A STUDY OF THE EFFECTIVENESS OF A TEACHING UNIT ON LENGTH IN THE METRIC SYSTEM

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by

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ABSTRACT

The purpose of this study was to determine the effectiveness of a unit in teaching measurement in the metric system to grade seven students.

To do this the experimenter considered the following questions:

1. Is the unit effective in providing a gain in achievement on measurement in the metric system?

2. What is the effect of the unit on students' attitudes towards mathematics?

3. What are the teachers' attitudes towards the experimental unit?

4. How effective is the unit in helping students to reach each objective?

The design of this study was pre-test, post-test with no control group. The study consisted of presenting a fifteen lesson unit on length in the metric system to 320 grade seven students in ten classes at MacDonald Drive Junior High School, St. John's. Materials for the unit were taken from <u>World of Metric-Activity Book</u> by S. E. Odegard and restructured by the experimenter.

The experimenter constructed a pre-test and post-test in order to determine the student's achievement on the unit. The pre-test was administered and the post-test was given

after the fifteenth lesson. The items on the pre-test and post-test were identical but their order was changed. The items of the post-test were designed to test whether the behavioral objectives had been met. The Connelly Taxonomized Attitude Scale was given as a pre-test, post-test to determine the effect of the unit on student attitudes towards mathematics. An experimenter-made questionnaire was given to each of the six teachers who taught the unit in order to determine the attitudes of teachers towards the unit.

A gain in achievement was determined by the gain in the mean score from pre-test to post-test on measurement. A gain of 48.7% on the mean score indicated that the students can achieve on the experimental unit.

A dependent t-test for means was performed on the pre-test, post-test attitude scores of students. A t-value of -0.43 indicated that there was no significant change in the attitudes of students towards mathematics at the .05 level of significance during the teaching of the experimental unit.

From the questionnaire given to the teachers, responses indicated that

1. The unit was easy to read and appropriate for average students.

2. Teachers enjoyed teaching the unit and would recommend it to other metric teachers.

3. Some teachers felt they would encounter difficulty at the beginning with the activity approach of teaching used in the unit.

4. There was an indication that the unit would have some value for the students in the future.

5. Teachers indicated that the unit is an aid in "Thinking Metric."

A behavioral objective was considered met if its corresponding item on the achievement test was correctly answered by over 70% of the students. Four items out of 28 on the achievement post-test were not attained. Consequently, four behavioral objectives were not met.

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CHAPTER I: INTRODUCTION

Most countries of the world will presumably be metric in the future. In preparation for that time, there is an immediate need for greater emphasis on teaching the metric system and a consequent need for retraining teachers and revising the textbooks.

Textbooks are being revised by printing companies. Williams (1975) outlined in his master's thesis the implementation of an in-service program on the metric system in the Province of Newfoundland. As a result, there is a need for a closer look at teaching the metric system in the classroom. Consequently, a unit on length in the metric system was constructed by the experimenter.

Statement of the Problem

The purpose of this study was to determine the effectiveness of a unit in teaching measurement in the metric system to seventh-grade students.

To do this the experimenter considered four questions.

1. Is the unit effective in providing a gain in achievement on measurement in the metric system?
2. What is the effect of the unit on students' attitudes towards mathematics?
3. What are the teachers' attitudes towards the unit?
4. How effective is the unit in helping students to reach each objective?

Need for and Significance of the Study

Helgren (1973) pointed out that schools approached the use of the metric system in a way that gave little encouragement to its development and use. The following are some of the poorly conceived practices outlined by Helgren:

1. Metric measure was not studied as a system by itself.

2. Textbooks often contained only a single unit on the system, and problems were merely conversions from one system to the other.

3. The unit on the metric system was frequently at the end of the textbook. As a result, it was seldom taught.

4. Teachers had little knowledge of the system, and it was omitted because of lack of time.

The topic of measurement is perhaps the one which will be most affected when the metric system is introduced into the school curriculum.

One of the possible benefits to mathematics as a result of the introduction of metric units may well be reevaluation and possibly a dramatic change in the teaching of measurement.

Suydam (cited in Higgins, 1975) states

> "metrication provides the opportunity to (a) reevaluate the measurement component of the mathematics curriculum, (b) reconsider what we know from experience and from research about how children learn measurement concepts, and (c) restructure

the curriculum and modify instructional practices." (p. 81)

Williams (1975) suggested that the approach "learning by doing" to teaching measurement should stress student involvement in the estimating and measuring of objects in the world.

The present unit on length in the metric system has these aims:

1. To teach the metric system by itself so that students learn to "Think Metric."

2. To involve students through an activity approach.

The present study is considered to be significant to the extent that it will assess the effectiveness of teaching measurement to seventh-grade students through an activity approach. The results could be useful to curriculum developers when planning future units (mass, capacity, area, temperature, volume) in the metric system. The study could be used as a guide for further studies using other population samples.

Scope and Limitations

The design of this study was pre-test, post-test with no control group. The study consisted of presenting a fifteen lesson unit on length in the metric system to 320 grade seven students in ten classes at MacDonald Drive Junior High School, St. John's, in an attempt to answer the questions listed in the "Problem." Six teachers taught the unit to their respective mathematics classes. The experimenter was not one of these six teachers. All but one of these teachers had previous experience teaching in the metric system and had attended an in-service workshop on the metric system. Two teachers are mathematics majors. For the ten classes, there were limited homogeneous groups according to mathematical ability: four honours classes, six average-low average classes.

Sample

The sample consisted of 320 grade seven students at MacDonald Drive Junior High School, St. John's. The sample had students of all levels of mathematical ability from honours to low average. Each of the ten classes was taught by the regular mathematics teacher. The four houour groups had students whose mathematical abilities range from high to high average. The six average groups had students whose mathematical abilities range from average to low average.

CHAPTER II: REVIEW OF RELATED LITERATURE

Historical Background

The English system of measurement developed from man's meed to measure size and distance using units from the most readily available object-himself. He utilized his palm, span, finger, and a fathom for length; his foot, step, pace, an arrow's flight and a day's journey for distance.

There was little need for standardization until man began to travel and trade with other men. When standard units were developed, a new problem arose. Different countries used different definitions for the same unit. The foot was, first, the length of any man's foot. In some countries, it was the length of the king's foot and the foot could change as the king changed. Therefore standards had to be imposed. Henry I applied penal sanctions to weights and measures, also legalized "the yard as the distance between his nose and thumb of his out-stretched arm". (Bendick, 1960, p. 20)

Out of such confusion there developed a need for a simple, standardized system of measurement. The Twenty-First Yearbook of NCTM notes that the first person to propose a decimal system of measures was Simon Stevin at the beginning of the 17th century. Firl (1974) stated that Gabreil Mouton in 1670 proposed a decimal system of weights and measures having a fundamental unit based on the quadrant of one minute of a great circle of the earth. It took over a hundred years for a system of measurement like the one Mouton put forth to get official sanction.

In 1790, the French Academy of Sciences appointed a committee to create a measurement system that was to be, at once, simple and scientific. The committee observed the following criteria in its discussions and deliberations:

1. Any logical system of measurement should be based upon one fundamental unit of length taken from some unchanging absolute standard in the physical world.

2. The units of length, area, weight and volume should be directly related to one another.

With the above criteria in mind, the committee agreed that the unit of length should be a portion of the earth's circumference. It was further agreed, that the larger and smaller versions of each unit were to be created by multiplying or dividing the basic units by 10 and its multiples. Similar calculations in the metric system can be performed by simply shifting the decimal point. Thus the metric system also becomes a base-10 or decimal system.

George Washington on January 8, 1790, made the following statement to the First Congress of the United States in regard to the standardization of measures:

> "A uniformity of weights and measures is
> among the important objects submitted to

you by the constitution, and if it can be derived from a standard at once invariable and universal, it must be no less honorable to the public council than conducive to the public convenience."
(NCTM, 21th Yearbook, p. 39)

The French Academy according to Black (1974) assigned the name metre to the unit of length. This name was derived from the Greek word 'Metron', meaning 'a measure'. The physical standard representing the metre was to be constructed so that it would equal one ten-millionth of the distance from the north pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelone in Spain. However, errors were found in the calculations for the distance.

Firl (1974) wrote that in 1870, because of the problem of replicating and comparing metric units from country to country, France called an international convention of the metric counties to develop a unified metric system of measurement. As a result of these efforts, in 1875 the Treaty of the Metre was signed to establish the General Conference on weights and measures which meets to determine the offical definitions of the units used in the metric countries.

