that the content area of length contained seventeen test items out of a total of 48. Volume, mass, and temperature contained fifteen, eleven, and five test items respectively.

A total mean score of 25 out of a possible 48 indicates that grade seven students are generally lacking in the metric skills of measurement.

Statistical Analysis

The first two research questions will be analyzed on the basis of the students' mean scores in the eight categories of WTMS. The researcher determined the actual proficiency levels for each category by multiplying the ratio of students' mean score in a particular category to the total number of items in that category by 100. In this manner the actual proficiency levels were calculated for all eight categories of WTMS.

As detailed in Chapter 3, the expected proficiency levels were established by a panel of ten grade seven teachers who indicated the approximate percentage of students who should answer correctly each item in WTMS.

The attained proficiency levels of the subjects for each category of the metric test were determined by dividing the actual proficiency levels by the expected proficiency levels.

Question three, which dealt with sex differences, was analyzed using a t-test. Since math achievement scores were available for only a portion of the total sample, student's mathematical achievement, addressed in question four, was analyzed using correlation coefficients.

The remaining questions, questions 5 to 10, relating to completion of the metric chapter, size of school, and teacher variables were analyzed using a stepwise multiple regression.

Student Proficiency in Metric Skills

In this section, data are presented to answer research question 1: How proficient are grade seven students in their use of units and symbols, estimation, measurement, and conversion skills as measured by WTMS?

Table 4 provides a comparison of expected proficiency levels with actual proficiency levels for the four subsections of WTMS. The data reveal that students are well below expected proficiency levels in all four subsections of the metric test. Expected proficiency levels indicated that students should perform best in the area of units and symbols, followed by measurement, estimation, and conversion skills. Although actual proficiency was below expected proficiency, the performance of the students in the various subsections conformed with what was expected by teachers. That is, students performed best in the area of units and symbols followed by measurement, estimation, and conversion skills.

The total expected proficiency level for WTMS was projected by teachers to be 81.7 percent; however, the actual proficiency level was slightly more than 52 percent. Thus, after eight years of metric implementation, grade seven students have attained but 64 percent of expected proficiency and only 52.4 percent actual proficiency. In conversion and estimation skills, students scored well below the 50 percent level, reflecting a lack of knowledge and understanding of these areas of the metric system. Although the use of units and symbols was 20 percentage points below expected

Table 4

Comparison of Expected Proficiency Levels and Actual Proficiency Levels for Subsections of WTMS

Subsection	Expected Proficiency Level	Actual Proficiency Level*	Attained* Proficiency Level
Units/Symbols	89.9%	69.9%	77.8%
Estimation	78.0%	44.1%	56.5%
Measurement	81.1%	61.7%	76.1%
Conversion	77.7%	34.0%	43.8%
TOTAL	81.7%	52.4%	63.6%

*Percentage actual proficiency is of expected proficiency.

proficiency, students did tend to have a general understanding and knowledge of this subsection. In summary, grade seven students have not reached the proficiency level expected by teachers in the four subsections of WTMS, namely, use of units and symbols, estimation skills, measurement skills, and conversion skills.

Student Proficiency in Metric Content Areas

In this section, data are presented in answer to research question 2: How proficient are grade seven students in their understanding of length, mass, volume, and temperature as measured by WTMS? Comparisons of expected proficiency levels and actual proficiency levels for the four content areas of WTMS are contained in Table 5. As shown in Table 5, students are below expected proficiency levels in all four content areas. In descending order of actual proficiency, the content areas are arranged as follows: length, temperature, mass, and volume. The overall actual proficiency level for students was 52.4 percent while the expected proficiency level was 81.7 percent.

In the content areas, the concepts of volume and mass are below the 50 percent level of actual proficiency, suggesting a general lack of knowledge and understanding of volume and mass. Although the concept of length is nearly 19 percentage points below expected proficiency

Table 5

Comparison of Expected Proficiency Levels and Actual Proficiency Levels for the Content Areas of WTMS

Content Area	Expected Proficiency Level	Actual Proficiency Level	Attained* Proficiency Level
Length	86.2%	67.6%	78.4%
Volume	74.6%	37.6%	50.4%
Mass	82.1%	45.8%	55.8%
Temperature	84.0%	59.2%	70.5%
TOTAL	81.7%	52.4%	64.0%

*Percentage actual proficiency is of expected proficiency.

level, students generally have a fair understanding of this concept. In conclusion, grade seven students have not reached proficiency levels expected by teachers in the four content areas of WTMS, namely, length, mass, volume, and temperature.

Metric Achievement and Sex

In this section, data are presented to address research question 3: Is there a significant difference in metric achievement between boys and girls in the various subsections and content areas of WTMS? The results of the analysis of sex differences are displayed in Table 6. The application of a t-test indicated that there was no significant difference between boys and girls in the various sections of WTMS.

Metric Achievement and Mathematical Achievement

Table 7 displays data to answer research question 4: Is there a correlation between students' mathematical achievement as measured by the Canadian Test of Basic Skills and students' metric achievement? Table 7 indicates that there is a statistically significant relationship between students' mathematical achievement as measured by the Canadian Test of Basic Skills and students' metric achievement. This implies that a student of higher mathematical achievement tends to perform higher on WTMS than students of lower mathematical achievement.

