DEVELOPMENT OF INSTRUCTIONAL MATERIAL TO IMPROVE MIDDLE SCHOOL RULER READING

BY

Karen A Schrage

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Investigation Advisor

The graduate School
University of Wisconsin-Stout
December, 2000The Graduate School

University of Wisconsin-Stout
Menomonie, WI 54751

ABSTRACT

Schrage Karen A.
(Writer) (Last Name) (First) (Initial

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Over the years, teachers have complained about the students' inability to use a ruler. Nationwide mathematics tests have confirmed that half of eighth grade students can not read a ruler more accurately than one quarter of an inch. This research study tested the capability of a self-developed teaching aid to improve ruler- reading skills in middle school students.

This quantitative study began with a pilot test using a self-developed ruler reading assessment. This assessment was used with two classes of eight grade students at South Middle School, Eau Claire, Wisconsin. The results of the pilot study gave direction to the type of teaching aids needed to improve ruler-reading skills in middle school. The teaching aids were developed. A pretest and posttest were administered to two six-grade graphic communication classes at Chippewa Falls Middle School. The teaching aids were used as a self-paced homework program. The difference between the pretest and the posttest indicated the amount of skills learned with ruler reading.

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Introduction

Background of the Problem

Measurement, which contains both a number and a unit of measure, is a concept that is used daily. It is important for measurement to be done accurately. The Mars Climate Orbiter, which cost $125 million, did not function correctly in space because educated scientists mixed up the English and metric measurements (Fordahl, 1999). This is an example of a costly mistake involving a simple measurement concept.

Measurement is used extensively in government, industry, and business as well as in our homes and in our leisure activities. The above example demonstrates the importance of measurement in the space program. In industry, measurement is used in design, production, quality control, packaging, and shipping. In local business, the clerk needs to be able to measure chain and plastic sheeting at the hardware store, vacuum tubing and roll pins at the auto store, lumber and nails at the lumberyard, or fabric and trim at the quilt shop. In our homes we use measurement to determine where to hang a picture, if a new car will fit in the garage, and how wide to buy a window shade. Hobbies that involve making an object, such as woodworking, making models, sewing, and quilting, often require extensive measuring skills.

In our middle schools linear measurement is used in art, science, math, and technology education. Many teachers admit that their students are unable to read a ruler properly. In talking to the teachers, most have avoided the problem because of frustration in trying to teach ruler-reading skills. One art teacher explained that he found measuring so frustrating in his classroom, that he avoided measurement in his lesson plans. A math

teacher admitted that some of his students could not read a ruler, but felt that he needed to move on in the math curriculum in order to complete the assigned materials. Another math teacher admitted that she spent more time on understanding the concept of measuring units using customary units and metric units and the conversion between the two systems than she spent on teaching the use of the ruler. The technology teacher assisted students with learning ruler reading, but she did not have a lesson plan in place that broke the task down into small steps. When she presented the subject of measuring to the students, they acted as if they were bored.

Many different methods have been used to teach students to read a ruler, yet efficiency and accuracy in reading a ruler escapes them. This maybe because the students did not truly understand the concepts when they were taught to them or that they just forgot the skill when it came time to use it again. Reading a ruler involves eye-hand coordination, spatial relationships, formalization, and estimating. Ruler reading has several different sub-concepts that must be master in order to be successful at measuring. Because students learn in different ways, it may take several different teaching strategies in order to teach all of the students in the classroom how to read a ruler. When eighth grade students are presented with the topic of ruler reading, they act bored and complain that they know this stuff, yet the problem remains that many middle school students cannot read or use a ruler.

"Forty-seven percent of the 13-year-olds could not measure the length of a pencil to the nearest quarter of an inch" (Carpenter et. al., 1980, p. 45). In a more complex situation about half of the seventh graders could not measure a line when the beginning of the line to be measured was not aligned with the zero point on the ruler (Lindquist,

1989). The NAEP included a question on a recent eighth grade assessment that asked the measurement in inches of the length, width, and height of a model doghouse. The results found that 45% could not answer the three measurements correctly. The answers were 1, 1½", and 2"(NAEP, 2000).

Statement of the Problem

Almost half of eighth grade students enrolled in Technology Education classes have not learned to read a ruler at the level needed for success in high school Technology Education classes because the teaching method was not appropriate for the student's learning style. The inability for half the students to read a ruler is documented in national math performance tests. Discussion with local teachers in the areas of math, science, art, and technology education reaffirm the problem.

Purpose of the Study

The purpose of the study was to develop and evaluate an instructional unit that would address the ruler reading deficiencies of middle school students. The results of this study will add to the current knowledge of how students learn ruler reading. The results of the study will assist teachers in adapting more effective teaching methods for this essential topic.

Questions

The questions this study will answer are as follows:

1. To what extent did the materials that were developed effectively help students recognize parts and whole?
2. To what extent did the materials that were developed effectively help students draw parts to whole?

3. To what extent did the materials that were developed effectively help students divide a line and illustrate a fraction?
4. To what extent did the materials that were developed effectively help students name the lines on the ruler?
5. To what extent did the materials that were developed effectively help student read the lines on a ruler?
6. To what extent did the materials that were developed effectively help students measure efficiently?
7. To what extent did the materials that were developed effectively help students measure lines?
8. To what extent did the materials that were developed effectively help students estimate and measure objects?

Justification for the Study

Teachers and students alike continue to have problems and frustration with the subject of reading a ruler. Teachers may present a fine lesson in ruler reading only to find out that some students are not ready to learn the skill or that it does not met the needs of some students learning style. Other teachers may not teach ruler reading because they do not have the materials, the time, or the ability to break the topic down into small steps. Students may have not been taught the material in a style that meets their needs, or they have forgotten the material, or they need a review. Regardless of the reasons, reading a ruler is a skill that is necessary in work, home, and leisure.

Teaching strategies and instructional materials developed as a result of this study would be valuable to math, art, and technology teachers. If the evaluation of the learning

activity were positive, it would be beneficial to determine if other educators could obtain similar results.

Definition of Terms

Concrete operational: see logico-mathematical abstraction

Conservation of length: “Involves recognizing that the length of an object is not altered by a change in its spatial position (Hiebert, 1984, p. 19).