Under this system the metre was officially defined in 1889 as the distance between two engraved lines on a bar of platinum-Iridium alloy at zero degrees Celsius.

Over the years the General Conference has extended and refined the metric system. The unit of length is still the metre, but the metre is no longer based on the quadrant of the meridian or on the metre bar. In 1960 the General Conference redefined the metre as equal in length to "1 650 763.73 wave lengths of the orange-red line of krypton 86". (Black, 1974, p. 87) The Conference also adopted the System Internationale des Unites (SI). It is the SI metric system that is most used throughout the world today.

Hallerburg (1973) states that in 1968 and the two following years the U. S. Congress directed the National Bureau of Standards of the Department of Commerce to undertake a planned effort to convert to the metric system. This was known as the U. S. Metric Study. Following the three-year study, in 1971 the Report of the U. S. Metric Study made to the Congress of the United States five recommendations: (Helgren, 1973, p. 265)

1. That the United states change to the International Metric System deliberately and carefully.
2. That this be done through a coordinated national program.
3. That the Congress establish a target date of ten years ahead.
4. That there be a firm government commitment to this goal.
5. That early priority be given to educating every American schoolchild and the public at large to think in metric terms.

With all this, the United States is now committed to the metric system.

The Canadian Government has decided that Canada should adopt the metric system of measurement. In January, 1970 the White Paper on Metric Conversion in Canada was issued setting out Canadian Government policy and conclusions on metric conversion. It concluded that the adoption of the SI is inevitable and in the interest of the nation and that the changeover should be planned in such a manner as to achieve maximum benefits at a minimum cost to everyone.

In 1971, as a result of the White Paper, the Metric Commission of Canada was formed. The Commission is responsible for developing a plan for metric conversion. It must inform the public as to why the change is being made and how the change will affect them. It must also see that people are given a sufficient understanding of the SI measures. The units that will affect the most people will be the metre for length, the kilogram for mass, the litre for capacity and the degree Celsuis for temperature. The most common prefixes for everyday use will be kilo, centi and milli. Conversion to the metric system is a four-phase project of investigation, planning, scheduling and implementation. For most organizations, the peak of the investigation phase has been reached and the planning phase is underway.

Hughes (1975) writes

> "In August 1972 the U. S. Senate unanimously passed the Metric Coversion Act which would

> establish a national metric conversion board to coordinate the voluntary conversion to the metric system over a period of ten years." (p. 7)

The House of Representatives has now passed the proposed legislation to adopt the metric system in the United States.

From this brief history of the metric system there are three main thoughts:

1. The metric system resulted from concentrated effort to develop a rational system of measurement. It did not develop haphazardly.
2. The problem of standardization has been solved in the metric system, at least for the present.
3. The metric system is both popular and useful because of its simplicity.

Experimental Studies

Attacks have been made on both the quantity and quality of measurement activities in our schools. Studies have been done in the past which indicate that the portion of the program devoted to measurement is totally inadequate.

In 1944, York states that the metric system is not a basic system, but Johnson (1944) contradicted her and recommended teaching just three units: metre, litre, gram and avoiding conversion from system to system.

Wilson and Cassell (1953) concluded their report of a long-term study by stating

> "Most of the teaching of weights and measures has been ineffective ... If the work on measures in the schools had been omitted entirely, the results apparently would have been little different." (p. 585)

Corle (1960) tested both students and teachers on their estimations of "size" with discouraging results.

Bowles (1964) and Scott (1966) analyzed the measurement units in elementary school textbooks and concluded that children were being given relatively little opportunity to become familiar with measurement terms, much less with the nature of measurement.

Murphy and Polzin (1969) published A Review of the Research Studies on the Teaching of the Metric System, which concluded that:

1. Relatively few studies have been made.
2. Students have an inadequate knowledge of the metric system.
3. Students and teachers have difficulty in estimating the quantitative value of measures, metric or otherwise.
4. The metric system should be taught at the grade school level and the English system deemphasized.
5. Modern instruction is superior to traditional instruction in the area of measurement.

The U. S. Metric Study Interim Report on Education (1971) recommended:

1. A switch to the metric system be accompanied by a major revision of the elementary school curriculum.

2. In-service training for converting to the metric system be condensed into a short period of time (eight to fifteen hours) just before the teachers begin to teach the metric system.

The report also states that the metric system of measure should be easier to learn than the customary system since (a) the same prefixes are used for sub-units and multiples of basic metric units of length, mass and volume; and (b) the sub-units and multiples are in ratios of 1:10.

Gunderson (1972), in an analysis of elementary text books, noted the meagre attention given measurement. She reported that only 8% of the total grade-three program was devoted to measurement and of those topics included attention was given to only marginal or trivial aspects of measurement.

Helgren (1973) also indicated what should be done in the field of education to teach the metric system:

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

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

3. Before textbooks are changed, get metric workbooks for each teacher and each pupil. Then the system can be learned with very little individual effort.

4. Select one member of the faculty to be the metric authority for the school. He can get the information and material necessary to enable the school to "Go Metric."

5. Teach the metric system to all prospective teachers, for the change to the new system of measure is not just a mathematics or science project.

Silverman (1973) concluded that a unit about measurement can effect a positive change in (a) attitude towards mathematics; (b) self-concept.

Brooks (1974) wrote a thesis which concluded that teaching the metric system exclusively on its own is no more effective than teaching it in relation to the imperial system.

Houser and Trueblood (1975) conducted a study in which the results, under the conditions of their study, indicated that the ability to perform selected linear metric conversion problems following explicit instruction enabled subjects to perform other linear conversion tasks, mass conversion tasks, and volume conversion tasks with no further instruction. Hence, an efficient instructional sequence would be to instruct to criterion on linear metric relationships before introducing metric mass and volume problems. Also there is support to the argument that metric system relationships are easier to learn than relationships in the customary measurement system. For example, it would seem unlikely that under similar conditions, subjects would demonstrate mastery of relationships among the customary units-cups, quarts, and gallon, by learning the relationship among the linear units-inches, feet, yards and miles.

Teaching the Metric System

With Canada going metric, there is a major drive to include the metric system of measurement in the school curriculum and to improve the teaching strategies of measurement. New life can be put in the learning of measurement and major ideas can be learned by paying attention to the essential prerequisite skills and understandings, to the emphasis on relationship between measures, and to activities that encourage thinking and estimating in the measurement system. The teacher's role will be essential in providing the correct pedagogical approach to teaching the metric system.

Instructional Considerations

The following are a variety of topics that are to be considered when teaching the metric system.

Active Learning

To promote metric thought, the teacher should emphasize active learning. Oberlin (1967), Crane (1971) and Hughes (1975) stress a program that is student-centered and uses the experiences of the students to build concepts and strategies. Measuring activities, puzzles, games, posters and chart-making tend to be effective because the student becomes actively involved.

Picard (1969) states two things about the learning theory of Piaget:

1. A child must be allowed to practice things over and over again and thus reassure himself what he has learned.
2. This practice should be enjoyable.

Corle (1964), and Bright and Jones (1973) provide an interesting way to encourage students to actively "Think Metric" through estimation exercises. Let the student estimate, measure and remeasure since these activities are necessary. Two different kinds of estimation can be used to help students develop concepts of the metric lengths. The first consisted of specifying an object, and asking for estimates of one of the dimensions of the object. (Students verify their guesses independently). The second consisted of stating a measurement and asking the students to locate an object that had a dimension with the specific measure. Each student would then measure the object he selected to determine whether his choice was a good one.

Conversion

Helgren (1967), Bright and Jones (1973) and Hughes (1975) strongly discouraged conversion or comparison to the Imperial system as it confuses the student and tends to turn him off the metric system. It is true that we will have two systems for several years, but conversion charts are available if a person finds it necessary to use one. Perhaps students should be taught how to use conversion charts rather than memorize conversion factors. The time spent on memorizing conversion factors could be used more profitably on work within the metric system.

Testing

A short quiz at various points throughout the course forces the student to learn many of the necessary facts and skills. For example, if the student does not learn the names and values of some of the metric prefixes, it is difficult for him to visualize the metric system as the neat base ten system that it actually is. A test can be used to determine the direction the student should take. The teacher would then have a better idea of the student's strengths and weaknesses and could prescribe exercises or activities accordingly.