Table 6

t-Test Results Comparing Males and Females on the Various Subsections of WTMS

Subtest	Sex	N	Mean	SD	t-value*	DF
Units/Symbols	M	198	8.232	2.098	-1.35	197
	F	182	8.549	2.423		181
Estimation	M	198	5.460	1.849	0.759	197
	F	182	5.104	1.920		181
Measurement	M	198	7.581	1.847	0.378	197
	F	182	7.203	1.891		181
Conversion	M	198	4.045	2.340	0.262	197
	F	182	4.110	2.492		181
Length	M	198	11.682	2.554	1.457	197
	F	182	11.286	2.730		181
Mass	M	198	4.985	2.061	-0.55	197
	F	182	5.104	2.140		181
Volume	M	198	5.636	2.237	0.165	197
	F	182	5.632	2.466		181
Temperature	M	198	2.990	1.042	0.563	197
	F	182	2.929	1.067		181
TOTAL	M	198	25.338	6.025	0.544	197
	F	182	24.978	6.799		181

*CV of t at 0.05 level is 1.960

Table 7

Correlation Between Mathematical Achievement, as Measured by the CTBS and Metric Achievement as Measured by WTMS

r	n	t	df
0.7399	83	9.89*	81

*Significant at the 0.01 level.

Metric Achievement and Completion of Metric Chapter, Size of School, and Teacher Variables

Student metric achievement, as it relates to completion of the metric chapter, size of school, and the teacher variables of mathematical and science qualifications, inservice metric training, years of teaching experience, and exposure to the metric system during preservice training was analyzed by means of a stepwise multiple regression. In a stepwise multiple regression the best predictor is selected in step 1, and a one-predictor regression equation is provided. In step 2 the variable that would contribute the most additional relevant variance is selected and a two-predictor regression equation is determined. Each successive step progresses in a similar manner - the next predictor variable entered into the regression equation would be the variable that has the largest correlation with metric achievement when all variables already included in the previous regression equations have been partialed out.

A stepwise multiple regression was calculated for the four subsections of WTMS, namely, use of units and symbols, estimation, measurement, and conversion skills and for the four content areas of length, volume, mass, and temperature. Table 8 contains the results of the stepwise multiple regression for the subsections of WTMS. The variables which had a statistically significant effect on students' performance in the use of units and symbols

Table 8

Stepwise Multiple Regression for the Subsections of WTMS

Dependent Variable	Variable* Entered	Step	R^2	F	Probability
Units/Symbols	X_1	1	0.57	39.21	<0.001
	X_2	2	0.69	32.81	<0.001
	X_3	3	0.76	30.04	<0.001
Estimation Skills	X_2	1	0.58	41.65	<0.001
Measurement Skills	X_2	1	0.31	13.59	<0.001
Conversion Skills	X_1	1	0.38	18.75	<0.001
	X_2	2	0.53	16.17	<0.001
Total Score	X_2	1	0.54	35.42	<0.001
	X_1	2	0.73	39.82	<0.001

* X_1 = Chapter Completed

X_2 = Size of School

X_3 = Number of Science Courses completed by teacher.

were completion of the metric chapter, size of school, and the number of science courses completed by teacher.

The size of the school was the only variable which had a statistically significant effect on students' performance in the areas of estimation and measurement skills. Since the variable of completion of the metric chapter did not have a significant effect upon students' performance in these areas, it may indicate that the skills of estimation and measurement are not strongly affected by the metric curriculum and that factors outside the school environment influence these skills.

Conversion skills, however, are positively affected by completion of the metric chapter, as well as by the size of school. Both these variables were statistically significant in relation to student performance in the conversion section of WTMS.

Table 9 contains the results of the stepwise multiple regression for the content areas of WTMS. Both completion of the metric chapter and size of school had a statistically significant effect upon the content areas of length, volume, and mass. The size of school was the only factor that had a statistically significant effect upon temperature.

No significant relationship was found to exist between teachers' mathematical qualifications, inservice metric training, years of teaching experience, or exposure to the metric system during their preservice training and

Table 9

Stepwise Multiple Regression for the Content Areas of WTMS

Dependent Variable	Variable Entered*	Step	R^2	F	Probability
Length	X_1	1	0.47	26.60	<0.001
	X_2	2	0.65	27.48	<0.001
Volume	X_2	1	0.44	23.91	<0.001
	X_1	2	0.59	20.81	<0.001
Mass	X_1	1	0.54	35.11	<0.001
	X_2	2	0.61	23.14	<0.001
Temperature	X_2	1	0.51	31.14	<0.001
Total Score	X_2	1	0.54	35.42	<0.001
	X_1	2	0.73	39.82	<0.001

* X_1 = Chapter Completed

X_2 = Size of School

their respective students' mean metric achievement in the skills and content areas of WTMS.

In conclusion, the mean overall score of grade seven students in WTMS was significantly affected by size of school and completion of the metric chapter in the mathematics curriculum.

Summary

Within the limitations of this study, the following observations may be made:

1. Grade seven students are not proficient in their use of units and symbols, estimation skills, measurement skills, and conversion skills as measured by WTMS. While expected proficiency was 81.7 percent, the actual proficiency level reached only 52 percent.

2. Grade seven students are not proficient in their understanding of length, mass, volume, and temperature as measure by WTMS. While expected proficiency was 81.7 percent, the actual proficiency level reached only 52 percent.

Statistically significant differences were found in the following areas:

1. Students with higher levels of mathematical achievement as measured by the Canadian Test of Basic Skills had higher levels of metric achievement than students with lower levels of mathematical achievement.

2. Students in larger schools had higher achievement scores than students in smaller schools.

3. Students who had completed the metric chapter in the grade seven mathematics curriculum scored higher than students who had not completed the chapter.

4. Students taught by teachers with a stronger science background scored significantly higher in the subsection of WTMS that dealt with the use of units and symbols than students taught by teachers with a weaker science background.

Statistically significant differences were not found in student metric achievement when students were grouped by sex, their teacher's mathematical qualifications, the amount of inservice metric training received by teachers, the number of years of teaching experience of the teacher, nor the exposure of the teacher to the metric system during their preservice training.