Estimating: to make a general calculation without the aid of measuring tools

Formal: see formalization

Formalization: synonym-formal refers to the computation of measurement using conventional units and their symbolic representation (Heraud, 1989a).

Intuitive: "Refers to a global perception of the notion at hand; it results from a type of thinking based essentially on visual perception; it provides rough non-numerical approximations" (Heraud, 1989a, p. 84).

Length: "unmeasured one-dimensional physical magnitude" (Heraud, 1989a, p. 85).

Linear measurement: measurement in a straight line between two points

Logico-mathematical abstraction: (synonym-concrete operational) Is the use of a measuring standard or units to understand logico-physical abstractions (Heraud, 1989a).

Logico-physical abstraction: Refers to the ability to recognize the length of an object or line even if figural transformations have been made that tend to give erroneous information via visual perception (Heraud, 1989a).

Measurement: “Contains both a number and a unit of measure” (Bright, 1976, p. 88).

Measuring: "The process of comparing an attribute of a physical object to some unit selected to quantify that attribute" (Bright, 1976, p. 88).

Procedural: "Refers to the acquisition of logico-physical procedures which the learners can relate to their intuitive knowledge and use appropriately" (Heraud, 1989a, p. 84). Or "Refers to the acquisition of explicit logico-mathematical procedures which the learner can relate to the underlying preliminary physical concepts and use appropriately" (Heraud, 1989a, p. 85) also see preoperational.

Preoperational: synonym-procedural (measurement) The first concept in measurement, which involves unit iteration. (Heraud, 1989a).

Transitivity: "Refers to the ability to deduce a third relationship from two other relationships" (Kamii, 1995, p. 113).

Unit iteration: Refers to the repeated use of a measuring unit to determine the length of lines or objects (Kamii, 1995).

CHAPTER TWO

Chapter Review of Literature

Almost half of eighth grade students enrolled in technology education classes have not learned to read a ruler at the level needed for success in high school Technology Education classes because the teaching method was not appropriate for the student's learning style. The inability for half the students to read a ruler was documented in national math performance tests. Discussions with local teachers in the areas of math, science, art, and technology education reaffirm the problem.

The purpose of the study was to develop and evaluate an instructional unit that would address the ruler reading deficiencies of middle school students. The results of this study would add to the current knowledge of how students learn ruler reading. The study would also assist teachers in adapting more effective teaching methods for this essential topic.

Two of the standards from the Wisconsin Department of Public Instruction apply to ruler reading. After the eighth grade, students should be proficient at using tools in technological designs and they should be able to use skills from other disciplines in the technological activities (Wisconsin Department of Public Instruction, 1998). Project 2061 sets a benchmark for sixth through eighth grade as being able to calculate the circumferences and areas of different geometric shapes (American Association for the Advancement of Science, 1993). With the standards in mind this chapter will look at the development of a child's concepts of length and measurement, the problems middle school students have with ruler reading, strategies used in middle school to teach ruler reading and the instructional materials used to teach ruler reading.

Development of a child's concepts of length and measurement

This section covered the aspects of length, measurement, and ruler reading as they develop in elementary school students. The terms used to describe the concepts of length and measurement varies from author to author. Synonyms were noted for some terms under definitions. The ideas presented here use a consistent set of terminology. The concept of length was divided into intuitive, procedural, and logico-physical abstraction. The understanding of measurement was divided into procedural, logico mathematic abstraction, and formalization.

Intuitive length Length is a description of the physical concepts. It starts at about age four or five with the children making the comparisons based purely on perception. Children begin to describe length using terms such as "a little" and "a lot". Heraud (1989b) did a study of third grade children on this very issue. He gave the children a group of straws with lengths varying by 3mm in order by size and asked them to arrange them by length. The results showed that 92 percent of the children had no difficulty with this task.

Procedural length. The next step in understanding length is using procedural length. This occurs in children between the ages of five and seven. Here the children are learning to manually bring the objects together for a more accurate comparison. The comparison is still visual (Steffe & Hirstein, 1976). Children in this stage, for example, will slide two towers together to compare the height. Heraud (1989a) cites more advanced examples. In one example the students were given a set of rods that are arranged in order over length, but with one missing rod. The students are asked to choose the missing rod by a comparison with those that laid on the table. In another example, the students were asked to arrange rods in order from long to short. They are given rods that

are so close together in length that the students must put the rods next to one another in order to compare their length.

Logico-physical abstraction Logico-physical abstraction is the ability to recognize the length of a line when added lines change the figure and give erroneous visual perceptual information (Heraud, 1989a). The classical example in this area is the a pair of lines, one with arrows on the end of the line pointing in and on the other with arrow at the end of the line pointing out. Visually the line with the arrows pointing in makes that line appear to be shorter than the line with the arrows pointing out. Similarly, when two lines are the same length, but are drawn perpendicular to one another, the vertical line appears to be longer than the horizontal line. Another example of logico-physical abstraction is to realize that two rods are the same length even though one is cut up and the pieces spaced apart. Logico-physical abstraction occurs in a student when he is able to recognize the situations in which visual perception gives erroneous information as to length and to then adjust for it.

Measurement

The mathematical concept of measurement consists of three components, which are procedural, logico-mathematical abstraction, and formalization (Heraud, 1989a). Learning these concepts is more strongly related to the child's ability to process information than to a strong developmental sequence (Boulton-Lewis, 1987). Boulton-Lewis was measuring the knowledge of children aged 3-7 with respect to measuring. Sequences were predicted from theory, from review of literature, and from demands of the tasks. The test results showed that a child's understanding measurement was best predicted by the demands of the tasks. The only exceptions were responses with a ruler

and transitive reasoning, which occurred later than predicted by theory and a review of literature.

Procedural measurement Procedural measurement involves understanding the unit. Understanding the unit starts with questions from the student. Eventually the student begins placing units one after another. As the students get more sophisticated, fewer units are needed. Finally one unit is used as a measuring standard (Heraud, 1989a). Kamii (1991) repeated Piaget's experiment with the lines that are the same length and perpendicular to one another. She gave the students a block to use as a measuring device. She noted that around age eight, they began to use the block to measure the length of a line. Such use of the block was unit iteration. She went on to conduct a unit iteration test on 383 students in grades one through five. The students were given a block and asked if they could use it to prove that one line was longer than another. This concept of unit iteration was understood by: ten percent of first grade, 33 percent of second grade students, 55 percent of third grade students, 76 percent of fourth grade students and, 78 percent of fifth grade students. Kamii (1995) repeated the above study with two fourth grade classes. Each class was given a pre/posttest and three days of instruction. The study found 86 percent of the students were able to demonstrate the logic of unit iteration at the end of the test. The success rate in this test was ten percent higher than in the study done by the same author four years earlier. In her conclusion Kamii states that she thought teaching ruler reading in fourth grade would be appropriate and easy because 86 percent of the students understood unit iteration. Kamii stated, "However, this logic turned out to be far from sufficient for the learning I expected" (1995, p. 7). She

continued by saying that more research needs to be done to understand the children's thinking about measurement.