Integration

The metric system should not be taught merely as a separate unit. There are innumerable ways that the metric system can be incorporated throughout the curriculum. For example, perimeter, area, volume exercises, geometric constructions and mathematical problems can be done in metric units.

Drake (1974) writes that

"Metrication involves Science, Math, Social Studies, Home Economics, Industrial Arts-all areas of study. Introduce the metric system whenever linear, capacity and volume measurements are used." (p. 50)

Interrelated Topics

Bowles (1964) and Helgren (1967) suggest that the student should have a good understanding of place value and whole number operations before he is formally introduced to the metric system. Decimal fractions, rather than common fractions, should be emphasized since we will be using decimals much more than fractions after the metric conversion. It is also important for students to learn how to multiply and divide by 10, 100 and 1000 by moving the decimal point, as most of the work in the metric system is based on powers of ten.

Guidelines

Success for the changeover to the metric system will depend on

1. how well the guidelines are followed
2. the degree to which we provide appropriate experiences for maximum development of student understanding.

Helgren (1967), the NCTM Metric Implementation Committee (1974), Suydam (cited by Higgins, 1975) offer guidelines for the teaching of the metric system. In summary, these are the guidelines:

1. The metric system should be taught by itself.
2. Teach students to "Think Metric."
3. Teach linear measure first. Metric units of length are the basic units from which the units of mass and volume are derived.

4. Initial emphasis in instruction should be placed on teaching the fundamental units-metre, gram and litre and the common prefixes that indicate the multiples of ten.

5. Develop meaning and feeling for units through experiences centering around estimating and checking of the estimates.

6. Conversion factors should not have to be learned.

7. Use metric units at every opportunity in all subject-matter fields.

We are forced to "Think Metric." The system is responsive to current good practices in mathematics curriculum and teaching in the elementary and junior high school. Further the change allows us to involve our students in some actual experiences from which we as teachers and students can profit. It is up to the teachers to make sure that sound curriculum decisions regarding the system are made and that time and experience necessary for learning are provided.

CHAPTER III: PROCEDURE AND TEST INSTRUMENTS

The unit on length consisted of sixteen sections (See Appendix A). At the start, a pre-test and Connelly Taxonomized Attitude Scale were administered to 320 students in grade seven. The unit was taught in fifteen periods over a period of approximately two weeks by six teachers. After the completion of the unit, the post-test (original pre-test) and Connelly Taxonomized Attitude Scale were given. Both teachers and students were supplied with a copy of the unit. All teachers were given in-service training concerning the unit. The training consisted of (a) preview of the unit (b) how each section of the unit should be taught.

The suggested time allocation is listed for each topic and its quiz (See Appendix F).

1. Understanding Linear Measurement and Quiz (1 period)
2. Learning About Length and Quiz (1 period)
3. Learning About Units of Length and Quiz (½ period)
4. Equivalent Unit Lengths and Quiz (1 period)
5. Measuring Length and Quiz (½ period)
6. Drawing Line Segments and Quiz (½ period)
7. Metric Review-Sections 1-6 (1 period)
8. Student Activity (1 period)
9. Estimating Lengths and Quiz (½ period)
10. Drawing Line Segments By Estimation and Quiz (½ period)
11. Making a Metric Tape Measure (1 period)
12. Estimating and Measuring, and Quiz (1 period)

13. Working With Units of Length and Quiz (2 periods)
14. Using the Metric System and Quiz (2 periods)
15. Metric Review-Sections 9-14 (1 period)
16. Metric Crossword Puzzle (½ period)

In addition to the fifteen periods allocated for the lessons, a period was used for each of (a) introducing a film-strip on length in the metric system, (b) pre-test and Connelly Taxonomized Attitude Scale, and (c) the post-test and Connelly Taxonomized Attitude Scale.

To answer the first question, "Can the unit be effective in providing a gain in achievement on measurement in the metric system?", the experimenter administered a pre-test and post-test on measurement in the metric system (See Appendix B).

To answer the second question, "What is the effect of the unit on students' attitudes towards mathematics?", the experimenter performed a dependent t-test on the Connelly Taxonomized Attitude Scale as pre-test, post-test using Objective II items of that scale (See Appendix C).

To answer the third question, "What are the attitudes of teachers toward the experimental unit?", an experimenter-made questionnaire was administered to the six teachers at the end of the experimental period (See Appendix D).

To answer the fourth question, "How effective is the unit in helping students to reach each objective?", the experimenter first constructed a set of behavioral objectives for the experimental unit (See Appendix E). Then the experimenter constructed the pre-test, post-test on measurement in order to ascertain whether or not the behavioral objectives had been attained.

CHAPTER IV: ANALYSIS OF DATA

Student Achievement

The pre-test and post-test (original pre-test) used to measure the achievement of students on the experimental unit were constructed by the experimenter. The items on each test were designed to test whether the behavioral objectives had been met. Each item of the pre-test and post-test was assigned a point. The total possible score on each test was 28 points. Each score out of 28 was converted to percentage. This score represented the student's achievement on the experimental unit for each of the pre-test and post-test. A student's score was included if the student completed both tests. Approximately 91% of the students completed both tests. A gain in achievement was determined by the gain in mean score from pre-test to post-test. The mean score for achievement on the pre-test and post-test respectively was 33.1% and 81.8%. A gain of 48.7% on the mean score indicated that the students can achieve on the experimental unit.

Student Attitudes

The opinionnaire used to measure attitudes was the Connelly Taxonomized Attitude Scale designed by Dr. R. Connelly of Memorial University of Newfoundland. The reliability coefficient for the opinionnaire is .87. There are sixteen items on this instrument, each with five possible responses: strongly agree, agree, no opinion, disagree, strongly disagree. Items

1-6 were negatively stated and items 7-16 were positively stated.

The responses were scored as follows:

	Items 1-6	Items 7-16
Strongly agree	1	5
Agree	2	4
No opinion	3	3
Disagree	4	2
Strongly disagree	5	1

The highest possible score was 80 indicating a most positive attitude towards mathematics. The lowest possible score was 16 indicating a most negative attitude towards mathematics. A score of 48 was considered neutral.

The opinionnaire was administered before and after the teaching of the unit. A student's score was included if the student completed the opinionnaire at both times. Approximately 91% of the students completed both opinionnaires.

A dependent t-test for means was performed on the set of difference scores from these opinionnaires. A t-value of -0.43 indicated that there was no significant change in attitudes towards mathematics at the .05 level of significance, during the period in which the experimental unit was taught.

<u>Teacher Attitudes</u>

A short questionnaire of thirteen items was given to each teacher who taught the experimental unit. On the questionnaire teachers were asked to indicate their opinions regarding certain aspects of the experimental unit.

Responses to Question 1 were that three teachers indicated that the material was written for the average student while the other three teachers indicated that the material was appropriate for students of all abilities.

One teacher indicated that the material was easier to read and understand than other mathematical topics while five teachers indicated that the material was about the same level.

In Question 3, two teachers enjoyed teaching the experimental unit better than other mathematical topics and four enjoyed teaching it as well as the other topics.

Three teachers indicated that they would strongly recommend the materials to other metric teachers while three would recommend the materials.

Four teachers felt that they would not have any difficulty with the activity approach. One indicated that there would be definite trouble and another teacher would have some trouble.

Responses to Question 6 indicated that three teachers never and three teachers seldom sought aid from the other teachers and/or experimenter.

Four teachers used less time and two used about the same amount to prepare these lessons compared to other new topics. All teachers felt that the unit would have value for the students in the future. To five teachers the behavioral objectives were always clear while often clear to one teacher.

Two teachers strongly agreed and four teachers agreed that the activities helped them to begin to "Think Metric". The unit was rated excellent by one teacher and good by five teachers.

Positive aspects of the unit indicated by the teachers were as follows:

1. Its activity approach
2. Developed the ability to "Think Metric"
3. Students were required to estimate before actually measuring.
4. The easy steps for converting from one unit to another.
5. Comprehensive

Teachers also indicated that the following aspects of the experimental unit were done poorly:

1. Not enough emphasis placed on the larger metric units.
2. Lack of emphasis on basic methods of writing metric symbols and numerals.

Several additional comments were made. One teacher said that the students enjoyed estimating, in that they were interested in how close they were to the actual measurement. Another teacher indicated that more difficult problems were needed for honour students. Several teachers noticed that in making a metric tape students were hampered with the physical task of making the tape and lost sight of the real purpose for its construction (that of learning the sizes of the various metric units and their relationships to one another). It was also noted that the unit was taught too early in the school year.