CHAPTER 5

CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

Measurement is a basic skill required by all individuals in everyday experiences. We need the skills of measurement to calculate distances, heights, areas, volumes, masses; to purchase gasoline, foods; to perform common carpentry and household tasks; along with a multitude of other activities. The importance of teaching this life skill is widely accepted in schools throughout the world.

The metric system is the system of measurement officially used in Canada. At the time of this study the metric system of measurement had been the sole system of measurement in Newfoundland schools for eight years. Thus, grade seven students in the Newfoundland school system had been exposed exclusively to this system since entering school. The investigator felt that a comprehensive assessment of the teaching of measurement and the metric system would identify students' strengths and weaknesses and suggest recommendations for future curriculum revision.

Overview of the Study

The major purpose of this study was to assess the metric measurement skills of grade seven students in a selection of Newfoundland schools and to ascertain the effects of various variables upon metric achievement. Since no standardized metric achievement test was available, one of the first tasks was to identify and modify a test of metric achievement that would be suitable for use with students in the Newfoundland school system. After a comprehensive review of the related literature, Williams' Test of Metric Skills (WTMS) was identified as the most suitable evaluation instrument for the purposes of this study.

Using WTMS as the evaluation instrument, and a short teacher questionnaire, the study was designed to answer the following questions:

1. How proficient are grade seven students in their use of units and symbols, estimation, measurement, and conversion skills as measured by WTMS?

2. How proficient are grade seven students in their understanding of length, mass, volume, and temperature as measured by WTMS?

3. Is there a significant difference in metric achievement between boys and girls in the various subsections and content areas of WTMS?

4. Is there a correlation between students' mathematical achievement as measured by the Canadian Test of Basic Skills and student metric achievement?

5. Is there a relationship between student metric achievement and completion of the metric chapter in <u>Math Is I</u>, the mathematics textbook used in grade seven?

6. Is there a relationship between size of school and student metric achievement as measured by WTMS?

7. Is there a relationship between teachers' mathematical and science qualifications and their respective students' metric achievement?

8. Is there a relationship between the amount of inservice metric training received by teachers and their respective students' metric achievement?

9. Is there a relationship between students' metric achievement and number of years of teaching experience of their teachers?

10. Is there a relationship between students' metric achievement and the exposure of their teacher to the metric system during their preservice training?

To secure answers to the questions posed, WTMS was administered to a random sample of 380 students on the Avalon Peninsula. The mathematics teachers of those students involved in the study were invited to participate by completing a short questionnaire pertaining to their preservice and inservice education.

WTMS was administered in March, 1986. It was felt that the measurement strand on metric in the Math Is I program would be completed by grade seven students at this time. Using the Statistical Package for the Social Sciences (SPSSX), a student data file and a teacher data file were established and computer analysis was employed to summarize and analyze the data.

Conclusions

The analysis of the data led to the following conclusions:

1. Grade seven students are not proficient in their use of units and symbols, estimation skills, measurement skills, and conversion skills as measured by WTMS. While expected proficiency was 81.7 percent, actual proficiency level reached only 52 percent.

2. Grade seven students are not proficient in their understanding of length, mass, volume, and temperature as measured by WTMS. While expected proficiency was 81.7 percent, actual proficiency level reached only 52 percent.

Statistically significant differences were found in the following areas:

1. Students with higher levels of mathematical achievement as measured by the Canadian Test of Basic Skills had higher levels of metric achievement than students with lower levels of mathematical achievement.

2. Students in larger schools had higher achievement scores than students in smaller schools.

3. Students who had completed the metric chapter in the grade seven mathematics curriculum scored higher than students who had not completed the chapter.

4. Students taught by teachers with a stronger science background scored higher in the subsection of WTMS that dealt with the use of units and symbols than students taught by teachers with a weaker science background.

Statistically significant differences were not found in student metric achievement when students were grouped by sex, their teacher's mathematical qualifications, the amount of inservice metric training received by teachers, the number of years of teaching experience of the teacher, nor the exposure of the teacher to the metric system during their preservice training.

Discussion

This section of Chapter 5 will present a number of observations concerning the conclusions reached as a result of the analysis of data. These observations are as follows:

1. Grade seven students have a relatively low level of knowledge of the metric system. This low level of proficiency suggests that prior to grade seven, exposure of students to the metric system is extremely limited. This low level of student proficiency leads one to believe that the <u>Investigating School Mathematics</u> program presently taught in the primary and elementary grades is insufficient in its treatment of the metric system of measurement. Thus, for many students, the grade seven program serves as the first meaningful encounter with this measurement system rather than serving as a review and extension of the basic metric concepts. Because so many new concepts are presented in this program, many students are unable to cope adequately with the measurement system.

2. The poor performance of students on the conversion subsection of WTMS indicates that students may be lacking in their understanding of the decimal numeration system. In the present Newfoundland mathematics curriculum fractions are introduced before the decimal numeration system. The conversion from the imperial system of measurement to the metric system necessitates a de-emphasis on the early use of fractions and a stronger focus on the understanding of the decimal numeration system. This re-organization of these various mathematical concepts would assist greatly in a child's understanding and application of the metric system.

3. Factors other than the metric education programs within the schools affect the metric achievement of students. This is reflected in the significant relationship between size of school and student metric achievement. Factors that may contribute to this variation in achievement are the degree of exposure to the metric system within the community, the frequency of multi-grade classes, the degree of teacher specialty within the schools, or instructional materials and resources available to the schools. Any single factor or combinations of factors may account for the differences in metric achievement due to size of school.

