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ABSTRACT

THE 4M COMPANY is an elementary school metric measurement program being developed in Hawaii. In previous years the K-4 portions of the program were pilot-tested; during the spring of 1977 the portions for grades 5 and 6 were pilot-tested with 932 students in 8 schools. Pretests, progress tests, and posttests were administered; pilot teachers recorded daily experiences; and tests on the customary system of measurement were administered to two control schools and one pilot school. On the posttest, 79.5% of the fifth graders and 81.3% of the sixth graders responded correctly to the items. Students using THE 4M COMPANY learned significantly more about the metric system and about the customary system than did students studying only the customary system. Test scores and analyses are reported; teacher comments are summarized by topic and grade level. Sample test items are also included. (MS)

Evaluation Report on the Pilot Testing of the Fifth and Sixth Grade Levels of THE 4M COMPANY, an Elementary School Metric Measurement Program

prepared by

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ABSTRACT

THE 4M COMPANY is an elementary school metric measurement program being developed by the University of Hawaii with the cooperation of the Hawaii State Department of Education. In previous years the kindergarten through grade four portions of the program had been pilot tested throughout the state. During the spring of 1977 the fifth and sixth grade portions of the program were pilot tested in the following schools with 932 students: Waiakeawaena School (Hawaii District); Iao and Wailuku Schools (Maui District); Kaneohe School (Windward Oahu); Waikiki School (Honolulu District); Eleele School (Kauai District); Honowai School (Leeward District); and Webling School (Central Oahu).

The evaluation design included the following procedures:

1) Pretests and posttests were administered to the students;

2) Progress tests were administered to the students during the instructional period in order to monitor student progress;

3) The pilot teachers recorded their daily experiences in a Log Book; and

4) Tests on the U.S. Customary system of measurement were administered to two control schools and to one pilot school.

The major results were as follows:

1) Across all items on the posttest, an average of 79.5% of the fifth graders and 81.3% of the sixth graders responded correctly to each item on the test;

2) Students studying THE 4M COMPANY learned significantly more about the metric system than regular students learned about the U.S. Customary system of measurement;

3) Students studying THE 4M COMPANY learned significantly more about the U.S. Customary system of measurement than did regular students.

Introduction

In April, 1972, the Hawaii State Legislature passed resolutions requesting the College of Education, University of Hawaii, to pilot test the teaching of the metric system in the schools of Hawaii. In response to these resolutions, the COE's CRDG established the Metric Project. Since existing textbooks did not give adequate attention to the metric system, a decision was made to develop and pilot test an elementary school metric measurement program.

The materials underwent a cycle of three trials with students: 1) at University Elementary School; 2) at Aliiolani Elementary School; and 3) at seven elementary schools, one from each district in the state. During the final pilot test, student performance was monitored, and teachers kept records of their experiences. The K-3 materials were pilot tested during the 1974-1975 school year, the fourth grade materials were pilot tested during the 1975-1976 school year, and the fifth and sixth grade materials were pilot tested in 1976-1977. This report summarizes the evaluation of the pilot testing of the fifth and sixth grade materials.

Description of Evaluation Procedures

In March, 1977, Metric Liaison Teachers from each of the seven pilot schools (one school in each of the state's seven school districts) met with the metric project staff to plan the pilot testing of the 5th and 6th grade portions of THE 4M COMPANY.

Each school was provided with metric instructional materials, student booklets, and teacher's guides, and the Metric Liaison Teachers conducted orientation sessions for teachers in their respective schools. The pilot teachers then presented the program to their students.

When the pilot testing was completed, the Liaison Teachers again met with the metric project staff for a debriefing session.

Four evaluation activities were undertaken as an integral part of the pilot testing:

1) A pretest and posttest were written to measure each objective in the program. These were administered before and after instruction; 2) teachers administered progress tests which were designed to monitor student learning at key checkpoints in the program; 3) teachers were provided with log books in which they recorded, on a daily basis, their reactions to the material; and 4) tests on the US customary system of measurement were written, and these were administered to fifth and sixth grade students in two elementary schools which had studied measurement from a regular mathemetics textbook. These same tests were administered to the fifth and sixth grade students of Waikiki Elementary School, one of the seven metric pilot schools.

This report summarizes the outcomes of these evaluation activities.

PART I: PRETESTS / POSTTESTS

Prior to instruction, pretests were administered to all students, and upon completion of instruction, posttests were administered to all students. The results are discussed below.

Grade Five

The fifth grade tests (see Appendixes A and B) contained twenty-five items. Both pretest and posttest were administered by the classroom teachers who read the test instructions from a prepared script. Table 1 summarizes the results.