Upon analyzing the responses of the teacher questionnaire several statements seem apparent:

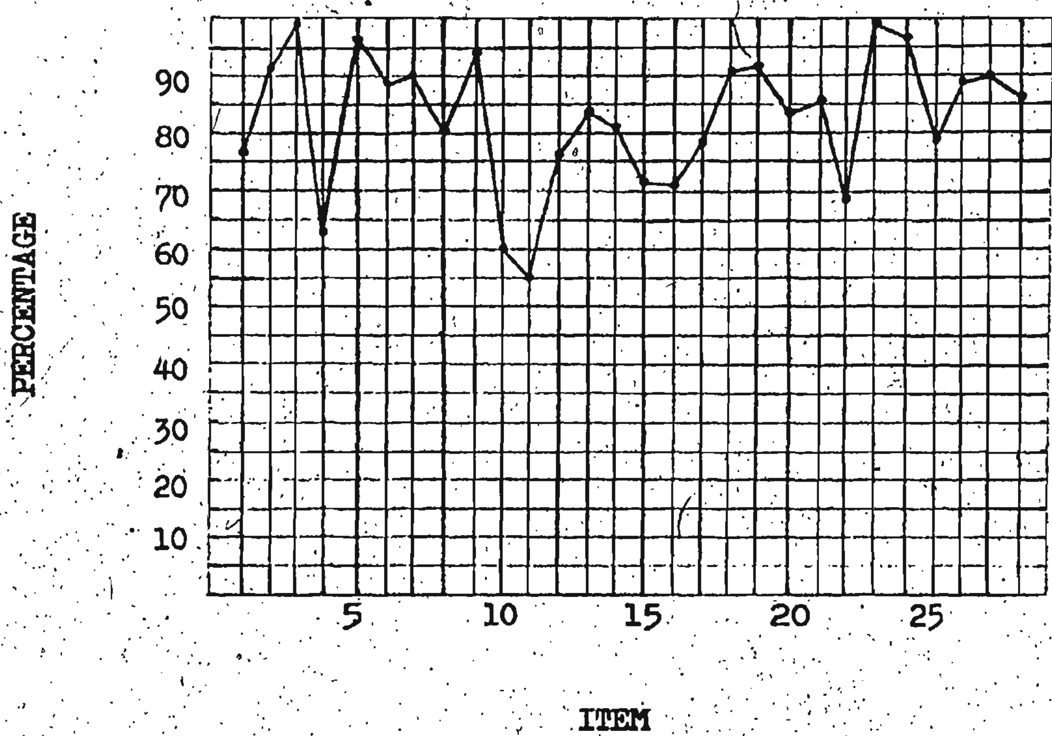
1. The experimental unit was written for average student.
2. The material was as easy to read and understand as other topics in mathematics.
3. The teachers enjoyed teaching the materials as well as the other topics.
4. The teachers would recommend the unit to other metric teachers.
5. Some teachers felt they would have difficulty at the beginning with the activity approach of teaching used in the unit.
6. Aid from other teachers and preparation of lessons was low.
7. The unit would have some value for the students in the future.
8. Behavioral objectives were generally clear.
9. The unit helped to "Think Metric."
10. All teachers rated the experimental unit as good.

<u>Item Analysis</u>

Each item of the achievement test of measurement was matched with a particular behavioral objective. A behavioral objective was considered met if the corresponding item on the achievement test was correctly answered by over 70% of the students who completed the test.

Figure 1

ITEM ANALYSIS



NOTE. An item was attained if it was answered correctly by over 70% of the students on the achievement (post) test.

According to Figure 1 four items on the achievement test were not correctly answered by over 70% of the students. The four items and their corresponding behavioral objectives were

Section	Behavioral objective	Test Item
II	A student should be able to list the relationships of the units of length to the metre.	In relation to the metre, millimetre means ____.
IX	At the end of this activity, a student should be able to estimate the length of a given line segment in centimetres within ½ cm.	Estimate the length of the line segment to the nearest centimetre. ____ cm ____________________ line segment
X	A student given the length in centimetres or millimetres should be able to draw line segments with a straightedge within 10% of the given length.	Using a straightedge, draw a line segment that you estimate as having a length of 28 mm.

Section	Behavioral Objective	Test Item
XIV	A student should be able to apply the units of length in the metric system.	Which is the better buy for the same type of rope? ____ (a) 2 m of rope for \$16.00 (b) 250 cm of rope for \$16.90

CHAPTER V: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the effectiveness of a unit in teaching measurement in the metric system to grade seven students.

To do this the experimenter considered the following questions:

1. Is the unit effective in providing a gain in achievement on measurement in the metric system?
2. What is the effect of the unit on students' attitudes towards mathematics?
3. What are the teachers' attitudes towards the experimental unit?
4. How effective is the unit in helping students to reach each objective?

The design of this study was pre-test, post-test with no control group. The study consisted of presenting a fifteen lesson unit on length in the metric system to 320 grade seven students in ten classes at MacDonald Drive Junior High School, St. John's. Materials for the unit were taken from <u>World of Metric-Activity Book</u> by S. E. Odegard and restructured by the experimenter.

The experimenter constructed a pre-test and post-test in order to determine the student's achievement on the unit. The pre-test was administered and the post-test was given after the fifteenth lesson. The items on the pre-test and post-test were identical but their order was changed. The items of the post-test were designed to test whether the behavioral objectives had been met. The Connelly Taxonomized Attitude Scale was given as a pre-test, post-test to determine the effect of the unit on student attitudes towards mathematics. An experimenter-made questionnaire was given to each of the six teachers who taught the unit in order to determine the attitudes of teachers towards the unit.

A gain in achievement was determined by the gain in the mean score from pre-test to post-test on measurement. A gain of 48.7% on the mean score indicated that the students can achieve on the experimental unit.

A dependent t-test for means was performed on the pre-test, post-test attitude scores of students. A t-value of -0.43 indicated that there was no significant change in the attitudes of students towards mathematics at the .05 level of significance during the teaching of the experimental unit.

From the questionnaire given to the teachers, responses indicated that

1. The unit was easy to read and appropriate for average students.

2. Teachers enjoyed teaching the unit and would recommend it to other metric teachers.

3. Some teachers felt they would encounter difficulty at the beginning with the activity approach of teaching used in the unit.

4. There was an indication that the unit would have some value for the students in the future.

5. Teachers indicated that the unit is an aid in "Thinking Metric."

A behavioral objective was considered met if its corresponding item on the achievement test was correctly answered by over 70% of the students. Four items out of 28 on the achievement post-test were not attained. Consequently, four behavioral objectives were not met.

<u>Conclusions</u>

The conclusions in this report pertain to the questions asked in the "Problem" section of the report.

Question 1. Is the unit effective in providing gain in achievement on measurement in the metric system?

Conclusion: A mean score gain of 48.7% on achievement indicated that students can achieve on the experimental unit.

Question 2. What is the effect of the unit on students' attitudes towards mathematics?

Conclusion: A t-value for means of -0.43 indicated that there was no significant change in attitudes of the students towards mathematics at the .05 level of significance during the teaching of the experimental unit.

Question 3. What are the teachers' attitudes towards the experimental unit?

Conclusion: All teachers indicated that the unit was easy to read and appropriate for average students. They enjoyed teaching the unit and would recommend it to other metric teachers. The unit was an aid to "Think Metric" and would be valuable to the students in the future.

Question 4. How effective is the unit in helping students to reach each objective?

Conclusion: The unit was effective in helping students to attain all but four of the behavioral objectives. The four behavioral objectives were

Section	Behavioral Objective
II	A student should be able to list the relationships of the units of length to the metre.
IX	At the end of this activity, a student should be able to estimate the length of a given line segment in centimetres within ½ cm.
X	A student given the length in centimetres or millimetres should be able to draw line segments with a straightedge within 10% of the given length.

Section	Behavioral Objective
XIV	A student should be able to apply the units of length in the metric system.

Recommendations

From the above study the experimenter has concluded that the unit on length in the metric system can be effectively taught to grade seven students. To anyone who decides to include a unit on length in the metric system in the grade seven mathematical program the experimenter would recommend the use of the experimental unit.

In using the experimental unit, the experimenter would recommend that:

1. The unit should be taught after the topic on decimals is completed so that the students can become more familiar with the place value system (1000, 100, 10, 1, 0.1, 0.01, 0.001).
2. Emphasis should not be placed on the larger metric units in grade seven but in grade eight.
3. There should be a revision of the unit used in the present study. More practice should be provided in
    1. Estimating
    2. Problem solving.