4. Although students did not reach expected proficiency levels in length and temperature, they did perform better in terms of the percentage of correct

responses on those items concerned with these areas than on items concerned with mass and volume. This may be due, in part, to the conversion timetable established by the Metric Conversion Commission which established temperature and length as the first two units to be converted to metric units in Canada. Another plausible explanation for the noticeable difference in these metric areas could be the greater exposure to temperature and length in the various forms of media.

5. The findings relating to mathematical achievement and metric achievement confirm the findings of McFee (1967), Slobojan (1974), Houser (1974), and Williams (1978). The best predicator of metric achievement is mathematical ability.

6. Although no significant difference was found between the metric performance of boys and girls, boys did perform slightly better than girls in six out of the eight subsections of WTMS. This phenomenon may be worth monitoring to determine whether the slight differences are related to gender or whether other variables account for these differences.

7. The lack of a statistically significant relationship between teacher variables and student metric achievement indicates that factors outside the context of education may influence metric achievement. This study identifies the mathematical ability of students, size of school, and completion of the metric chapter as some of

these factors. Further research is needed to identify other factors which affect student metric achievement.

8. The lack of a statistically significant relationship between student metric achievement and a teacher's exposure to the metric system during preservice training suggests that a teacher's understanding of the metric system has little influence upon his/her respective students' metric achievement. Another plausible explanation would be the ineffectiveness of metric preservice programs.

Recommendations

As a result of this study and an extensive review of the related literature concerning metric measurement, the following recommendations have emerged:

1. The emphasis placed upon the system of metric measurement in the primary and elementary grades must be increased. Before entering junior high school, students should have a thorough understanding of the concepts of length, volume, mass, and temperature, as well as the organization of the metric system by multiples of ten. They should also be familiar with conversion skills.

2. For many years curriculum development specialists have recommended that concrete manipulative materials be used with primary and elementary school children. Thus, it is recommended that primary and elementary level students be exposed extensively to

manipulative or hands-on activities so that the various metric concepts are understood and retained.

3. Research is needed to determine the order of presentation of various mathematical concepts in the elementary mathematics program. The conversion from the imperial system of measurement to the metric system may necessitate a de-emphasis on the early introduction of fractions and a stronger focus on the understanding of the decimal numeration system.

4. Further research is needed to identify the factors outside the metric education program that affect the metric achievement of students. Factors that appear to be worthy of isolation are those that relate to the family and community.

5. Further research is needed to identify the factors other than mathematical ability and size of school that may affect the metric achievement of students. Attitudes of students and teachers toward the metric system may be worthy of study, as well as the influence of a teacher's metric knowledge in relation to his/her respective student's metric knowledge.

6. Research is needed to evaluate the metric needs of teachers involved in preservice training and the extent to which these needs are being met by the various course requirements involved in the preparation of an individual for the role of teacher.

The findings of this study are applicable to the population of students and teachers on the Avalon Peninsula, the area from which the sample population was drawn. However, the involvement of students from urban, rural, and suburban communities in the study, perhaps, indicates that students from other communities in Newfoundland may have characteristics in metric achievement similar to those of this study.

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APPENDIX A

Evaluation Forms for Williams' Test of Metric Skills

CONSULTANT EVALUATION FORM

EVALUATOR: ____________________

POSITION: ____________________

1. Please read each item for ambiguity and/or paper wording.

2. Verify each answer.

3. At which earliest age level do you think that students can properly work with the metric measures on this test?

   ___ 5-9 years ___ 10-11 years ___ 12 -14 years

4. Comments on specific questions. (Use back of paper if necessary.)

5. Comments on specific questions that may not pertain to the Newfoundland setting.

6. Comments in general. (Use back of paper if necessary.)

TEACHER EVALUATION FORM

Section I

Please indicate by checking the appropriate column whether each item in the test measures simply knowledge or both knowledge and understanding.

Section II

Please indicate by checking the appropriate column whether or not each item is suitable for Newfoundland students who have completed grade seven. (Keep in mind that some measuring instruments in Part C of the test may have been introduced to students in the science programs of previous years).

Section III

Please indicate the approximate percentage of students that should answer correctly each item.

	Section I		Section II		Section III
	Knowledge Only	Knowledge And Understanding	Suitable Item Yes	No	Percentage of Correct Responses
PART C					
1	___	___	___	___	___
2	___	___	___	___	___
3	___	___	___	___	___
4	___	___	___	___	___
5	___	___	___	___	___
6	___	___	___	___	___
7	___	___	___	___	___
8	___	___	___	___	___
9	___	___	___	___	___
10	___	___	___	___	___
11	___	___	___	___	___
12	___	___	___	___	___
PART D					
1	___	___	___	___	___
2	___	___	___	___	___
3	___	___	___	___	___
4	___	___	___	___	___
5	___	___	___	___	___
6	___	___	___	___	___
7	___	___	___	___	___
8	___	___	___	___	___
9	___	___	___	___	___
10	___	___	___	___	___
11	___	___	___	___	___
12	___	___	___	___	___

	Section I		Section II		Section III
	Knowledge Only	Knowledge And Understanding	Suitable Item Yes	No	Percentage of Correct Responses
PART A					
1	___	___	___	___	___
2	___	___	___	___	___
3	___	___	___	___	___
4	___	___	___	___	___
5	___	___	___	___	___
6	___	___	___	___	___
7	___	___	___	___	___
8	___	___	___	___	___
9	___	___	___	___	___
10	___	___	___	___	___
11	___	___	___	___	___
12	___	___	___	___	___
PART B					
1	___	___	___	___	___
2	___	___	___	___	___
3	___	___	___	___	___
4	___	___	___	___	___
5	___	___	___	___	___
6	___	___	___	___	___
7	___	___	___	___	___
8	___	___	___	___	___
9	___	___	___	___	___
10	___	___	___	___	___
11	___	___	___	___	___
12	___	___	___	___	___