Logico-mathematical abstraction Logico-mathematical abstraction is related to logico-physical abstraction, but it is verified with units. Logico-physical abstraction is the ability to recognize the length of a line and to adjust for visual perceptual changes with the use of a rod or a ruler. Logico-mathematical abstraction includes the concepts of transitivity and conservation of length.

The term transitivity refers to the ability to deduce a third relationship from two other relationships (Kamii, 1991). Linear measurement depends on the transitive reasoning (Steffe & Hirstein, 1976). This begins with what is known as body transfer. Students that are five to seven years old use their body to measure the height of a tower and compare it to the height of a second tower. The research shows that presence of the transitivity concept in children four to seven years old is inconsistent in studies (Carey & Steffe, 1968; Steffe & Carey, 1972; Owens, 1972).

The method used to assess the presence of this abstraction has been based on figures that tend to give questionable information when judged by a visual means only. Piaget, Inhelder, and Szeminska (1960) were the leaders in studying students' understanding of the concept of length. Piaget's classic examples are: 1) two straws, one of which is cut into two pieces and placed under and parallel to the first straw, 2) identical straws perpendicular to each other, and 3) two straws the same length with one fragmented and placed in a non rectilinear path. The results of his studies showed that transitive reasoning is evident in some students between five and six, but that fifty percent of eight years did not display transitive reasoning. Steffe and Hirstein (1976)

studies seven years old students. They were given a measuring rod and asked to measure building towers. They were able to do so with encouragement if the measuring rod was longer than the towers. They were not able to use a measuring rod that was shorter than the building towers. Kamii (1991) did a similar study with seven year olds. She gave them a ruler to use. The students found the ruler useless. Piaget's experiment was repeated by Heraud (1989a). The results showed that twenty percent of the nine year old students had difficulties with the concept of logico-physical abstraction. Kamii (1991) did a study with 383 students in grades 1-5. The students' understanding of transitivity increased gradually with grade level. Twenty-nine percent of first grade, 72 percent second grade, 85 percent third grade, 86 percent fourth grade, and 92 percent of fifth graders understood the concept of transitivity. It appears that one can successfully teach students the concept of transitivity in one situation and then find out that the students have difficulty applying the concept to a closely related problem (Owens, 1972). The student needs to understand that the actual length of an object being measured does change as a result of the unit chosen for measurement (Heraud, 1989a). This concept is referred to as conservation of length (Hiebert, 1984). Heraud (1989b) studied logio-mathematical abstraction by having eleven third grade students perform two different tests. The first test compared rods with respect to displacement and the second compared rods with respect to displacement and unit. The first task involved two rods 12 cm. and 9 cm. The bottom rod was offset about 3 cm. The students were asked to show with a piece of paper what had to be done with the short rod to make it as long as the longer rod. The second task involved the same concept with equally marked units on the rods. Five of the eleven students succeeded on the two tasks. For the other six, they were able to do

the first task, but became confused with the added units. Three students attempted to solve the problem by visually looking at the rods. Three students added the unit, but without taking into account the length of the unit. The concept that the unit can be different, but once chosen the unit needs to be consistent in the measuring process is not always comprehended (Heraud, 1989b).

Crucial to understanding measurement is the concept of the relationship between the unit and the number of units in the measurement. Lindquist (1989) studied this concept. Almost two-thirds of the third graders knew that it took more of the small units than large units to equal the length of a given line. However, when she gave this problem, "Sam reported the length of an object to be 8 of his units, and Sue reported that its length was 6 of her units" (Lindquist, 1989), over half of the third and seventh graders named the person who measured the most units as the one using the largest unit. Similar results were obtained by Bright and Hoeffner (1993).

Formalization Formalization is the last concept in the understanding of measurement. This concept covers the computation of measurement using conventional units and their symbolic representation (Heraud, 1989a). After this concept is understood, ruler reading can begin. According to Heraud, ruler reading involves two skills: understanding the use of the lines on the ruler and eye hand coordination. Heraud (1989b) did several studies with ruler reading. His findings included students having difficulty placing the zero mark of the ruler on the end of the line to be measured and not understanding the meaning of the numbers on the ruler. Kamii (1991) reported that only eleven students out of seventy-six fifth grade students were able to use the zero on the ruler correctly. Difficulty comes from two areas. The first is that students measure from

the “one” on the ruler instead of from the zero on the ruler. The students state that they do so because they count 1, 2, 3 not 0, 1, 2, 3. This problem was reported by others (Heraud, 1989a; Hart et al., 1981; Kamii, 1995). Students also had difficulty knowing if the zero point was on the end of the ruler or if the zero point was in a small distance in from the end of the ruler (Hiebert, 1984; Kamii, 1995). The zero point on a ruler is generally either where the ruler begins, in which case the zero is not marked, or the zero point is 1/16” to 1/8” in from the end of the ruler, in which case the zero is marked. Occasionally, a triangular shaped architecture or engineering ruler is used. On these rulers the zero mark maybe anywhere from 1/16” to three inches in from the end of the rule.

Measurement can be taught more successfully if estimating is included in the curriculum. Bright and Hoeffner (1993) stated that practice at estimating helps students develop flexible and useful concepts. He felt that more experience with estimating was needed when teaching students ruler reading.