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APPENDIX A

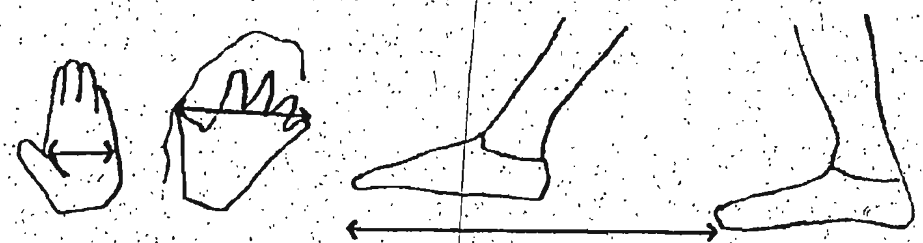
EXPERIMENTAL UNIT

<u>Section 1--Understanding Linear Measurement</u>[1]

Objective:

A student should be able to explain why a standard unit is necessary for measuring length.

Investigation:



1. Measure the width of your desk to nearest palm.

   ____ palms

2. Measure the length of your desk to nearest span.

   ____ spans

3. Measure the length of your classroom to nearest pace.

   ____ paces

Set the class up into five groups and compare the results in 1, 2, and 3 above.

Group Discussion:

Discuss each question below with your group and write the answer in the blank provided.

Did all your classmates get the same answer to each question? ____

[1]This section is a revision of a section from <u>World of Metric-Activity Book</u> by S. E. Odegard. p. 2.

Why? ____________________

As a group, what can you conclude about measuring distances? ____________________

Section 2--Learning About Length[2]

Objectives:

A student should be able to list

1. the units of length.
2. the corresponding symbols for the units of length.
3. the relationships of the units of length to the metre.
4. the basic unit of length in the metric system.
5. the units of length which are commonly used.

Units of Length

Unit	Symbol	Relation to Metre
kilometre	km	1000 m
hectometre	hm	100 m
decametre	dam	10 m
metre	m	1 m
decimetre	dm	0.1 m
centimetre	cm	0.01 m
millimetre	mm	0.001 m

The most common units of length are the kilometre, metre, centimetre and millimetre. The metre is the basic unit of length in metric system.

Section 3--Learning About Units of Length[3]

Objectives:

At the end of this activity, a student

1. when given a metre stick, should be able to identify

[2] Ibid., p. 10.
[3] Ibid., p. 11.

decimetre, centimetre and millimetre without error.

2. should be able to complete the following statements.

(a) 1 m = ____ dm

(b) 1 m = ____ cm

(c) 1 m = ____ mm

3. should be able to draw line segments with length of 1 mm, 1 cm and 1 dm.

Materials:

metre stick

Investigation:

Look at a metre stick. It is one metre long.

1. Find one millimetre on the metre stick.
2. Find one centimetre on the metre stick.
3. Find one decimetre on the metre stick.

Discussion:

1. (a) What is the symbol for millimetre? ____

   (b) Draw a line segment one millimetre long.

   (c) How many millimetres are there in one metre? ____

2. (a) What is the symbol for centimetre? ____

   (b) Draw a line segment one centimetre long.

   (c) How many centimetres are there in one metre? ____

3. (a) What is the symbol for decimetre? ____

   (b) Draw a line segment one decimetre long.

   (c) How many decimetres are there in one metre? ____

Section 4--Equivalent Unit Length

Objective:

At the end of this activity, a student with the aid of a metre stick should be able to express one unit of length (mm, cm, dm) as an equivalent unit of length (mm, cm, dm).

Materials:

metre stick

Discussion:

Using the metre stick, complete each of the following:

1. 2 cm= ____ mm
2. 4.5 cm= ____ mm
3. 3 dm= ____ cm
4. 4.2 dm= ____ cm
5. 60 cm= ____ dm
6. 28 cm= ____ dm
7. 40 mm= ____ cm
8. 40 mm= ____ dm
9. 61 mm= ____ dm
10. 101 mm= ____ cm
11. 243 mm= ____ dm
12. 965 mm= ____ cm
13. 965 mm= ____ dm

Section 5--Measuring Length[4]

Objectives:

A student should be able

1. to measure the lengths of given line segments and

[4]Ibid., p. 12.

objects in centimetres and in millimetres within 1 mm.

2. to discover the relationship 10 mm = 1 cm.

Materials:

centimetre ruler

Investigation:

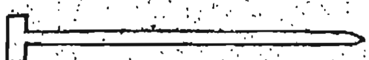
Measure each line segment first in centimetres and then in millimetres.

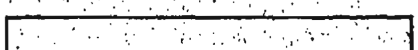
______________________ 1. a. ____ cm b. ____ mm

___________ 2. a. ____ cm b. ____ mm

_______________ 3. a. ____ cm b. ____ mm

Measure each object in centimetres and then in millimetres.

 4. a. ____ cm b. ____ mm

 5. a. ____ cm b. ____ mm

Discussion:

Compare the number of centimetres and millimetres in each of the above measurements.

There are ____ mm in one cm.

Section 6--Drawing Line Segments[5]

Objective:

A student should be able to draw line segments having the given lengths in millimetres, centimetres or decimetres within one mm of the correct measure.

Materials:

centimetre ruler

Investigation:

Using a centimetre ruler, draw line segments having

[5]Ibid., p. 13.

the given lengths.

1. 2 cm
2. 7 mm
3. 1 dm
4. 4 cm
5. 23 mm
6. 5.4 cm
7. 1.2 dm
8. 60 mm
9. 12.6 cm
10. 1.14 dm

Section 7--Metric Review-Sections 1-6

1. Which one below is a standard unit? ____
   (a) span (b) pace (c) metre (d) palm
2. The prefix kilo means ____
   (a) 10 (b) 100 (c) 1000 (d) 1
3. The basic unit of length in the metric system is ____.
4. Which one below is not a common unit of length? ____
   (a) centimetre (b) kilometre (c) millimetre
   (d) hectometre
5. The symbol for centimetre is ____.
6. In relation to the metre, millimetre means ____.
   (a) 0.1 m (b) 0.01 m (c) 0.001 m
7. mm is a symbol for ____.
8. Which segment on the right represents each below?
   (a) centimetre ____ 1. ________________________________

(b) millimetre ____ 2. _

(c) decimetre ____ 3. ___

9. In one metre, there are

(a) how many centimetres? ____

(b) how many millimetres? ____

(c) how many decimetres? ____

10. (a) 1 m= ____ mm (b) 1 m= ____ dm (c) 1 m= ____cm

11. 1 cm= ____ mm

12. (a) 2 cm= ____ mm (b) 4.1 dm= ____ mm (c) 63 mm= ____ cm

(d) 9.4 dm= ____ cm (e) 602 mm= ____ m

13. Measure each segment in millimetres.

(a) __________ ans: ____ mm (b) ________________ ans: ____mm

14. Measure each segment in centimetres.

(a) ______________ ans: ____ cm

(b) ___________________________ ans: ____ cm

15. Using a centimetre ruler, draw line segments having measures of:

(a) 4 cm

(b) 32 mm

(c) 1.4 dm

(d) 2.7 cm

(e) 1.13 dm

(f) 84 mm

Section 8--Student Activity[6]

Each student complete this activity and record the data.

Materials:

centimetre ruler, two dice, pencil, sheet of paper with

[6]Ibid., p. 13.

rectangle marked on it.

Rules:

Dice are to be located inside the rectangle (not outside or on the rectangle).

Procedure:

1. Toss two dice so they will land inside the rectangle.
2. Minimum distance to drop the dice is 10 cm.
3. Make a small dot on the paper at each of the two closest corners. Join the dots.
4. Measure the distance to the nearest millimetre between the two dots.
5. Record the distance in centimetres.
6. Do this for five tosses and record the total.

Data:

Tosses

1. ____ cm
2. ____ cm
3. ____ cm
4. ____ cm
5. ____ cm

Total: ____ cm

Outcome:

Set up five groups in the class. In each group, the smallest total is the winner. Also the group with the smallest average total is the winner.

Section 9--Estimating Lengths[7]

Objective:

At the end of this activity, a student should be able to estimate the length of a given line segment in centimetres within ½ cm.

Materials:

centimetre ruler

Procedure:

1. Estimate the length of each line segment in centimetres before distributing the centimetre ruler.
2. Measure the length of each line segment in centimetres using the centimetre ruler.
3. Subtract to find out if your estimated length was too long (+) or too short (-).