APPENDIX B

Teacher Questionnaire and Parental Permission Form

TEACHER QUESTIONNAIRE

1. Sex: _____ Male _____ Female

2. How many years of teaching experience do you have?
   _____ Years

3. Have you completed any math courses either educational or academic while attending university which dealt with a unit on the metric system? _____ Yes _____ No

4. How many hours of metric inservice have you received (not included in 3)? _____ Hours

5. How many math courses, other than educational math courses, have you completed during your university years (in semester courses)? _____

6. How many science courses, other than educational science courses such as Science 115A & B, have you completed during your university years (in semester courses)? _____

7. Have you completed chapter five on measurement in the <u>Math Is I</u> program? _____ Yes _____ No
   If no, do you expect to complete it before the end of the school year? _____ Yes _____ No

8. How many years have you taught the metric system of measurement? _____ Years

9. What is the total number of grade seven students enrolled in your school? _____

10. When teaching the conversion aspect of metric measurement do you use a horizontal or vertical approach?
    _____ Horizontal _____ Vertical

March 3, 1986

Dear Parents:

I am a teacher presently teaching in the St. John's area. I am in the process of conducting a survey of metric achievement among grade seven students on the Avalon Peninsula, as part of my Master's degree program at Memorial University. One purpose of this survey is to determine how successful we have been in educating our young people in metric measurement.

One element of my study examines students' metric achievement as it relates to their mathematical achievement. To complete this particular aspect of my study, I request your permission to obtain from school records your child's mathematics achievement score as measured by the Canadian Test of Basic Skills. If you consent to this request, I guarantee confidentiality.

May I add that this study has the support of many educators, including the Mathematics Consultant of the Department of Education. Also, the Avalon Consolidated School Board has granted me permission to conduct this study. Without your permission, however, I cannot obtain the required information.

Thanking you in advance.

Sincerely,

Judy Moakler

JM/mk

Judy Moakler

Do we have your permission to obtain from school records your child's mathematics achievement score as measured by the Canadian Test of Basic Skills? Please place a check beside your answer.