Table 1

Fifth Grade Pretest/Posttest Scores

Item	N = 445 Percent of correct responses on pretest	N = 445 Percent of correct responses on posttest	Net Gain
1	75.8	92.4	+16.6
2	11.2	69.5	+58.3
3	32.6	75.3	+42.7
4	66.8	89.8	+23.0
5	82.1	97.6	+15.5
6	80.0	91.1	+11.1
7	22.4	65.5	+43.1
8	1.8	24.5	+22.7
9	91.5	95.9	+4.4
10	89.6	92.8	+3.2
11	82.3	92.2	+9.9
12	72.0	88.2	+16.2
13	34.0	78.0	+44.0
14	27.9	74.1	+46.2
15	71.1	85.6	+14.5
16	19.4	62.1	+42.7
17	11.7	78.2	+66.5
18	60.5	87.2	+26.7
19	27.0	85.6	+58.6
20	74.9	90.4	+15.5
21	88.8	95.2	+6.4
22	15.6	50.5	+34.9
23	88.6	95.9	+7.3
24	0.3	77.3	+77.0
25	50.4	54.0	+3.6
Average	51.1	79.5	+28.4%

The number of correct responses per item averaged 51.1% on the pretest and 79.5% on the posttest. This an average gain of 28.4% per item.

Seven items fell below the preestablished 75% success criterion. Of these, five were judged to be suitable objectives, and a more careful and thorough development of the concepts involved were added to the Teacher's Guide. The other two objectives - measure in centimeters (or millimeters) and record the results as hundredths (or thousandths) of a meter - were eliminated from the program.

Grade Six

The sixth grade test contained thirty items (see Appendixes C and D). Table 2 summarizes the results.

Table Two.

Sixth Grade Pretest/Posttest Scores

Item	N = 428 Percent of correct responses on pretest	N = 428 Percent of correct responses on posttest	Net Gain
1	37.9	48.1	+10.2
2	37.7	74.1	+36.4
3	33.9	88.4	+54.5
4	54.5	81.7	+27.2
5	64.7	93.7	+29.0
6	75.3	88.0	+12.7
7	52.2	83.1	+30.9
8	37.2	79.3	+42.1
9	32.8	70.7	+37.9
10	25.5	94.0	+68.5
11	42.1	78.1	+36.0
12	24.1	71.5	+47.4
13	83.0	97.9	+14.9
14	59.2	81.6	+22.4
15	91.9	96.0	+4.1
16	88.8	94.5	+5.7
17	47.7	77.4	+29.7
18	26.7	78.7	+52.0
19	59.4	89.0	+29.6

(continuation of Table 2)

Item	Percent of correct responses on pretest	Percent of correct responses on posttest	Net Gain
20	1.2	74.3	+73.1
21	23.4	73.6	+50.2
22	30.2	69.4	+39.2
23	42.4	71.3	+28.9
24	31.5	87.3	+55.8
25	55.2	75.1	+19.9
26	63.1	91.8	+28.7
27	9.4	50.0	+40.6
28	78.5	93.5	+15.0
29	67.6	91.4	+23.8
30	75.3	94.3	+19.0
Average	51.6	81.3	+29.7

The number of correct responses per item averaged 51.6% on the pretest and 81.3% on the posttest, an average gain of 29.7% per item.

Eight items fell below the 75% success criterion. The average pretest / posttest gain on these eight items was 44.2% (as compared to 29.7% for all other items). After analyzing the Pilot Teacher's log books, a decision was made to retain these objectives. The Teacher's Guide was rewritten to place greater emphasis on these objectives.

PART II: PROGRESS TESTS

Six progress tests were administered during the course of the pilot testing to provide interim glances of student progress. Each test covered from one to three sections of study.

Grade Five

The results of the fifth grade progress tests are summarized in Table 3. There were fourteen sections in the program, but no tests were administered for sections 1 and 11. Appendix E contains the fifth grade progress tests.

Table 3

Percent of Students Passing Each Item on the Progress Tests

Section	Sample Size	Item 1	Item 2	Item 3	Item 4	Item 5
2	N = 354	70.4	68.0	67.6	72.6	67.6
3	N = 354	95.0				
4	N = 362	66.6	41.8			
5	N = 362	94.5	89.5			
6	N = 327	94.2	87.8			
7	N = 353	78.2	73.7			
8	N = 353	70.3	87.0			
9	N = 353	64.0	66.9			
10	N = 365	93.7	84.2			
12	N = 365	88.0				
13	N = 365	89.6	93.5			
14	N = 365	98.7	95.7			

The average across all items is 80.0%.

Grade Six

The results of the sixth grade progress tests (see Appendix F) are summarized in Table 4. There were thirteen sections, but no progress test was administered for section 1.

Table 4

Percent of Students Passing Each Item on the Progress Tests

Section	Sample Size	Item 1	Item 2	Item 3	Item 4
2	N = 384	81.0	79.2	80.8	79.5
3	N = 384	92.2	74.5		
4	N = 384	96.6			
5	N = 425	81.9	79.3		
6	N = 425	91.8	90.4		
7	N = 396	83.6	74.0		
8	N = 396	97.5	84.6		
9	N = 396	67.2	85.2		
10	N = 381	87.5	77.7	74.9	
11	N = 381	71.4	59.1		
12	N = 398	62.9	62.9	65.4	
13	N = 398	79.9	79.9	60.1	

The average across all items was 78.8%.

PART III: PILOT TEACHER'S LOG BOOKS

Each pilot teacher was provided with a pilot teacher's log book. This section summarizes the results.