Segments	Estimated Length	Measured Length	Difference
________	____	____	____
____________________	____	____	____
________________	____	____	____
__________________	____	____	____
____	____	____	____

Section 10--Drawing Line Segments by Estimation[8]

Objective:

A student given a length in centimetres or millimetres should be able to draw line segments with a straightedge within 10% of the given length.

Materials:

centimetre ruler, strip of cardboard

[7]Ibid., p. 14.
[8]Ibid., p. 15.

Procedure:

1. Using the strip of cardboard, draw line segments that you estimate having the following lengths.

2. Using the centimetre ruler, measure to see how accurate each of your line segments is.

Investigation:

Length	Measured Length
(a) 4 cm	____
(b) 25 mm	____
(c) 1.5 cm	____
(d) 62 mm	____
(e) 6 cm	____

Section 11--Making a Metric Tape Measure[9]

Objective:

At the end of this activity, a student should have constructed a metric tape and used it to measure off a distance of 10 m.

Materials:

metre stick, adding machine tape at least one metre long, sharp coloured pencils or ballpoint pens.

Procedure:

1. Follow these steps to make a metric tape measure.

(a) Cut the piece of tape approximately one metre long.

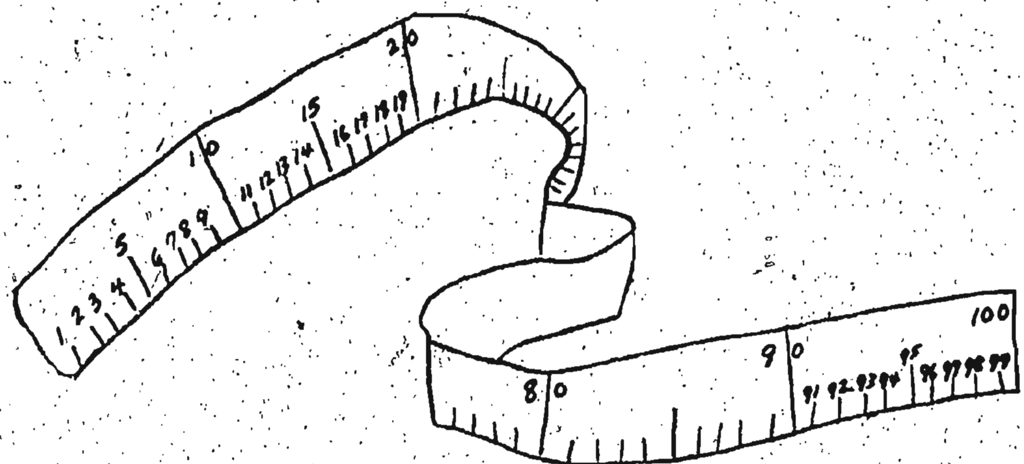
(b) Mark each of the 10 decimetre divisions from 10 to 100 with one colour.

[9] Ibid., p. 16.

(c) Mark each decimetre into 10 centimetres using another colour.

(d) Mark at least two centimetres into 10 millimetres using another colour.

(e) Label the centimetre divisions from 1 to 100 on your tape.



2. Using your metric tape, measure a distance of 10 metres.

Section 12--Estimating and Measuring[10]

Objective:

A student should be able to estimate within 10% error and measure the length of given body parts and various objects using metric units.

Materials:

centimetre ruler, metric tape

Procedure:

Complete part 1 first.

1. Estimate the length of each in centimetres.

[10]Ibid., p. 17.

2. Measure the length of each in centimetres or metres.

	Estimated Length (First)	Measured Length (Second)
(a) length of your thumb	____	____
(b) length of your desk	____	____
(c) width of this page	____	____
(d) distance around your waist	____	____
(e) height of the door	____	____
(f) length of your arm	____	____

<u>Section 13--Working with Units of Length</u>

Objectives:

A student, without the aid of a metre stick,

1. should be able to express one common unit of length equivalent to another by using the method below.

2. should be able to compare units of length using the symbol <, > or =.

Method:

Example I		Example II
14. cm= 140. mm	kilometre hectometre decametre metre decimetre centimetre millimetre	187. cm= 1.87 m

Steps

1. Locate each unit in the hierarchy.

2. Count the number of moves from one unit to another.

3. If you move up, move the decimal point in the number that many places to the left. (To express a small unit of

length as a large unit of length, you will receive fewer large units.)

4. If you move down, move the decimal point in the number that many places to the right. (To express a large unit of ldngth as a small unit of length, you will receive more small units.)

Section 13-- Working with Units of Length[11]

1. Complete each of the following:

(a) 48 mm= ____ cm= ____ m

(b) 25 km= ____ m= ____ cm

(c) 16 cm= ____ m= ____ mm

(d) 4.7 m= ____ cm= ____ mm

(e) 4 dm= ____ cm= ____ mm

(f) 2 m= ____ cm= ____ mm

2. Complete each of the following by placing the correct symbol <,> or = in the blank.

(a) 240 mm ____ 24 cm

(b) 1 m ____ 50 cm

(c) 62 cm ____ 602 mm

(d) 2.1 cm ____ .21 dm

(e) 38 m ____ .38 km

(f) 781 mm ____ .7 m

[11]Ibid., p. 19.

Section 14--Using the Metric System

Objective:

A student should be able to apply the units of length in the metric system.

1. What is the most suitable unit of length to use when referring to each of the following?

   (a) your height ____

   (b) distance between two cities ____

   (c) thickness of your ruler ____

   (d) length of school ____

2. If you can walk 6 km in one hour, how far can you walk in 7 hours? ____

3. An airplane is at a height of 2500 m. It descends at a rate of 100 m per minute. How many minutes will it take the airplane to reach the runway? ____

4. Joyce wants to make two pairs of curtains. Each curtain is to be 130 cm long when finished. For the heading and the hem on each curtain, she plans to allow 28 cm.

   (a) How many metres of material does she need? ____

   (b) The material can be bought only by the metre and half metre. What length should she order? ____

   (c) Find the cost of the material at $5.00 per metre and $3.00 per half metre? ____

5. Check which is the better buy.

   (a) 150 cm of terry cloth for $6.00 ____

   (b) 1 m of terry cloth for $4.50 ____

6. Rain had fallen for 15 hours. John went to his rain gauge and measured a total of 45 mm of rainwater. What was the average rate of rainfall per hour? ____

7. If a garden is 15 m by 20 m

(a) What is perimeter of the garden? ____

(b) If posts are placed in the ground every 5 m, how many posts will be used? ____

(c) If a post cost $2.08, what is the total cost for the posts? ____

(d) A wire fence is to be placed around the garden at a cost of $9.10 per meter. What is the cost of wire fence? ____

(e) What is the total cost for posts and wire fence? ____

Section 15--Metric Review-Sections 8-14

Do not give out the centimetre ruler until the estimated parts are finished.

1. Estimate the length of the given line segments allowing ½ cm.

Segments	Estimated Length	Measured Length	Difference
____________	____	____	____
________________	____	____	____

2. (a) Draw line segments with a strip of cardboard within 10% error.

(b) Using the centimetre ruler, measure each line segment.

Length	Measured Length
0.2 dm	____
17 mm	____

3. (a) Estimate the length of each in centimetres or metres within 10% error.

(b) Measure the length of each.

	Estimated Length	Measured Length
distance around your wrist	____	____
length of your foot	____	____
height of the door	____	____
width of corridor	____	____

4. Complete each of the following:

(a) 300 mm= ____ cm

(b) 2.4 dm= ____ mm

(c) 83 mm= ____ m

(d) 114 cm= ____ m

(e) 4 km= ____ m

(f) 61 cm= ____ dm

5. Place the correct symbol <, > or = in the blank.

(a) 4178 m ____ 4.178 km

(b) 71 m ____ 710 cm

(c) 861 cm ____ 8.61 mm

6. What is the most suitable unit of length to use when referring to each of the following?

(a) width of your book ____

(b) length of football field ____

7. Find the total length of two sticks in metres when each stick has a length of 14 dm and 178 cm. ____

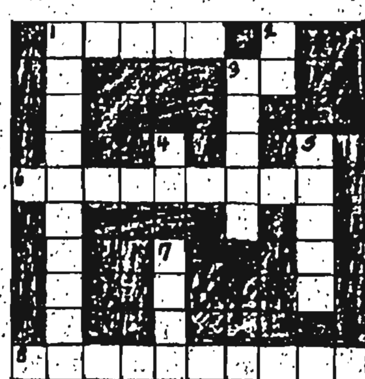
8. If you can walk 3 km in one hour, how many metres can you walk in 4 hours? ____

9. Check which is the better buy.

(a) 0.47 km of pavement costing $1700.00 ____

(b) 47000 cm of pavement costing $1700.00 ____

<u>Section 16--Metric Crossword Puzzle</u>[12]



Each clue represents either a metric unit, a prefix, or a symbol.