Yes ______ No ______

APPENDIX C

Modified Version of Williams' Test of Metric Skills

WILLIAMS' TEST OF METRIC SKILLS

Part A -- Use of Units and Symbols

_____ 1. The symbol "cm" is the correct symbol for the unit

A. cubic metre
B. Celsius
C. cents per metre
D. centimillimetre
E. centimetre

_____ 2. The correct symbol for the unit "gram" is

A. grm.
B. Gm
C. gr.
D. g
E. gm

_____ 3. The correct symbol for the unit "millimetre" is

A. MM
B. mm
C. m/m
D. mM
E. ml.

_____ 4. The correct symbol for the amount "250 millilitres" is

A. 250 mL
B. 250 mls
C. 250 Mlls.
D. 250 mml
E. 250 mms.

_____ 5. The correct symbol for "50 kilometres per hour" is

A. 50 kph
B. 50 Kph
C. 50 K/h
D. 50 km/h
E. 50 Kmph

_____ 6. One hundredth (0.01) of one gram is called a

A. milligram
B. centigram
C. decigram
D. kilogram
E. Megagram

_____ 7. One thousand (1000) litres is called a

A. millilitre
B. centilitre
C. decilitre
D. kilolitre
E. Megalitre

_____ 8. The best unit to measure the length of a pencil would be the

A. kilometre
B. litre
C. milligram
D. gram
E. centimetre

_____ 9. The best metric unit to measure your own mass is the

A. Litre
B. kilogram
C. gram
D. kilometre
E. centimetre

_____ 10. The volume of your kitchen sink would be measured in

A. kilolitres
B. centimetres
C. litres
D. milligrams
E. millilitres

_____ 11. The distance between cities is measured in the unit

A. metre
B. kilometre
C. kilograms
D. Megametre
E. kilolitre

_____ 12. A farmer might sell his land using the unit called a

A. metre
B. kilometre
C. square centimetre
D. hectare
E. kilolitre

Part B -- Estimation

_____ 1. Ten metres is reasonable length for a

A. pencil
B. desk
C. classroom
D. football field
E. city block

_____ 2. Two millimetres is about the thickness of a

A. piece of paper
B. penny
C. book
D. brick
E. set of encyclopedias

_____ 3. The distance a person might walk in an hour is about

A. 0.5 kilometres
B. 5 kilometres
C. 50 kilometres
D. 50 decimetres
E. 5000 centimetres

_____ 4. A basketball filled with water would contain about

A. 0.5 litres
B. 3 litres
C. 15 litres
D. 50 litres
E. 500 litres

_____ 5. The volume of an average glass of water is about

A. 30 millilitres
B. 300 millilitres
C. 3 litres
D. 30 litres
E. 300 litres

_____ 6. The <u>volume</u> of an average egg is about

A. 0.5 cubic centimetres
B. 5 cubic centimetres
C. 5 cubic decimetres
D. 5 cubic metres
E. 50 cubic centimetres

_____ 7. An average man might have a <u>mass</u> of about

A. 0.75 kilograms
B. 7.5 kilograms
C. 75 kilograms
D. 175 kilograms
E. 1750 kilograms

_____ 8. The <u>mass</u> of one penny is about

A. 5 grams
B. 50 grams
C. 0.5 grams
D. 5 kilograms
E. 50 kilograms

_____ 9. If children are all outside building snowmen, the temperature is probably about

A. -30°C
B. -10°C
C. 10°C
D. 20°C
E. 30°C

_____ 10. If everyone hopes to go swimming in the lake, the temperature outside is probably about

A. 0°C
B. 10°C
C. 30°C
D. 75°C
E. 90°C

_____ 11. To bake cookies, you should set the oven temperature to

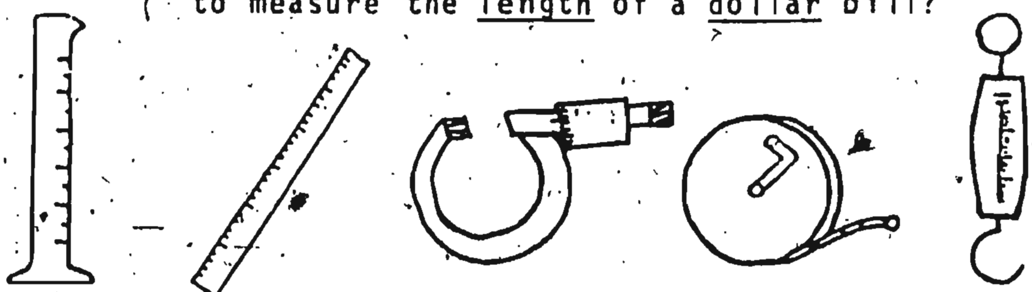
A. 60°C
B. 160°C
C. 360°C
D. 650°C
E. 1000°C

_____ 12. The area of this page is closest to

A. 6 square metres
B. 6 square centimetres
C. 6 square decimetres
D. 6 square hectometres
E. 6 square millimetres

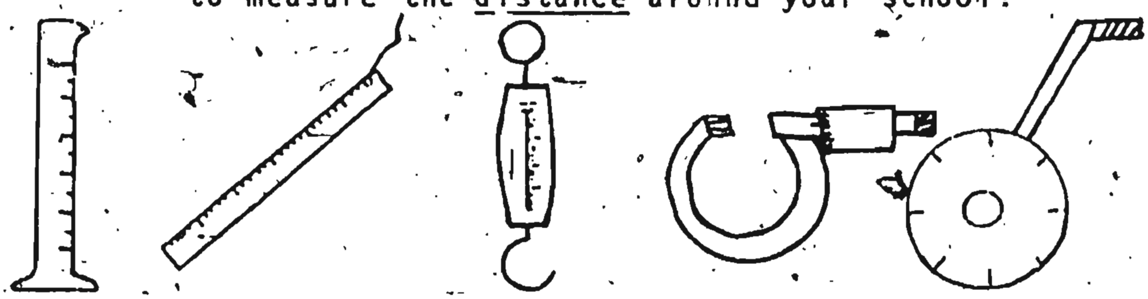
Part C -- Measurement

_____ 1. Which measuring instrument would be best to use to measure the <u>length</u> of a <u>dollar</u> bill?



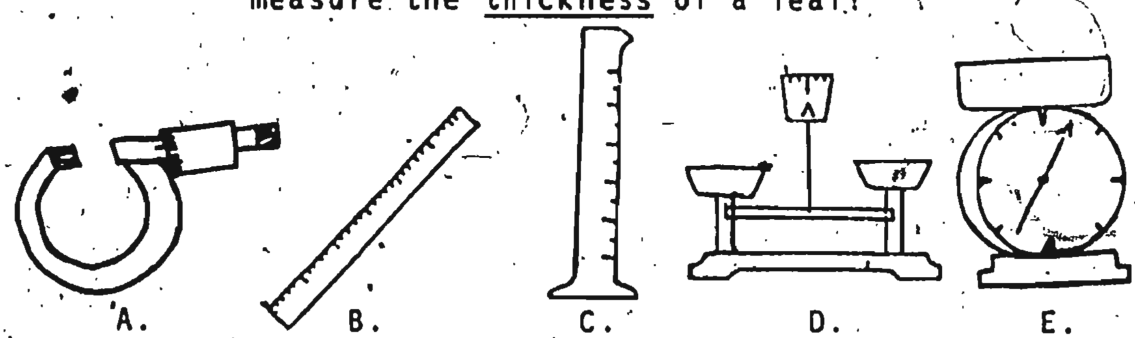
A. B. C. D. E.

_____ 2. Which measuring instrument would be best to use to measure the <u>distance</u> around your school?



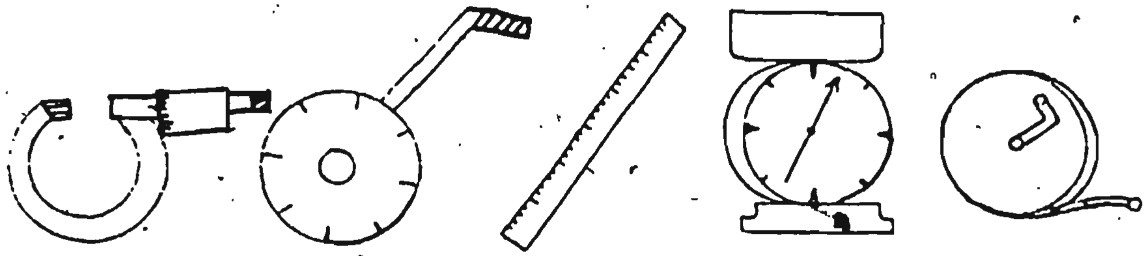
A. B. C. D. E.