A. INFORMATION ABOUT THE PILOT CLASSES

	Fifth	Sixth
1. Total number of students in pilot test:	401	447
2. Total number of classes participating:	16	17
3. Ability level of students (# of classes)		
Above average	1	2
Average	3	5
Below average	3	3
Mixed	9	7
4. Percent of students who had participated in pilot test last year	70.2	0
5. Type of class		
Self-contained	7	11
Team	9	7
6. Number of teachers who had attended a 16-hour metric workshop.	7	8
7. Number of teachers who had not attended a 16-hour metric workshop.	9	9
8. Average number of minutes devoted to math each day.	47.4	47.9

B. AVERAGE NUMBER OF CLASS PERIODS SPENT ON EACH SECTION OF THE 4M COMPANY

Section	Fifth	Sixth
1	1.1	1.3
2	1.1	1.3
3	1.4	2.1
4	1.1	1.4
5	0.8	1.9
6	1.0	1.3
7	1.3	1.6
8	1.3	2.2
9	1.3	2.7
10	1.3	1.4
11	1.3	1.9
12	1.4	2.0
13	1.4	1.0
14	0.7	1.0
15	0.7	1.5
TOTAL	17.2	24.6

C. SECTION BY SECTION TEACHER COMMENTS

The log book provided space for teachers to comment on each section of the program. Their comments are summarized in this section.

Grade Five

Section 1: Introduction

Several teachers suggested that the students be given blank charts to fill in. This was done in the revision.

Section 2: Prefixes and Symbols

Students encountered some difficulty in distinguishing between upper case and lower case symbols. The revision contains a special page on this topic.

Section 3: Length

Six teachers mentioned the fact that students didn't know the names of the Hawaiian Islands. That was the purpose of the lesson, to teach a little geography.

Section 4: Decimals

This was the most difficult section in the program. Students in general were unable to measure in millimeters and record the results as a three place decimal. This objective has been eliminated from the program.

Section 5: Add and Subtract Decimals

This was an easy section for all students.

Section 6: Perimeter

Students had no difficulty with perimeter. They especially enjoyed measuring the figures taped on the floor.

Section 7: Area

Two teachers noted that students were confusing area with perimeter. Otherwise there were no problems.

Section 8: Multiplication of Decimals

Slower students encountered difficulty with multiplication. The revision recommends that teachers review multiplication before starting this lesson.

Five teachers made favorable comments on converting areas of countries from square miles to square kilometers.

Section 9: Division of Decimals

As with multiplication, slower students had difficulty. Others did well.

Section 10: Capacity

Two teachers noted that slower students made mistakes in converting milliliters to liters.

Section 11: 3-D Drawings

This was a popular section. Teachers tied it in with geometric concepts.

Section 12: Volume

Several teachers felt the concept was too difficult for students. However, students did well on this objective on the posttest.

Section 13: Mass

This was popular with the students, especially the activities involving the two-pan balance.

Section 14: Temperature

Four teachers mentioned that they did not use hot water because they felt it was dangerous. Otherwise the comments were all favorable.

Section 15: More Metric Prefixes

Teachers liked this lesson because it provided a good review of the entire program.

Grade Six

Section 1: Introduction

The students enjoyed the cartoons and puns, and in general they were able to understand how the metric system of prefixes work.

Section 2: Symbols

Most all students learned the symbols. A new page on correct symbols was added to the revised edition.

Section 3: Length

Several teachers expressed concern about the format of page 7. It has been redrawn to avoid confusion. One teacher said that students wanted more instruction in the workbooks.

Section 4: Perimeter

This section went well with nearly all students, and no major comments were made.

Section 5: Area

Several teachers noted that slower students had difficulty remembering how to use exponents. Page 24 caused some problems, and it has been deleted from the program. It was also suggested that the geometric figures be label A,B,C,D, etc. This has been done in the revised edition.

Section 6: 3-D Drawings

This section was very popular with students, but making 3-D letters was difficult for some students. This page was changed in the revised edition.

Section 7: Volume

Two teachers suggested more practice was needed. In the revised edition, a more careful development was included.

Section 8: Capacity

At this point one teacher commented that the cartoons were too violent. Students enjoyed this section, but took a lot of time.

Section 9: Mass

Students enjoyed the mass activities. Two teachers felt that page 43 confused some students. Three teachers mentioned that time was becoming a factor, and they were rushed.

Section 10: Add and Subtract Decimals

This was easy for nearly all students.

Section 11: Multiply and Divide Decimals

Three teachers requested more problems to work.

Section 12: Conversion

Ten teachers noted that some students encountered difficulty, especially when zeros had to be added to correctly place the decimal point.

Section 13: Temperatures

Several teachers felt that the boiling water was dangerous, and several did not do the salt experiment.

Section 14: More Prefixes

Five teachers said that students made up their own words using metric prefixes.

Section 15: Review

Several teachers again noted the time pressures. The review was considered by five teachers to be very helpful.

D. ANSWERS TO SPECIFIC QUESTIONS IN THE TEACHER'S LOG

Grade Five

IN GENERAL DID STUDENTS UNDERSTAND THE CHART ON PAGE 2?

Yes: 16 No: 0

IN GENERAL DID STUDENTS UNDERSTAND HOW PREFIXES ARE USED?

Yes: 15 No: 0

WERE STUDENTS ABLE TO CHOOSE AND MEASURE SEVEN (7) THINGS AS DIRECTED ON PAGE 7? Yes: 14 No: 0

WERE MOST STUDENTS ABLE TO USE THE CHARTS ON PAGES 8 AND 9?