Deficiencies middle school students have with ruler reading

Measurement is a topic in mathematics that is regarded as useful math (Hart et al., 1981). Measurement is a subdivision of math in which there is a dramatic discrepancy between opportunity to learn and actual performance (Bright & Hoeffner, 1993). General reasoning ability is more important than the age of the students in predicting a students’ performance in ruler reading (Bright & Hoeffner, 1993). Many middle school students have difficulty with the fundamental concepts of measurement. Some students have not acquired the skills, while others have forgotten them and need the skill to be taught again (Bright & Hoeffner, 1993; Hart et al., 1981). When reading a ruler, Hiebert (1984) said

that students often read off the answer without really understanding what the answer represents. The line being measured represents the distance between the beginning and end point is not understood. The use of fractions or a ruler made the task of ruler reading more difficult (Hart et al., 1981). Thirty percent of secondary school students were not convinced that the length of an object does not change when it is moved and 40 percent of secondary school students forgot the importance of the type of unit used (Hart et al., 1981). Another problem was that students counted the number marks on the ruler including the zero mark, rather than the spaces in between the marks (Bright & Hoeffner 1993; Hart et al., 1981). Hart reported this problem in 10 to 18 percent of 12 year olds he tested. When teaching secondary students who have not learned the ruler reading skills, students should be given the opportunity to use such skills to solve real problems (Hart et al., 1981; Bright & Hoeffner, 1993).

Interesting facts emerged when one examines the national performance assessments of students. Example one: a ruler was illustrated on a page of the assessment with a line above the ruler that ran from the number three to the number eight. Fifty percent of the seventh graders were unable to determine the correct length of the line (Lindquist, 1989). Example two: even when 9 and 13 year old students knew a concept, they had difficulty applying it to an actual problem. Eighty-seven percent of 13 year olds knew twelve inches equals one foot. However, 53 percent of the students could not solve the problem: "Mr. Hernandez needs a ribbon 6'5" long. How many inches of ribbon does he need" (Carpenter et al., 1980)? Nine percent of the 13-year-old students could not measure the length of a line to whole inches. Forty-seven percent of those students could not measure the line to the nearest ¼" (Carpenter et al., 1980). The newest NAEP math results asked

the students to measure an object on three different planes. The answers required precision to ½". This question had results as follows: 47% correct, 23% partial, 22% incorrect, 8% omitted item, and 1% off task (NAEP, 2000).

In eighth grade 17 percent of the teachers reported putting a heavy emphasis on measurement and fifty percent of them reported putting a moderate emphasis on measurement. It is interesting to note that the students in classes where the teacher reported putting a moderate degree of emphasis of ruler reading were more proficient in ruler reading than the students in classes where the teacher reported putting either a heavy emphasis or little emphasis on ruler reading (Mullis, Dossey, Owen, & Phillips, 1991). Teachers reported using rulers with 28 percent of eighth grade students on a weekly basis (Mullis et al., 1991). Carpenter et al. (1980) reported 81 percent of 9 year olds and 91 percent of 13 year olds could measure a line to the nearest whole number on a ruler, even if the line was longer than the ruler. Lindquist (1989) found that 75 percent of seventh graders could read a ruler to the nearest quarter of an inch. Carpenter et al. (1980) found 53 percent of 13 year olds could measure the length of a pencil to the nearest quarter of an inch. Carpenter et al. (1989) went on to comment that a slight change in the context of the problem revealed that the students had a superficial understanding of the basic concept of measurement. In a national math test of eighth grade students, 31 percent of eighth grade students were unable to measure the side of a rectangle (Mullis et al., 1991).

Strategies used in middle school ruler reading

Measurement is used in many different areas. One area is as important as another. Steffe and Hirstein (1976) said the areas to be address when teaching measurement are: cognitive and affective aspects of the individual, social aspects, mathematical content to be taught, and the method of presenting mathematical content. Many students do not understand that a ruler is an indirect method of laying down units of length end to end (Thompson & Van de Walle, 1985). Thompson and Van de Walle (1985) presented ideas on how to teach ruler reading in the classroom. They started with the units and then added numbers to the units to help students understand what the numbers meant. Next they introduced the standard ruler. They explained to the students why the numbers were written below and not between the longest line and what the other shorter lines represent. They finally stressed that linear measurement was done by repeatedly laying the unit length end-to end. Kamii (1995) stressed that it is necessary to make measuring relevant to students. They need a purposeful reason for learning ruler reading.

Peterson, Ridenour, and Somers (1990) did a study that looked at the relationship between declarative, conceptual, and procedural knowledge in ruler reading skills. Four sections of sixth grade industrial arts students at two schools were involved in the study with two teachers. Two groups were formed. One group was taught by a method that emphasized an understanding of how the lines on a ruler divide the basic unit into smaller fractions. The second group was taught by the unit identification method that taught the students the meaning of the various lengths of the lines. The results showed that the students who were taught ruler reading by line identification were superior in initial acquisition and retention of ruler reading skills. The study showed that these students

used procedural knowledge to infer the conceptual knowledge. The issue not addressed in the study was that the system taught was specific for a standard U.S. ruler and would not work with a metric ruler. The authors of this study felt that the line identification method of teaching ruler reading was also useful in improving the students' understanding of fractions.

Bright (1976) and Bright and Hoeffner (1993) are authors who did studies about estimating and measurement. The following ideas are from their papers. Estimation is the use of units to measure in a mental way. Estimating is an educated guess, not just a guess. Measuring and estimating are processes; measurements and estimations are products. Tools are needed for measurements, but not for estimating. There are eight types of estimating. The two major groups are named objects and unnamed objects. Under each of the major groups are divisions with the object present or absent and finally whether or not the unit is present or absent (Bright, 1976). Practice in estimating helps students to develop flexible and useful concepts (Bright & Hoeffner, 1993). Estimating starts by asking students to estimate the length of a line or object and then having the student measure it. By having students compare their estimations to the measurement, the students are able to improve their skills of estimation. Estimation should be taught with familiar objects. Students need some understanding of measurement before they can begin estimating. They need to be encouraged to make reasonable estimates. They need to use all eight types of estimating, to practice, and continue to practice in order to maintain their estimating skill (Bright, 1976). Measurement can be taught more successfully if estimating is part of the instructional activity (Bright, 1976).

Two studies commented on the fact that measuring should involve actual physical measurements and that the measurements should be relevant to the children (Kamii, 1995; Bright & Hoeffner, 1993). Hart et al. (1981) stated that there was no information on the relationship between a student's practical measuring experiences and the student's success in measurement objects. Although Kamii discussed some applications of practical measuring experiences, she did not formally study its relationship to success. No research on this topic has been found.