<u>Across</u>

1. Basic unit of length
3. One-hundredth of a metre
6. Unit for 1000 metres
8. Unit for 0.01 m

1. Unit for 0.001 m
2. Symbol for 1000 metres
3. Prefix meaning 0.01
4. Symbol for 0.001 m
5. Prefix meaning 100
7. Prefix meaning 0.1

[12] Ibid., p. 79.

APPENDIX B

ACHIEVEMENT TEST

PART A

Collect this part before giving out PART B. Do not use centimetre ruler for this part.

1. Explain why a standard unit is necessary for measuring length. ____

2. Place each of the following units of length in order from smallest to largest. Metre, decametre, kilometre, millimetre, hectometre, decimetre, centimetre

(a) __________ (b) __________ (c) __________

(d) __________ (e) __________ (f) __________

(g) __________

3. The symbol for kilometre is ____.

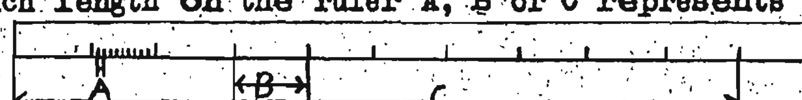
4. In relation to the metre, millimetre means ____.

5. The basic unit of length in the metric system is ____.

6. Underline the unit of length below which is not commonly used in the metric system.

millimetre, kilometre, hectometre, centimetre

7. Which length on the ruler A, B or C represents a decimetre?



8. 1 m= _____ mm

9. 1 cm= _____ mm

10. Estimate the length of the line segment to the nearest centimetre. _____ cm

____

line segment

11. Using a straight edge, draw a line segment that you estimate as having a length of 28 mm.

12. Estimate the length of the chalkboard to the nearest metre. ____

Complete each of the following:

13. 7 mm= ____ cm

14. 500 cm= ____ m

15. 4.9 km= ____ m

Place the correct symbol <, > or = in the blanks below.

16. 94 cm ____ 9.4 mm

17. 741 m ____ 7.41 km

Complete each of the following using an appropriate unit of length.

18. The length of the classroom is about 10 ____ long.

19. A hand span is about 15 ____ long.

20. If the cost of material is $6.00 per metre, the cost of 50 cm is ____.

21. If a car is driven at an average speed of 30 km per hour, how far can it travel in 4 hours? ____

22. Which is the better buy for the same type of rope? ____

(a) 2 m of rope for $16.00

(b) 250 cm of rope for $16.90

PART B

A centimetre ruler is required for this part.

23. Draw a line segment having a length of one centimetre.

24. 60 mm= ____ cm

25. Measure the length of the line segment below in millimetres. ____ mm

line segment

26. Measure the length of the line segment below in centimetres. ____ cm

line segment

Draw a line segment having the given length

27. 34 mm

28. 5.7 cm

APPENDIX C

STUDENT QUESTIONNAIRE

Name: ____________________

Class: ____________________

In the space provided write your name and class. This is not a test and will not be used in any way to produce a grade for you. The items on this instrument are statements about mathematics. For each item select a response which best describes your impression of the statement and place your response in the space provided at the left. The response choices are:

A - strongly agree
B - agree
C - no opinion
D - disagree
E - strongly disagree

____ 1. I have nothing but contempt for mathematics.

____ 2. I regard mathematics as a lasting tribute to man's ignorance

____ 3. I feel under great strain in a mathematics class.

____ 4. Mathematics makes me feel as though I'm lost in a jungle.

____ 5. Mathematics makes me feel uncomfortable.

____ 6. Mathematics is mainly pencil pushing.

____ 7. The very existance of humanity depends on mathematics.

____ 8. Mathematics may be compared to a great tree, ever putting forth new branches.

____ 9. Mathematics is a subject which I have enjoyed studying in school.

____ 10. I feel mathematics is the greatest means for increasing world's knowledge.

____ 11. Mathematics is stimulating to me.

____ 12. Working with various mathematical topics is fun.

____ 13. I see nothing wrong with learning a variety of mathematical topics.

____ 14. I feel mathematics makes other subjects easier to understand.

____ 15. Mathematics fascinates me.

____ 16. My general attitude towards mathematics is favorable.

APPENDIX D

TEACHER QUESTIONNAIRE

1. In general, I feel that the material is written for

____ (a) the above average student

____ (b) the average student

____ (c) the below average student

____ (d) all of the above students

in grade seven in the school.

2. Compared with other mathematical topics I have taught, this material is

____ (a) easier to read and understand

____ (b) at about the same level

____ (c) harder to read and understand

3. Compared with other mathematical topics in the prescribed textbook, I enjoyed teaching the experimental unit.

____ (a) less than

____ (b) as well as

____ (c) better than

4. I

____ (a) would strongly recommend

____ (b) would recommend

____ (c) am indifferent to

____ (d) would not recommend

this material to other metric teachers.

5. When you first began to teach this material did you feel you would have trouble with the activity approach?

____ (a) definitely

____ (b) somewhat

____ (c) not really

6. How often did you have to consult with other teachers because you had difficulty understanding the materials yourself?

____ (a) often

____ (b) sometimes

____ (c) seldom

____ (d) never

7. Compared with other new topics that you have taught, how much time was required to prepare the lessons?

____ (a) less time

____ (b) about the same

____ (c) more time

____ (d) considerably more

8. Do you feel that the materials will have any value for the students in the future?

____ (a) not at all

____ (b) maybe

____ (c) yes, definitely

9. The objectives were made clear.

____ (a) always

____ (b) often

____ (c) sometimes

____ (d) seldom

____ (e) never

10. The activities helped you to begin to "Think Metric."

____ (a) strongly agree

____ (b) agree

____ (c) neutral

____ (d) disagree

____ (e) strongly disagree

11. How would you rate the unit?

____ (a) excellent

____ (b) good

____ (c) fair

____ (d) poor

12. What do you consider were ~~the~~ positive aspects of this unit?

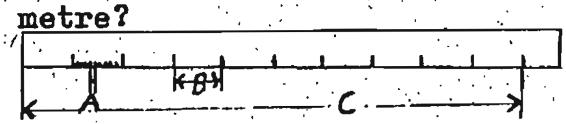
13. What aspects of this unit were poorly done?

Additional remarks:

APPENDIX E

BEHAVIORAL OBJECTIVES AND CORRESPONDING TEST ITEMS

Section	Behavioral Objective	Test Item
I	A student should be able to explain why a standard unit is necessary for measuring length.	1. Explain why a standard unit is necessary for measuring length.
II	A student should be able to list 1. the units of length. 2. the corresponding symbols for the units of length. 3. the relationships of the units of length to the metre. 4. the basic unit of length in the metric system. 5. the units of length which are commonly used.	1. Place each of the following units of length in order from smallest to largest. metre, decametre, kilometre, millimetre, hectometre, decimetre, centimetre. 2. The symbol for kilometre is ____. 3. In relation to the metre, millimetre means ____. 4. The basic unit of length in the metric system is ____. 5. Underline the unit of length below which is not commonly used in the metric system. millimetre, kilometre, hectometre, centimetre

Section	Behavioral Objective	Test Item
III	At the end of this activity, a student 1. when given a metre stick, should be able to identify a decimetre, centimetre and millimetre without error. 2. should be able to complete the following statements (a) 1 m= ____ dm (b) 1 m= ____ cm (c) 1 m= ____ mm 3. should be able to draw line segments with lengths of 1 mm, 1 cm, and 1 dm.	1. Which length on the ruler A, B or C represents a decimetre?  2. 1 m= ____ mm 3. Using a centimetre ruler, draw a line segment having a length of one centimetre.
IV	At the end of this activity, a student with the aid of a metre stick should be able to express one unit of length (mm, cm, dm) as an equivalent unit of length (mm, cm,dm).	1. Using a centimetre ruler, 60 mm= ____ cm.