Yes: 15 No: 0

ANY PROBLEMS WITH PAGE 10? IF SO, WHAT?

No: 7; cited problems naming the islands.

WERE MOST STUDENTS ABLE TO COMPLETE PAGE 11?

Yes: 16 No: 0

HOW ABOUT PAGE 13?

Yes: 15 No: 0

DID THE DEMONSTRATIONS WITH ADDING MACHINE TAPE GO OKAY?

Yes: 11 No: 0. Four teachers did not do the activity due to lack of time.

ON PAGES 26 AND 27 AREA IS USED TO EXPLAIN THE RULE FOR MULTIPLYING DECIMALS.

DO YOU THINK IT HELPED YOUR STUDENTS ANY?

Yes: 9 No: 5

ANY COMMENTS ON PAGE 30?

Four teachers liked this activity very much; three cited problems in finding the square miles; and four teachers said the numbers were too large.

ON PAGES 31 and 32 AREA IS USED TO EXPLAIN THE RULE FOR DIVIDING DECIMALS.

WAS THIS APPROACH HELPFUL?

Yes: 12 No: 3. Seven teachers noted that slower students had difficulty placing the decimal.

ON PAGE 35 WERE STUDENTS ABLE TO READ THE CALIBRATED CYLINDERS IN ml?

Yes: 15 No: 0

ANY PROBLEMS ON PAGE 37?.

Eight teachers said no, three cited difficulty in conversing ml to l.

WERE MOST STUDENTS ABLE TO COMPLETE PAGES 39 AND 40 SUCCESSFULLY?

Yes: 6 No: 5. Had to do a lot of explanation.

DO YOU THINK THIS SECTION IS HELPFUL FOR STUDENTS?

Yes: 12 No: 2

HOW DID PAGE 47 GO?

This page was challenging for brighter students, very difficult for slower ones.

Grade Six

SECTION 1 IS INTENDED TO ILLUSTRATE TO STUDENTS THAT THE METRIC SYSTEM IS A SIMPLER SYSTEM THAN THE ENGLISH SYSTEM. DID THIS MESSAGE GET ACROSS TO YOUR STUDENTS?

Yes: 13 No: 2

WERE MOST STUDENTS ABLE TO UNDERSTAND THE USE OF METRIC SYMBOLS?

Yes: 15 No: 2

ROUGHLY WHAT PERCENT OF YOUR STUDENTS UNDERSTOOD?

Average of 92%.

STUDENTS ARE ASKED TO MEASURE WITH THREE DIFFERENT UNITS; THE METER, CENTIMETER, AND MILLIMETER. DID THIS CAUSE ANY DIFFICULTIES FOR THE STUDENTS?

Yes: 1 No: 15

IF YES, HOW MANY STUDENTS HAD DIFFICULTY?

4 students.

PAGE 6 ASKS EIGHT (8) QUESTIONS ABOUT PAGE 5. ANY DIFFICULTIES HERE?

Yes: 7 No: 8

PAGES 9, 10, AND 11: WERE STUDENTS ABLE TO READ DISTANCES CORRECTLY FROM THE CHARTS?

Yes: 12 No: 3

ON PAGE 14 STUDENTS WILL HAVE TO USE A RULER. DID STUDENTS HAVE DIFFICULTY WITH THIS PAGE?

Yes: 2 No: 4

PAGE 15 WAS A CHALLENGE. HOW DID STUDENTS DO WITH IT?

Most teachers thought it was a good page.

ON THE BOTTOM PROBLEM OF PAGE 17, WERE STUDENTS ABLE TO FIND THAT B WAS LARGER THAN A?

Yes: 15 No: 0

WERE STUDENTS ABLE TO USE A RULER TO FIND THE AREAS ON PAGE 21?

Yes: 12 No: 0

DID PAGE 22 POSE ANY PROBLEMS? IF SO, WHAT?

No: 10; two teachers mentioned computational problems.

DID PAGE 24 POSE ANY PROBLEMS? IF SO, WHAT?

No: 10

WERE STUDENTS ABLE TO COMPLETE PAGES 25 AND 26 CORRECTLY?

Yes: 12 No: 1

IN GENERAL, WERE STUDENTS ABLE TO DETERMINE VOLUME FROM 3-D DRAWINGS?

Yes: 11 No: 2

IN GENERAL, HOW DID THE STUDENTS DO ON PAGE 40?

Eleven favorable responses.

ANY COMMENTS ON PAGE 42?

Three teachers noted difficulties.

ANY COMMENTS ON PAGE 43?

Three teachers noted difficulties.

WERE STUDENTS ABLE TO READ THE DECIMALS ON PAGE 44?

Yes: 15 No: 0

ANY PROBLEMS ON PAGE 45?

There were 10 no responses; one teacher cited labeling as a problem.

HOW MANY STUDENTS WERE ABLE TO FOLLOW THE DEVELOPMENT ON MULTIPLICATION, PAGES 49-52?

most of them: 13 about half: 2 hardly any of them: 0

HOW MANY STUDENTS WERE ABLE TO FOLLOW THE DEVELOPMENT ON DIVISION, PAGES 53-55? all: 1 most: 6 about one-half: 4

HOW DID THE EXPERIMENT OF PAGE 61 GO?