Instructional materials

Two guides for classroom teachers and one textbook were reviewed. The first guide was for a 50-minute lesson that is a part of a 110-hour high school course on metals. One of the lesson's objectives was to teach students to correctly measure with a tape rule or ruler. Instructional aids included a transparency of a ruler with additional transparencies to overlay the ruler with divisions of eighths, sixteenths, and thirty-seconds. The guide also included an outline of a lecture about the divisions of an inch and an explanation of the lines accompanied the transparencies (Higa, 1986).

The second guide was a program written for instructors serving the occupational needs of the special need students. The instructional materials were self-paced and self-contained. The objectives were for the students to identify tools and materials used in reading and measuring with a ruler, reading the ruler in whole numbers, reading fractions of an inch on a given ruler, measuring objects with a ruler, and drawing lines and objects to length using a ruler. This guide started with illustrations of the ruler, tape, and folding rule. It then explained the uses for each and asked the student to get a ruler. The guide has illustrations of the ruler with 1", ½", ¼", 1/8", and 1/16" increments. The caption for

the illustration said to use the divisions of the ruler and practice reading whole, half, quarter, eighth, or sixteenth units. The guides then illustrated a folding ruler. The student was asked to identify the measurement of the fractions indicated in the drawing. The guide has one page on learning the terms length, width, and height and one page on drawing lines. Next was a page asking for the identification of the three measuring tools. The final page was a checklist for the student and instructor to use as the lessons are completed (Herd, 1981).

Three technology education textbooks were reviewed for their discussion of rulers and measurement. Living with Technology (Hacker & Barden, 1992) and Technology Today and Tomorrow (Fales, Kuetemeyer, and Brusic, 1997) do not address the subject of rulers or measurement. Understanding Technology (Wright & Smith, 1993) does not discuss ruler measurement. It had one page devoted to measurement, which stated that measurement created numbers that were useful in solving problems.

Two math textbooks were reviewed. The math textbooks reviewed were a seventh grade book and an eighth grade book in the same series. The math textbooks were Math Advantage (Burton & Maletsky, 1998a; 1998b) published by Harcourt Brace and Company.

The seventh grade textbook index had fourteen citations for “rulers”. Three of these citations explained using the ruler to draw straight lines with no measuring and four of these citations were concerned with metric measurements. The remaining citations explained the use of finding midpoints, ratios, scale, and volume. One page discussed the terms length and width, and two pages discussed height. The index had citations to seven pages that discussed length. Of the seven pages, three were devoted toward estimation,

two and a half pages devoted to the greatest possible error, one half page on estimating millimeters, and one page contained a problem about the number of 1/2" units in 13'10½", and one page on metric measurement. The book also contained a conversion table for metric and customary units (Burton & Maletsky, 1998a).

The eighth grade textbook index also had fourteen citations for "rulers". Two of the fourteen pages were metric exercises, three pages discussed using the ruler as a straight edge, and three pages used the ruler measuring to whole numbers only. In the remaining five pages, one page discussed measuring to an accuracy level of ¼", one page discussed an accuracy level of 1/8", and three pages discussed an accuracy level of 1/16". The index had citation for fifteen pages that discussed length. The textbook's discussion of length was divided into three areas. The first area was patterns in measurement systems and explained conversions between metric units and customary units. The second explained measuring length and discussed the significant digits. The third discussed the measurement of the perimeter of geometric shapes. The topics discussed in this area were algebraic equations for calculating the length of the perimeter, significant digits, maximum and minimum perimeter, and area with whole numbers, and doubling and halving in two dimensions.

Summary

The results of the literature search show that most children's development of the concept of length can be related to age, but that the development of the concept of measurement is more related to a child's ability to process information. Studies show over and over again that a posttest items presented in a different manner resulted in poor understanding of measurement concepts. The NAEP's report of the measurement

abilities of eighth grade students was not defined by how precise the students can measure. Forty-seven percent of the 13 year-olds could not measure the length of a pencil to the nearest quarter of an inch (Carpenter et al., 1980, p.45). Forty five percent could not measure the longer side of a rectangular floor, the shorter side of a rectangular floor, and the height from the floor to the highest point of the roof in a model of a doghouse. The answers to these questions required precision to ½" (NAEP, 2000). Different people, primarily in the field of mathematics and psychology have developed programs through research to help students learn to read a ruler. The textbooks in technology education do not address ruler reading. A seventh and eight grade math series showed that seventh grade devoted one page to a problem about the number of ½" units in 13'10 ½". The eighth grade math book, one page discussed precision of ¼", one page 1/8", and three pages 1/16".

It appears that approximately 50 percent of the students in middle school will understand the concept of measuring with a ruler and be proficient for their needs in high school. The other 50 percent will struggle with the concept. Many of these students will not understand the concept even as adults. Some of these adults will be in positions to use measurement daily and will be forced to use compensating techniques because they were never taught the basic skill of reading a ruler.

CHAPTER THREE

Methods and Procedures

The purpose of this study was to determine the effectiveness of self-paced packets by statistically comparing the pretest and posttest results. This chapter outlines the methods and procedures used in this study of middle school students' ruler reading skills. The methods and procedures used in this study of ruler reading are explained in this chapter under the headings of (1) research design, (2) sample selection, (3) instrumentation, (4) perspectives of testing instrument, (5) procedures, (6) statistical analysis, and (7) limitations of the study.

Research Design

A review of the literature had identified several findings that were significant to the design of the research instrument. Pertinent concepts that contributed to the rationale of the ruler reading were:

- Children's development of the concept of length was related to age.
- Children's development of the concept of measurement was related to a child's ability to process information.
- Middle school students had difficulty reading a ruler more accurately than ¼".
- Middle school technology education and math books have very limited to no coverage on ruler reading.
- Fifty percent of the students in middle school will not be proficient in ruler reading skill to meet their needs in high school.

All of these concepts contributed to understanding of the unique nature of learning to read a ruler by middle school students. Students many not have been ready to understand the concepts when they were taught to them in elementary school or they forgot the skill. Ruler reading involves eye-hand coordination, spatial relationships, formalization, and estimating. It also involves the understanding of the sub-concepts in order to read a ruler successfully. An attempt was made to identify an existing measurement instrument for this research, but none was found. The author developed the measurement instrument used in this research.