_____ 3. Which measuring instrument would be best to measure the <u>thickness</u> of a leaf?



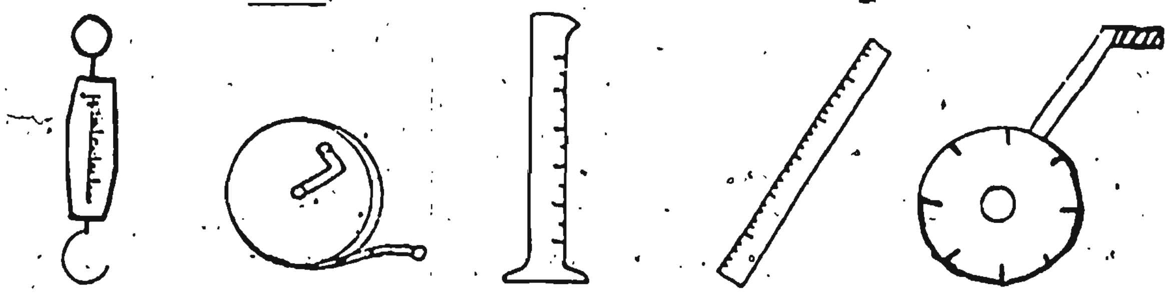
A. B. C. D. E.

_____ 4. Which of the following would you use to measure the mass of a book?



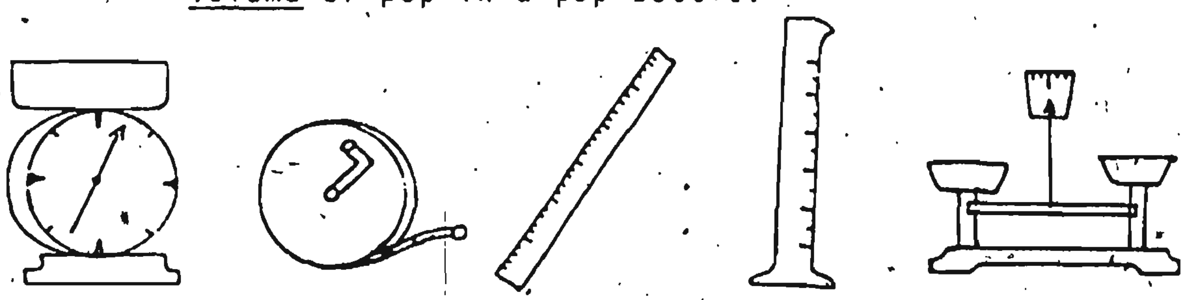
A. B. C. D. E.

_____ 5. Which of the following might you use to measure the mass of a tennis racket?



A. B. C. D. E.

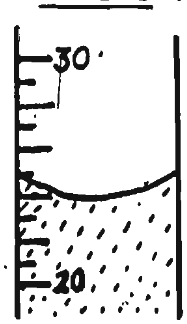
_____ 6. Which of the following might you use to find the volume of pop in a pop bottle?



A. B. C. D. E.

_____ 7. The correct reading of volume units in the cylinder is

A. 20 units
B. 24 units
C. 25 units
D. 28 units
E. 29 units



_____ 8. The correct reading on the thermometer is

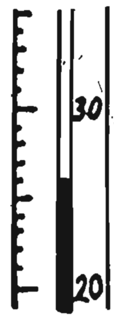
A. 20°

B. 22°

C. 23°

D. 24°

E. 26°



_____ 9. The correct reading on the thermometer is

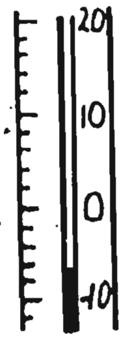
A. 13°

B. 7°

C. -13°

D. -7°

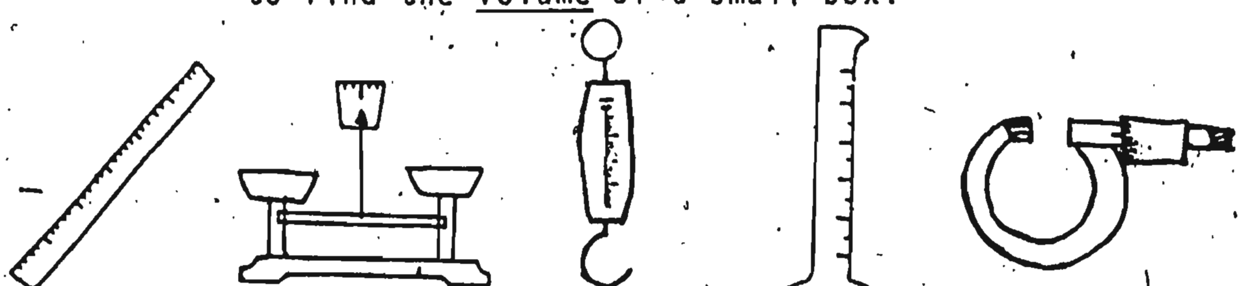
E. -3°



_____ 10. Which measuring instrument would be best to use to find the <u>area</u> of an envelope?

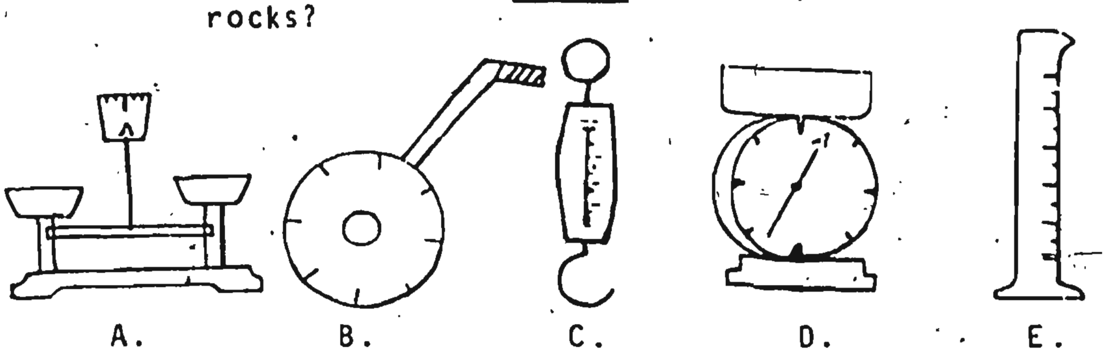
A. B. C. D. E.