Four teachers said it was okay; one thought it was excellent, and four did not do it due to a lack of time.

E. RESULTS OF THE SUMMARY QUESTIONAIRE

Grade Five

	Excellent	Good	Fair	Poor	Comments:
Children's Workbooks:					
General Appearance of pages	4	12	0	0	
Difficulty-level for my class	1	11	1	0	too easy-0 about right-12 too difficult-2
Number of problems per concept	0	5	4	0	too many-0 too few-10
Teacher's Manuals:					
Visual clarity (pictures, organization, etc.)	4	11	1	0	
Verbal clarity (language, directions, etc.)	3	13	0	0	
Statements of objectives	4	12	0	0	
Suggested procedures, activities	2	13	1	0	
Measuring exercises	2	11	3	0	
Order of lessons	4	12	0	0	
Curriculum:					
Flexibility of curriculum for children of different abilities, interests, etc.	0	12	4	0	
Children's interest during use of materials	4	11	1	0	
Metric equipment and other aids	2	11	2	0	
Adequacy of program for teaching metric measurement concepts.	3	12	0	0	

ADDITIONAL QUESTIONS

1. Was your training adequate to prepare you for the task of teaching THE 4M COMPANY? Yes: 13 No: 1

2. Should THE 4M COMPANY be placed on the DOE instructional material list?

Yes: 13 No: 0

Grade Six

	Excellent	Good	Fair	Poor	Comments:
Children's Workbooks:					
General appearance of pages	6	10	0	0	
Difficulty-level for my class	1	4	2	0	too easy-5 about right-7 too difficult-3
Number of problems per concept	1	3	4	0	too many-0 too few-9
Teacher's Manuals:					
Visual clarity (pictures, organization, etc.)	2	12	2	0	
Verbal clarity (language, directions, etc.)	1	15	1	0	
Statements of objectives	3	13	1	0	
Suggested procedures, activities	2	14	1	0	
Measuring exercises	4	12	0	0	
Order of lessons	7	10	0	0	
Curriculum:					
Flexibility of curriculum for children of different abilities, interests, etc.	1	14	1	0	
Children's interest during use of materials	9	9	0	0	
Metric equipment and other aids	8	8	0	0	
Adequacy of program for teaching metric measurement concepts.	7	8	1	0	

ADDITIONAL QUESTIONS

1. Was your training adequate to prepare you for the task of teaching THE 4M COMPANY? Yes: 13 No: 2

2. Should THE 4M COMPANY be placed on the DOE instructional materials list?

Yes: 14 No: 0

F. REMARKS ON REVISION

The evaluation identified several areas where revision was needed. The major changes are listed below.

Grade Five

1. A brief section on "spelling" and "symbols" was added to the introduction of the Teacher's Guide.

2. Student Progress Tests were included in the Teacher's Guide.

3. The Suggested Procedures and activities sections were revised in an attempt to strengthen areas of weakness and detected by the Post-tests and teacher comments.

4. Section 4, "Decimals; Measuring and Writing", was changed to simply "Decimals". The original objective called for the students to measure with a centimeter (or millimeter) ruler and record the measurement as hundredths (or thousandths) of a meter. Students did so poorly on this objective that it was eliminated. It was replaced with the following objective: "Given a measurement in decimeter, centimeter, or millimeter, express it in terms of meters".

5. For practical reasons the number of pages was increased from 60 to 64.

6. The equipment list was trimmed to make the program less expensive to install.

Grade Six

1. A brief section on "spelling and symbols" was added to the introduction of the Teacher's Guide.

2. Student Progress Tests were added to the Teacher's Guide.

3. The "Suggest Procedures and Activity" sections of the Teacher's Guide were rewritten in an attempt to strengthen the weaknesses detected by the posttests and teacher comments. For example, a greater emphasis

was placed upon the correct usage of symbols and on converting from one metric unit to another.

4. A page with clinical thermometers - which show from 35 to 43°C - was added to the student booklet.

5. For practical reasons, the number of pages were reduced from 68 to 64. This was accomplished by deleting nonessential pages.

6. The equipment list was trimmed to make the program less expensive to install.

PART IV: TESTS ON U.S. CUSTOMARY SYSTEM OF MEASUREMENT

In addition to knowing how well students performed on each metric objective, we wanted to know if THE 4M COMPANY was providing adequate instruction in measurement. That is, were students studying THE 4M COMPANY learning as much about metrics as regular students were learning about the U.S. Customary System of Measurement?

In an attempt to answer this question, the fifth and sixth grade metric posttests were converted to tests on the U.S. Customary System. Each metric item was converted to a similar item using U.S. Customary units. To ensure fairness, concepts and skills from regular fifth and sixth grade math textbooks were used. The tests appear in Appendixes G and H.

The tests were administered to the fifth and sixth grade students at two elementary schools in Honolulu which teach the U.S. Customary System as part of their regular mathematics instruction. The results are summarized in Table 5.