The questions this study addressed are as follows:

1. To what extent did the materials that were developed effectively help students recognize parts and whole?
2. To what extent did the materials that were developed effectively help students draw parts to whole?
3. To what extent did the materials that were developed effectively help students divide a line and illustrate a fraction?
4. To what extent did the materials that were developed effectively help students name the lines on the ruler?
5. To what extent did the materials that were developed effectively help students read the lines on a ruler?
6. To what extent did the materials that were developed effectively help students measure efficiently?
7. To what extent did the materials that were developed effectively help students measure lines?

8. To what extent did the materials that were developed effectively help students' estimate and measure objects?

Sample Selection

A formal sample was not obtained for this study. The populations used in this study were volunteers obtained through technology education classes. This study had research done with two different groups of middle school students. The first group of students was used for the pilot study. This group of students was selected by finding a technology education teacher who was interested in ruler reading. The pilot study was administered to two eight-grade technology education classes of Mr. Mike Galloy at South Middle School in Eau Claire, Wisconsin. This test was administered at the end of the school year.

The second set of students was selected by the placement of the researcher in a student teaching assignment. The students were from two sixth grade classes in technology education at Chippewa Falls Middle School. The first class had fifteen students and the second twelve students. Of the twenty-seven students, two parents refused to have their children participate in the study and one student did not complete the study because he was transferred to another class. In addition to the test, a cover sheet addressed dependent variables in the areas of gender, age, previous education, where homework is done, noise, and who helps with homework. Completion of homework was also a dependent variable.

Instrumentation

The Ruler Reading Test (Appendix A) was developed by the author of this research and was used as the single instrument of measurement for the pilot study. The results of

the pilot study were used to determine the instructional material that was developed and to revise the testing instrument for the pretest and the posttest. The format of the pretest and the posttest are the same, but the questions vary in some areas. The Ruler Reading Test in Appendix B was the single instrument of measurement used in the pretest. Attached to the pretest was a cover sheet (Appendix C), which asked about the dependent variables. The Ruler Reading Test in Appendix D was the single instrument of measurement used in the posttest.

The pilot test instrument covered the following areas of ruler reading: recognizing parts/whole, drawing parts/whole, recognizing length, width, and depth, estimating, meaning of lines, dividing ruler, reading lines, measuring lines, measuring missing lines, and measuring objects. The pretest/posttest instrument covered the following areas of ruler reading: recognizing parts to whole, drawing parts to whole, dividing a line, meaning of lines, reading lines, measuring efficiently, measuring lines, and estimating and measuring objects. The test required accuracy to one-sixteenth of an inch. The test was a pencil and paper test. The students were supplied with the test and a packet containing a ruler, three objects with which to estimate dimensions, and three objects with which to measure dimensions. Three samples were done with each subdivision of ruler reading. The students were allowed approximately thirty-five minutes to complete the test.

Perspectives of Ruler Reading Test (pretest/posttest)

The Ruler Reading Test was designed to measure students' ability to answer questions about the sub-concepts of ruler reading. The content of the test was derived

primarily from Dr. Kenneth Welty's expertise and from problem areas noted in the literature search.

The test was divided into eight sections and consisted of fifty-seven questions. Some of the sections were further divided into subsections. The questions for most subsections had a completed example. All the parts used were illustrated with two, four, eight, or sixteen divisions. Section one: recognizing parts to whole had three subsections and a total of nine questions, section two: drawing parts to whole had three subsections and a total of nine questions, section three: dividing a line had three subsections and a total of nine questions, section four: meaning of lines had three questions, section five: reading lines had three questions, section six: measuring efficiently had three questions, section seven: measuring lines had three subsections and a total of nine question, and section eight had two subsections and a total of twelve questions.

The test packet that was use with the test included a ruler, one wooden clothespin, one large playing card, one small playing card, and one package of gum, an eraser, and a plastic screw anchor. The ruler included with the test packet was a clear, twelve-inch ruler that was divided into sixteenths of an inch. The other side of the ruler was a metric scale. Masking tape was placed over this edge to prevent students from using the wrong scale. The items included in the test packet were used in section eight for estimation and measuring.

Section one The first section was written to address the first research question, "To what extend did the materials that were developed effectively help students recognize parts and whole". This was accomplished by subdividing the section into three smaller areas. These areas asked the student: 1) into how many parts is each rectangle divided, 2)

how many parts are shaded in each rectangle, and 3) what is the number of parts shaded compared to the total number of parts? The test questions use rectangles that were divided into parts. In the first subsection, the student was asked to identify the number of smaller parts or boxes in the larger or whole rectangle. In the second subsection, the students was asked to identify the number of shaded parts in each rectangle and in the final subsection, the students was asked to write a fraction that compares the number of shaded parts to the total number of parts.

Section two The second section was written to address the second research question, "To what extent did the materials that were developed effectively help student draw parts to whole". This was accomplished by subdividing the section into three smaller areas. These areas asked the student to: 1) divide the rectangle into equal pieces, 2) divide the rectangle into equal pieces and shade the requested number of parts as written out, and 3) divide the rectangle into equal pieces and shade the requested number of parts as given in a fraction. The test questions gave a rectangle to draw the answer.

Section three The third section was written to address the third research question, "To what extent did the materials that were developed effectively help students divide a line and illustrate a fraction". This was accomplished by subdividing the section into three smaller areas. These areas asked the student: 1) into how many parts is each line divided, 2) express as a fraction the number of shaded parts to the total number of parts, and 3) using the given line, illustrate the requested fraction. In the first subsection the student was asked to count the number of parts in each line, the second subsection asked the student to write a fraction that was drawn with the given line, and the third subsection asked the student to draw the fraction on the given line.

Section four The fourth section was written to address the fourth research question, "To what extent did the materials that were developed effectively help students name the lines on a ruler". This section had arrows pointing to lines on a ruler. The students were asked a multiple-choice question. The question asked the student to name what the line on the ruler represented.

Section five The fifth section was written to address the fifth research question, "To what extent did the materials that were developed effectively help students name the lines on the ruler". This section the students are asked to figure out the length of an arrow that is above a one-inch section on a ruler.

Section six The sixth section was written to address the sixth research question, "To what extent did the materials that were developed effectively help students measure efficiently". In this section the students are asked to figure out the length of a line that is above a one-inch section of a ruler, but some of the lines on the ruler are missing. The missing lines do not allow a student to simply count the sixteenth and reduce the fraction. This requires the student to understand the meaning of the lines and to use short cuts to get the answer thus leading to more efficient ruler reading skills.