_____ 11. Which measuring instrument would be best to use to find the <u>volume</u> of a small box?



A. B. C. D. E.

_____ 12. Which measuring instrument would be best to use to find the volume of a couple of small rocks?



Part D -- Conversion Skills

_____ 1. Which of the following is the same as 150 centimetres?

A. 0.15 metres
B. 1.5 metres
C. 15 metres
D. 15 millimetres
E. 1.5 decimetres

_____ 2. Which of the following is the same as 25 millilitres?

A. 0.25 litres
B. 2.5 litres
C. 2500 litres
D. 2.5 centilitres
E. 0.25 of a litre

_____ 3. Which of the following is the same as 0.3 kilometres?

A. 300 metres
B. 3000 metres
C. 30 centimetres
D. 0.003 metres
E. 3 Megametres

_____ 4. Which of the following is the same as 200 milligrams?

A. 0.02 grams
B. 0.2 grams
C. 20 grams
D. 0.002 grams
E. 0.2 centigrams

_____ 5. 4.26 litres is the same as

A. 0.426 millilitres
B. 4.26 millilitres
C. 426 millilitres
D. 4260 millilitres
E. 426 kilolitres

_____ 6. One cubic centimetre is the same as

A. 0.5 millilitres
B. 1 millilitre
C. 1 cubic metre
D. 100 cubic decimetres
E. 0.01 cubic metres

_____ 7. One thousand (1000) cubic millimetres is the same as

A. 1 cubic metre
B. 1 cubic centimetre
C. 100 cubic centimetres
D. 10 cubic metres
E. 10 cubic centimetres

_____ 8. One litre of water has a mass of about

A. 1 gram
B. 100 grams
C. 1 kilogram
D. 10 centigrams
E. 100 milligrams

_____ 9. Which of the following is the same as 0.038 millimetres?

A. 38 metres
B. 0.00038 decimetres
C. 3.8 metres
D. 0.38 centimetres
E. 0.38 decimetres

_____ 10. Which of the following is the same as 420 grams?

A. 4.2 milligrams
B. 42 centigrams
C. 0.42 kilograms
D. 4.2 kilograms
E. 42 kilograms

_____ 11. Which of the following is the same as 1825 millilitres?

A. 18.25 litres
B. 1.825 litres
C. 1.825 centilitres
D. 1.825 decilitres
E. 182.5 kilolitres

_____ 12. 940 grams is how much less than one kilogram?

A. 60 grams
B. 60 kilograms
C. 6 milligrams
D. 6 kilograms
E. 60 centigrams

Part E -- Relating Imperial and Metric Measures

NOTE: The following questions are not a part of the school program in measurement. If you are able to answer the questions without guessing, please do so, but do not guess the answer if you are not reasonably sure.

_____ 1. A board that is two inches by four inches is about the same as a board that is

A. 20 by 40 centimetres
B. 50 by 100 centimetres
C. 5 by 10 metres
D. 2 by 4 centimetres
E. 5 by 10 centimetres

_____ 2. Ten kilograms is quite close to

A. 5 pounds
B. 10 pounds
C. 22 pounds
D. 60 pounds
E. 200 pounds

_____ 3. One gallon of gasoline is quite close to

A. 0.5 litres
B. 5 litres
C. 25 litres
D. 250 millilitres
E. 25 millilitres

_____ 4. 15°F (Fahrenheit) would be closest to

A. -30°C
B. -10°C
C. 15°C
D. 30°C
E. 50°C

Student Answer Sheet for Test of Metric Skills

PART A

1. A B C D E
2. A B C D E
3. A B C D E
4. A B C D E
5. A B C D E
6. A B C D E
7. A B C D E
8. A B C D E
9. A B C D E
10. A B C D E
11. A B C D E
12. A B C D E

PART B

1. A B C D E
2. A B C D E
3. A B C D E
4. A B C D E
5. A B C D E
6. A B C D E
7. A B C D E
8. A B C D E
9. A B C D E
10. A B C D E
11. A B C D E
12. A B C D E

PART C

1. A B C D E
2. A B C D E
3. A B C D E
4. A B C D E
5. A B C D E
6. A B C D E
7. A B C D E
8. A B C D E
9. A B C D E
10. A B C D E
11. A B C D E
12. A B C D E

PART D

1. A B C D E
2. A B C D E
3. A B C D E
4. A B C D E
5. A B C D E
6. A B C D E
7. A B C D E
8. A B C D E
9. A B C D E
10. A B C D E
11. A B C D E
12. A B C D E

PART E

1. A B C D E
2. A B C D E
3. A B C D E
4. A B C D E

APPENDIX D

Permission to Use Williams' Test of Metric Skills

UNIVERSITY OF VICTORIA

P.O. BOX 1700, VICTORIA, BRITISH COLUMBIA, CANADA V8W 2Y2
TELEPHONE (604) 721-7211, TELEX 049-7222

Faculty of Education
(604) 721-7766

October 21, 1985

Ms. Judy Moakler
14 McLoughlan Street
St. John's, Nfld.
A1E 4G2

Dear Ms. Moakler:

Your request to use my "Test of Metric Skills" and to modify as necessary for your own research is hereby granted with the proviso that no commercial use shall be made of the instrument or its modification.

I wish you well with your research, and ask that you share your results with me, perhaps even an abstract so I may keep abreast of the field. I have done nothing with metrics over the past 6 years except keep a file on development. Progress is slow, and I tend to blame the U.S. foot-dragging for that. I hope to follow-up in a few years time to see where we have been in this area.

Sincerely,

R.L. Williams
Associate Dean

RLW/cr
Enc. 1