Table 5

Metric Student's Performance on Test of the Metric System/Regular Student's Performance on Test of the U.S. Customary System

Percentage of correct responses by item:

	Grade Five		Grade Six	
Item	metric N = 445	regular N = 142	metric N = 428	regular N = 143
1	92.4	68.3	48.1	40.6
2	69.5	75.3	74.1	53.8
3	75.3	59.9	88.4	56.6
4	89.8	76.1	81.7	74.1
5	97.6	74.6	93.7	88.8
6	91.1	46.5	88.0	69.2
7	65.5	35.9	83.1	88.8
8	24.5	21.1	79.3	28.7
9	95.9	92.3	70.7	35.0
10	92.8	88.0	94.0	11.2
11	92.2	59.2	78.1	71.3
12	88.2	60.6	71.5	18.2
13	78.0	43.7	97.9	39.9
14	74.1	35.9	81.6	58.7
15	85.6	73.2	96.0	86.7
16	62.1	38.0	94.5	84.6
17	78.2	4.2	77.4	44.8
18	87.2	52.1	78.7	25.9

(Table 5 continued)

	Grade Five		Grade Six	
	metric	regular	metric	regular
Item				
19	85.6	31.7	89.0	90.9
20	90.4	66.2	74.3	6.3
21	95.2	93.0	73.6	25.9
22	50.5	23.2	69.4	32.2
23	95.9	93.0	71.3	88.8
24	77.3	2.8	87.3	82.5
25	54.0	46.5	75.1	45.5
26			91.8	62.2
27			50.0	46.9
28			93.5	77.6
29			91.4	87.4
30			94.3	93.7
Average Percentage	79.5	45.5	81.3	57.2

For both the fifth and sixth grades, students studying metrics in THE 4M COMPANY outperformed students studying the U.S. Customary System in regular textbooks. At the fifth grade level, an average of 79.5% of the students studying THE 4M COMPANY responded correctly to each item, but only 45.5% of the other students responded correctly to the items on the U.S. Customary System. At the sixth grade level, the metric students outperformed the other students 81.3% to 57.2%.

On the basis of this data, it seems safe to conclude that students studying THE 4M COMPANY learn more about metrics than regular students learn about the U.S. Customary System.

A further question arose: If students learn metric, will they be at a disadvantage in dealing with U.S. Customary units during the transition from the U.S. Customary System to the metric system?

In an attempt to answer this question, on the U.S. Customary units which were administered to the fifth and sixth grade students of Waikiki Elementary School, one of the seven metric pilot schools, the results are summarized in Table 6.

Table 6

Metric Student's Performance on Test of U.S. Customary System/
Regular Student's Performance on Test of U.S. Customary System

	Grade Five		Grade Six	
Item	metric N = 54	regular N = 142	metric N = 42	regular N = 143
1	68.5	68.3	47.6	40.6
2	75.9	75.3	54.8	53.8
3	42.6	59.9	76.2	56.6
4	81.5	76.1	69.0	74.1
5	85.2	74.6	95.2	88.8
6	44.4	46.5	92.9	69.2
7	27.8	35.9	95.2	88.8
8	16.7	21.1	85.7	28.7
9	96.3	92.3	69.0	35.0
10	94.4	88.0	85.7	11.2
11	92.6	59.2	78.6	71.3
12	79.6	60.6	50.0	18.2

(Table 6 continued)

Item	Grade Five		Grade Six	
	metric	regular	metric	regular
13	74.1	43.7	64.3	39.9
14	38.9	35.9	81.0	58.7
15	81.5	73.2	100	86.7
16	38.9	38.0	100	84.6
17	0	4.2	78.6	44.8
18	40.7	52.1	71.4	25.9
19	88.9	31.7	95.2	90.0
20	83.3	66.2	19.0	6.3
21	100	93.0	78.6	25.9
22	31.5	23.2	54.8	32.2
23	88.9	93.0	100	88.8
24	5.6	2.8	95.2	82.5
25	55.6	46.5	76.2	45.5
26			83.3	62.2
27			73.8	46.9
28			95.2	77.6
29			92.9	87.4
30			100	93.7
Average Percentage	61.3	45.5	78.7	57.2

The metric students outperformed the regular students: 61.3% to 45.5% at the fifth grade level, and 78.7% to 57.2% at the sixth grade level. A surprising result!

It thus appears that students studying the metric system in THE 4M COMPANY actually learn more about the U.S. Customary System of measurement than do students studying U.S. Customary units in regular mathematics textbooks. Why should this be so?

In 1970, the U.S. Metric Study Interim Report on Education found that the treatment of measurement in existing elementary school mathematics textbooks was woefully inadequate. The results of this study appear to support that observation.

PART V: DISCUSSION

The results of the pilot tests are encouraging: An average of about 80% of the students responded correctly to the test items on the posttest, and the students outperformed regular students, even on tests on the U.S. Customary System of measurement.

In addition to these positive outcomes, several other interesting facts should be mentioned. Because the metric system is decimal in nature, THE 4M COMPANY teaches computation with decimals as a practical application of metric measurement. Students who had studied THE 4M COMPANY outperformed regular students as follows:

Topic	Fifth Grade 4M COMPANY Students	Regular Fifth Grade Students	Sixth Grade 4M COMPANY Students	Regular Sixth Grade Students
Addition of decimals	95.9	92.3	96.0	86.7
Subtraction of decimals	92.8	88.0	94.5	84.6
Multiplication of decimals	85.6	73.2	77.4	44.8
Division of decimals	62.1	38.0	78.7	25.9

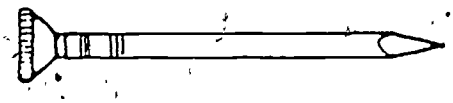
The differences are particularly large at the sixth grade level on the multiplication and division problems.