Section seven This seventh section was written to address the seventh research question, "To what extent did the materials that were developed effectively help students measure lines". This section had three subsections. This was the first section to use the supplied ruler. The three subsections required the students to use the ruler to measure a drawn line, to use the ruler as a straight edge, and to use the ruler to draw a line a requested length.

Section eight The eighth section was written to address: "To what extent did the materials that were developed effectively help students estimate and measure objects". This section had two subsections, which were estimation and measuring objects. The objects used for the estimation and measuring were found in the test packet that was distributed with the test. The objects included a plastic anchor, a clothespin, a small playing card, a large playing card, an eraser, and a package of gum. These objects were chosen because some of their dimensions were 16ths. The estimation and measuring subsections were presented in a similar fashion. The objects were given in the directions. One object was estimated/measured in length, one object in length and width, and one object in length, width, and depth. The terms length, width, and depth were written on all the objects except the plastic anchor. In order to receive credit for the estimation section, the student had to be within $1/16^{th}$ of an inch with measurement that were less than one inch and within $1/8^{th}$ of an inch with measurements that were more than one inch.

Procedures

The pilot school technology education teacher was given the evaluation instrument and the equipment needed for administrating the test. In addition the teacher was asked to record any difficulties with the direction of the test and instruction on returning the pilot test. The results of the pilot test were used to revise the ruler-reading test for the study.

The researcher responsible for the pretest administered the pretest, scored it, and established which areas the students performed less than 100% competency. The pretest determined what sections of the instructional materials the student should perform. The students were given one to three packets per week to complete and return to class. A

Figure was established to determine who was to receive the homework packets, when they returned the packets, and pertinent comments. A different colored folder with the student's name was used to contain the eight different self-paced lessons. If the students were absent, the folders were given to them on their first day back. Four days passed between the issuance of the last packet and the posttest. As the fourth and eighth packets were distributed, verbal reminders were made to students that were deficient in returning the homework packets.

The researcher responsible for the pretest administered the posttest. No retention test was given.

Statistical Analysis

The hypotheses of this study are as follows:

1. There is no relationship between the materials that were developed and students recognizing parts and whole.
2. There is no relationship between the materials that were developed and drawing parts to whole.
3. There is no relationship between the materials that were developed and dividing a line to illustrate a fraction.
4. There is no relationship between the materials that were developed and naming the lines on a ruler.
5. There is no relationship between the materials that were developed and reading the lines on a ruler.
6. There is no relationship between the materials that were developed and measuring efficiently.

7. There is no relationship between the materials that were developed and measuring lines.
8. There is no relationship between the materials that were developed and estimating and measuring lines.

The independent variable is prior enrollment in a sixth grade graphic communications class. The control variables associated with the students' ability to read a ruler were: a) gender, b) age, c) elementary school attended, c) where homework is done, d) degree of noise, e) who helps with homework, and, f) completion of homework.

Limitations of the Study

The limitations of the study are as follows:

1. The pilot study was limited to two classrooms of eighth grade middle school students at South Middle School, Eau Claire, Wisconsin.
2. The pre/post test was limited to two classrooms of sixth grade middle school students at Chippewa Falls Middle School, Chippewa Falls, Wisconsin.
3. The pretest and the posttest contained similar items, but the test was not exactly the same.

CHAPTER FOUR

Results

The purpose of this study was to develop and evaluate a series of self-paced packets that taught ruler-reading skills to middle school students. The researcher developed both the evaluation tool and the packets. A pretest, posttest, and packets were used in the study.

The population for this study was two classes of sixth grade students that the researcher was assigned for student teaching. The class was graphic communications in the technology education department at Chippewa Falls Middle School in Chippewa Falls Wisconsin. The students for the study were a population and not a sample. The two classes had total of twenty-seven students. Of the twenty-seven students, two lacked parental permission to participate and one student did not complete the class. The total number of students participating in the study was twenty-four.

The students were given the pretest (Appendix B). The researcher scored it. The students did not see the scored pretest. The pretest and the posttest were subdivided into eight sections. Any student that did not receive a hundred percent correct on the pretest in a subsection was given the homework packets (Appendix H-O). There were eight separate homework packet. Each packet consisted of three to five pages of directions, activities, and problems. Each packet was presented in different colored folder. Two to three packets were distributed per week. Four days after the last packet was distributed, the posttest (Appendix D) was administered.

Both the pretest and the posttest were similar in structure. Sections one, two, three, and seven had three subsection. On both tests, the questions under a subsection were

numbered one, two, and three. In the research data, the test questions under sections one, two, three, and seven were numbered one through nine. Section eight was divided in two subsections. The subsections were referred to as section 8A and 8B. Section 8A addressed estimating and section 8B addressed measuring objects. The questions were labeled one through three for section 8A and four through six for section 8B. The letters L, W, and D appear after the questions. These letters stood for length, width, and depth.

Demographic Information

The demographic information was collected from the students by asking them to complete a cover sheet (Appendix C) to the pretest. The cover sheet asked about gender, age, elementary school attended, where they study, how quiet their study area is, who helps them with homework, whether or not they have received instruction or learned how to read a ruler. Table 1 describes the demographic information. T tests were the type of statistical analysis that was used to compare the variables to the pretest and posttest results.

The population in the study was comprised of twelve males and twelve females. The results of the male and female students were studied and were found to be not significant. The total number of correct answers in the posttest and the gain in the total number of correct answers found no significant difference between the males and the females.

The twenty-four students were from six different elementary schools. One school had six students and one school had seven students respectfully. The remaining four schools had less than three students each. The number of students from each school was

too small to be used to make any valid comparisons between the schools. This variable was not addressed in the study.