Section	Behavioral Objective	Test Item
V	A student should be able 1. to measure the lengths of given line segments and objects in centimetres and in millimetres within 1 mm. 2. to discover the relationship 10 mm = 1 cm.	1. Using a centimetre ruler, measure the length of the line segment below in millimetres. ____ mm line segment 2. Using a centimetre ruler, measure the length of the line segment below in centimetres. ____ cm line segment 3. 1 cm = ____ mm
VI	A student should be able to draw line segments having the given lengths in millimetres, centimetres or decimetres within one mm of the correct measure.	1. Using a centimetre ruler, draw a line segment having the given length (a) 34 mm (b) 5.7 cm
VII	No objective	No test item
VIII	No objective	No test item

Section	Behavioral Objective	Test Item
IX	At the end of this activity, a student should be able to estimate the length of a given line segment in centimetres within ½ cm.	1. Estimate the length of the line segment to the nearest centimetre. ____ cm ______________________ line segment
X	A student given the length in centimetres or millimetres should be able to draw line segments with a straightedge within 10% of the given length.	1. Using a straightedge, draw a line segment that you estimate as having a length of 28 mm.
XI	At the end of this activity, a student should have constructed a metric tape and used it to measure off a distance of 10 m.	No test item
XII	A student should be able to estimate within 10% error and measure the length of given body parts and various objects using metric units.	1. Estimate the length of the chalkboard to the nearest metre.

Section	Behavioral Objective	Test Item
XIII	A student, without the aid of a metre stick, 1. should be able to express one common unit of length equivalent to another unit. 2. should be able to compare units of length using the symbol <, > or =.	1. Complete each of the following: (a) 7 mm = ____ cm (b) 500 cm = ____ m (c) 4.9 km = ____ m 2. Place the correct symbol <, > or = in the blanks below (a) 94 cm ____ 9.4 mm (b) 741 m ____ 7.41 km
XIV	A student should be able to apply the units of length in the metric system.	1. Complete each of the following using an appropriate unit of length (a) the length of the classroom is about 10 ____ long. (b) A hand span is about 15 ____ long. 2. If the cost of material is $6.00 per metre, the cost of 50 cm is ____. 3. If a car is driven at an average speed of 30 km per hour, how far can it travel in 4 hours? ____

Section	Behavioral Objective	Test Item
XIV		4. Which is the better buy for the same type of rope? ____ (a) 2 m of rope for $16.00 (b) 250 cm of rope for $16.90

APPENDIX F

QUIZZES

Section	Quiz
I	1. Explain why a standard unit is necessary for measuring length.

____

II		Unit	Symbol	Relation to Metre
	1.	centimetre	____	____
	2.	____	dm	____
	3.	____	____	0.001 m
	4.	____	m	____
	5.	kilometre	____	____

6. Which one below is not a common unit of length? ____
   (a) centimetre (b) metre (c) decametre (d) millimetre
7. The basic unit of length in the metric system is ____.

III

1. Draw a line segment of one centimetre.
2. One metre = ____ millimetres.
3. Draw a line segment of one decimetre.
4. One metre = ____ centimetres.
5. Identify one millimetre on a metre stick.
   Yes ____ No ____
6. Identify one decimetre on a metre stick.
   Yes ____ No ____
7. Identify one centimetre on a metre stick.
   Yes ____ No ____

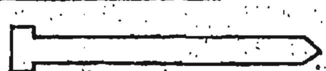
Section   Quiz

III   Questions 5, 6 and 7 are to be completed when the student is returning the quiz to the teacher.

IV
1. 14 mm = ____ cm
2. 2 dm = ____ mm
3. 6 cm = ____ mm
4. 30 cm = ____ dm
5. 280 mm = ____ dm
6. 1.3 dm = ____ cm
7. 14.8 cm = ____ mm
8. .7 m = ____ cm
9. 4.6 dm = ____ mm

V
1. Measure each in centimetres and millimetres.

(a) ______________________ 1. ____ cm 2. ____ mm

(b)  1. ____ cm 2. ____ mm

2. 1 cm = ____ mm

VI   Using a centimetre ruler, draw line segments having the given lengths.
1. 8 cm
2. 24 mm
3. 1.3 dm
4. 0.4 cm
5. 1.19 dm
6. 10.1 cm

Section	Quiz
VII	No quiz
VIII	No quiz
IX	Estimate the length of the given line segments allowing ½ cm error.

	Segments	Estimated Length	Measured Length	Difference
1.	______	____	____	____
2.	_______________	____	____	____
3.	__________	____	____	____
4.	__________________	____	____	____

X 1. Draw line segments with a strip of cardboard having less than 10% error.

2. Using a centimetre ruler, measure each line segment. Centimetre rulers will be distributed after part 1.

Length	Measured Length
(a) 35 mm	____
(b) 2 cm	____
(c) 80 mm	____
(d) 5.1 cm	____

XI No quiz

XII Complete part 1 before doing part 2.

1. Estimate each in centimetres or metres within 10% error.
2. Using centimetre ruler or metric tape, measure each.

Section | Quiz

XII

	Estimated Length	Measured Length
(a) Length of this page	____	____
(b) Length of your small finger	____	____
(c) width of the classroom door	____	____
(d) distance around your wrist	____	____
(e) width of the classroom	____	____

XIII 1. Complete each of the following:

(a) 40 mm = ____ cm

(b) 3 m = ____ cm

(c) 4.2 cm = ____ mm

(d) 3.1 dm = ____ m

(e) 59 cm = ____ dm

(f) 90 mm = ____ m

2. Place the correct symbol <, > or = in the blanks

(a) 25 cm ____ 2.5 mm

(b) 300 mm ____ 3 dm

(c) 0.4 m ____ 0.04 km

Section	Quiz

XIV 1. What is the most suitable unit of length to use when referring to each of the following?

(a) length of corridor ____

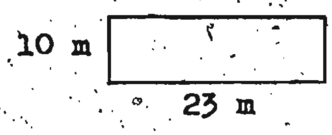
(b) diameter of a baseball ____

2. Which is the better buy for the same type of fishing line? ____

(a) 15 mm of fishing line for $2.00

(b) 1 cm of fishing line for $1.00

3. The perimeter of the block is ____.



4. In one hour, the rainfall was 13 mm. If that rate was continued, what would be the rainfall in 7 hours? ____

5. If a car can travel 1775 km in 25 hours, what was its average speed in km per hour? ____

APPENDIX G

MEDIA AIDS

<u>Books</u>

Allen, H. D. <u>Canada Measures Up-A Guide to Metric Practices</u>. Agincourt, Ontario: General Learning Press, 1973.

<u>Amusements in Developing Metric Skills</u>. Troy, Michigan:, Midwest Publications Company.

Asimov, I. <u>Realm of Measure</u>. Boston: Houghton Mifflin Company.

Bates, W. W. & Fullerton, O. <u>How to Think Metric</u>. Toronto, Ontario: Copp Clark Publishing Company.

Black, G. J. <u>Canada Goes Metric</u>. Toronto, Ontario: Doubleday Canada Limited, 1974.

Higgins, J. L. <u>A Metric Handbook For Teachers</u>. Virginia: National Council of Teachers of Mathematics, 1974.

Kelly, G. W. <u>Metric System Simplified</u>. New York: Sterling Publishing Company, 1973.

Odegard, S. E. <u>World of Metric-Activity Book</u>. Ginn and Company, 1975.

Troyer, J. <u>The Romance of Weights and Measures</u>. New York: The Viking Press, 1969.

Twentieth Yearbook of the National Council of Teachers of Mathematics. <u>The Metric System of Weights and Measures</u>. New York: Bureau Publications of Columbia University, 1948.

Williams, G. A Workshop on the Metric System of Measurement. Department of Education, Government of Newfoundland and Labrador, Canada, 1975.

Filmstrip

It's a Metric World. Addison-Wesley (Canada) Limited, 1975. (accompanied by cassette)

Overhead Transparencies

I.

Prefix	Meaning	Value
kilo	one thousand	1000
hecto	one hundred	100
deca	ten	10
deci	one tenth	0.1 or 1/10
centi	one hundredth	0.01 or 1/100
milli	one thousandth	0.001 or 1/1000

II.

Unit	Symbol	Relation to Metre
kilometre	km	1000 m
hectometre	hm	100 m
decametre	dam	10 m
metre	m	1 m
decimetre	dm	0.1 m
centimetre	cm	0.01 m
millimetre	mm	0.001 m

III. Centimetre ruler