A unique feature of THE 4M COMPANY is that it teaches students to draw three dimensional figures as preparation for studying volume. When asked to draw a three dimensional box (or rectangular solid), 88.9% of THE 4M COMPANY fifth grade students were able to do so, but only 31.7% of the regular fifth grade students were able to do so. At the sixth grade level, the difference was greater, 85.7% to 11.2%.

Thus, THE 4M COMPANY teaches other valuable skills in addition to measurement skills.

Appendix A: Sample of items on Fifth grade pretest

9. Use your millimeter ruler to find the length of this nail. Record your answer in decimal form as thousandths of a meter.



_____ m

10. Add.

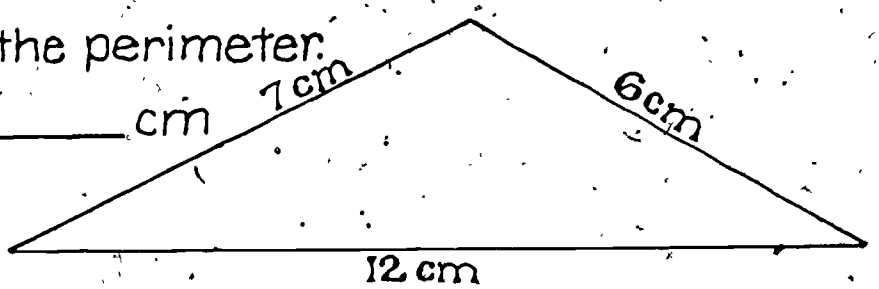
$$\begin{array}{r} 1.325 \\ +2.142 \\ \hline \end{array}$$

11. Subtract.

$$\begin{array}{r} 3.579 \\ -1.232 \\ \hline \end{array}$$

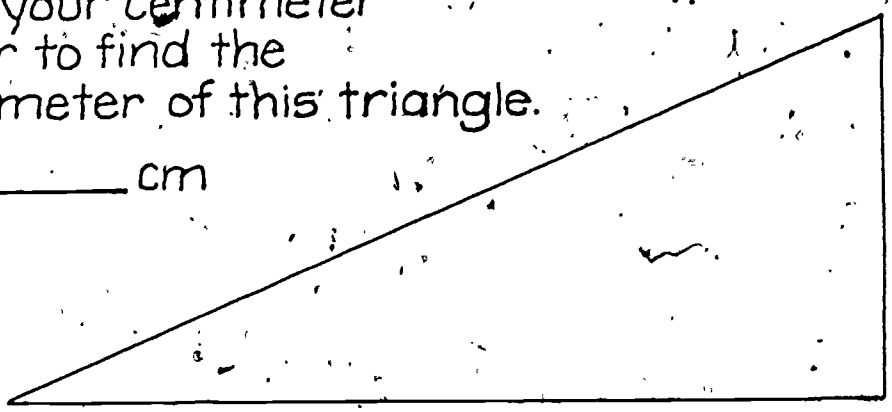
12. Find the perimeter.

_____ cm



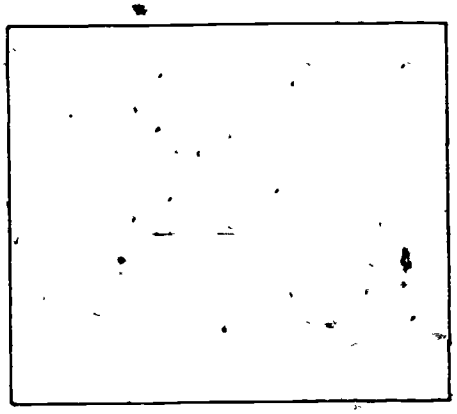
13. Use your centimeter ruler to find the perimeter of this triangle.

_____ cm



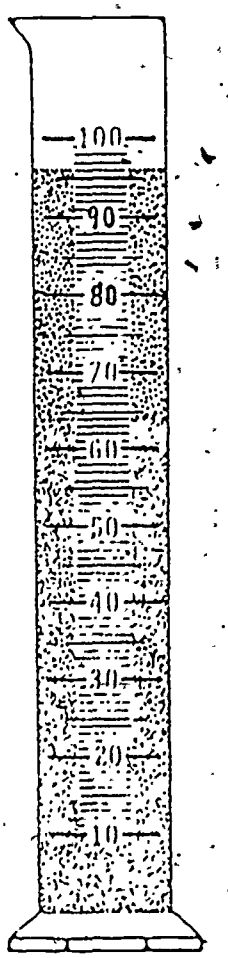
Appendix B: Sample of items on
Fifth grade posttest

14. Use your ruler to find the area. Area= _____ cm^2



15. 2.135×4

16. $5\overline{)2.675}$



17. 4675 mL = _____ L

18. How much water?

_____ mL

Appendix C: Sample of items on Sixth Grade pretest

Write the symbols for these units.

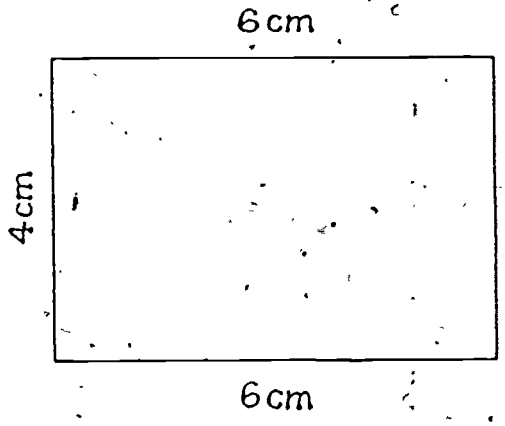
1. kilometer _____
2. hectoliter _____

Write the units for these symbols.

3. mg _____
4. cm _____
5. Circle the best unit for measuring the distance from New York to Hilo.

mm cm m km

6. Determine the perimeter.



_____ cm

7. Circle the best unit for measuring the area of this floor.

km^2 m^2 cm^2

Appendix D: Sample of items on Sixth Grade posttest

14. Write the next four decimals.

0.559				

15. $\begin{array}{r} 1.235 \\ +\ 2.132 \\ \hline \end{array}$

16. $\begin{array}{r} 2.845 \\ -\ 1.123 \\ \hline \end{array}$

17. $\begin{array}{r} 3.46 \\ \times\ \ 0.5 \\ \hline \end{array}$

18. $1.2\overline{)2.532}$

19. Circle the best unit for weighing an elephant.

mg g kg

20. For human beings, what is the normal body temperature? _____ C

Appendix E: Sample of items on
Fifth grade Progress Tests

Section 2: metric prefixes and symbols

1. Draw lines to connect each prefix to its corresponding value.

centi	1000
deci	100
deka	10
hecto	0.1
kilo	0.01
milli	0.001

Write the symbol.

2. decimeter _____
3. milligram _____

Write the units for these symbols.

4. km means _____
5. cL means _____

Appendix F: Sample of items on
Sixth grade Progress Tests

Section 10: Add/Subtract Decimals

1. Add.

$$\begin{array}{r} 5.347\text{m} \\ +\,2.401\text{m} \\ \hline \end{array}$$

2. Subtract:

$$\begin{array}{r} 9.851\text{m} \\ -\,6.237\text{m} \\ \hline \end{array}$$

3. Fill in the next four decimals.

5.998				

Section 11: Multiply/Divide Decimals

1.
$$\begin{array}{r} 3.6 \\ \times\ 5.2 \\ \hline \end{array}$$

2. $0.23\overline{)2.875}$

Appendix G: Sample of items on Fifth grade test on U.S. Customary System of Measurement

1. Write the word your teacher reads. _____

2. Draw lines to connect each prefix to its corresponding value.

1 yard	4 quarts
1 foot	12 inches
1 mile	5280 feet
1 gallon	36 inches
1 pint	2 cups

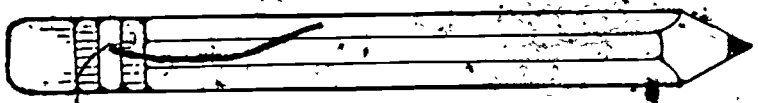
Write the symbol.

3. gallon _____

Write the unit.

4. lb. means _____

5. Use your ruler to measure the pencil.



_____ in.

6. Use your ruler to measure the insect.

_____ in.

Appendix H: Sample of items on Sixth grade test on U.S. Customary System of Measurement

Write the symbols for these units.

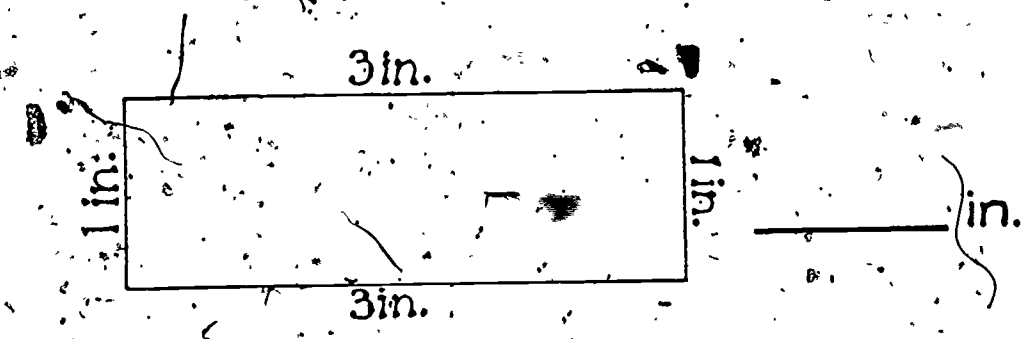
1. pounds _____
2. feet _____

Write the units for these symbols.

3. oz. _____
4. mi. _____
5. Circle the best unit for measuring the distance from New York to Hilo.

in. yd. mi.

6. Determine the perimeter.



7. Circle the best unit for measuring the area of this floor.

sq.in. sq.ft. sq.mi.