The third variable addressed the age of the students. The students were divided into two groups. One group was students 11.33 years or less and the second group was 11.42 years or more. The younger group had eleven students and the older group had twelve students. The number of correct answers on the pretest found the t test close to being significant. This indicates that the younger students did better on the pretest. However, the total gain on the number of correct answers found the older students close to being significant with the t-test in this statistic.

	t	df	Sig. (2-tailed)
Pretest total number of correct answers	1.967	21	.063
Gain on total number Of correct answers	-1.768	21	.092

The fourth variable addressed the location where the homework was done. Two students had multiple responses. One multiple response was for bedroom and kitchen table and the second multiple response was for kitchen table and living room. Since almost half of the students study in their bedroom, the comparison was made between those who study in their bedroom and to those who study in other locations. Of the two students with multiple answers, one was assigned to each side. The student who stated

Table 1

Sample Demographics

Demographic	Frequency	Percent
Gender		
Male	12	50.0
Female	12	50.0
Name of grade school where respondent was a student		
Halmstad	6	25.0
Hillcrest	3	12.5
Liberty	1	4.2
Parkview	7	29.2
Southview	4	16.7
Stillson	3	12.5
Place respondent usually does homework		
Kitchen table	4	16.7
Bedroom	11	45.8
Living room	6	25.0
Computer desk	1	4.2
Multiple response	2	8.3
How quiet is the place where homework is done?		
Quiet	15	62.5
Occasionally noisy	7	29.2
Noisy	1	4.2
Multiple response	1	4.2
Who helps with homework?		
Parent	15	62.5
Sister/brother	2	8.3
Other	1	4.2
Multiple response	6	25.0
Learn to use a ruler in elementary school		
Yes	23	95.8
No	1	4.2
I remember how to read a ruler		
Yes	22	91.7
No	2	8.3

bedroom/kitchen table was added to the group that studies in the bedroom location. The student who stated kitchen table/living room was added to the group that studies in other locations. The total number of correct answers on the posttest found the t test close to being significant. The significance is .096. The significance would have been stronger if the significance were a .05 or lower.

	t	df	Sig. (2-tailed)
Posttest total number of correct answers	-1.742	22	.096

The significance was that studying in other areas yields more correct answers on the posttest.

The fifth variable concerned how quiet was the place where homework was done. The students who gave multiple responses all chose “quiet” and “occasionally noisy”. Therefore the comparison was made between those students who study in a quiet place, including the multiple responders and the remaining students. This variable compared fifteen students that preferred quiet to nine students that preferred some noise. The results were not significant.

The next variable addressed who helps the student with homework had six multiple respondents. These multiple responses were: 1) parent/grandparent, 2) parent/friend, 3) parent/brother, 4) parent/sister/brother, 5) parent / homework hotline, and 6) parent/friend/homework hot line. By following the pattern set above, all these students were added to the parent category. The number of students in the “parent” versus the “non-parent” categories was twenty-one to three. Since the non-parent sample of three was too small for meaningful analysis, the study of this variable was dropped from the study.

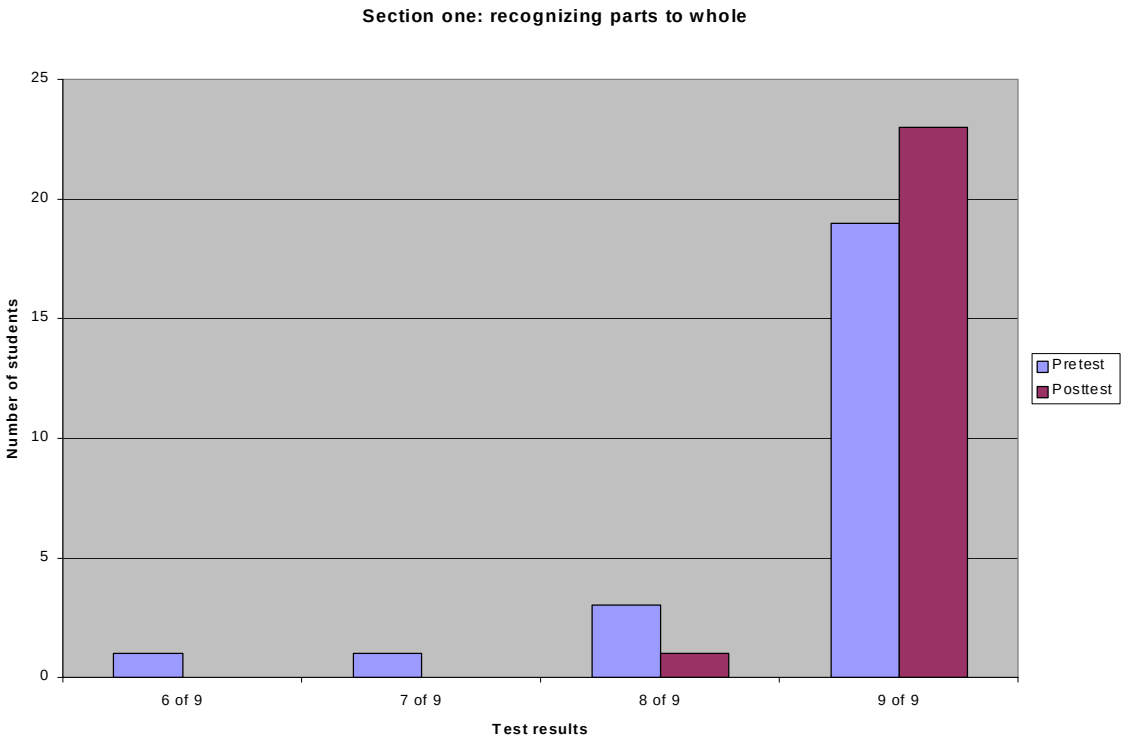
Similarly, the answers to the last two questions yielded groups that were too small for meaningful analysis. Whether or not the students learned to use a ruler in elementary school and whether or not the student remembered how to read a ruler were not compared to the pretest and posttest results.

Pretest/Posttest

The evaluation instrument used in the pretest and the posttest followed the same format. Each test was divided into eight sections, which test the students ability to recognizing parts to whole, drawing parts to whole, dividing a line, meaning of lines, reading lines, measuring efficiently, measuring lines, and estimating and measuring objects. Sections one, two, three, seven, and eight are subdivided. Each subdivision has at least three questions. The questions in sections 1-7 were similar in the pretest and posttest. The questions in section eight were the same for both tests. The results of the pretest/posttest will be discussed together.

Section one: recognizing parts to whole Section one was subdivided into three subsections. Subsections one asked the student into how many parts was a rectangle divided, subsection two asked the student how many parts were shaded in each rectangle, and subsection three asked the student what was the number of parts shaded compared to the total number of parts. Each subdivision had three questions. Figure 1 depicts the results for section one.

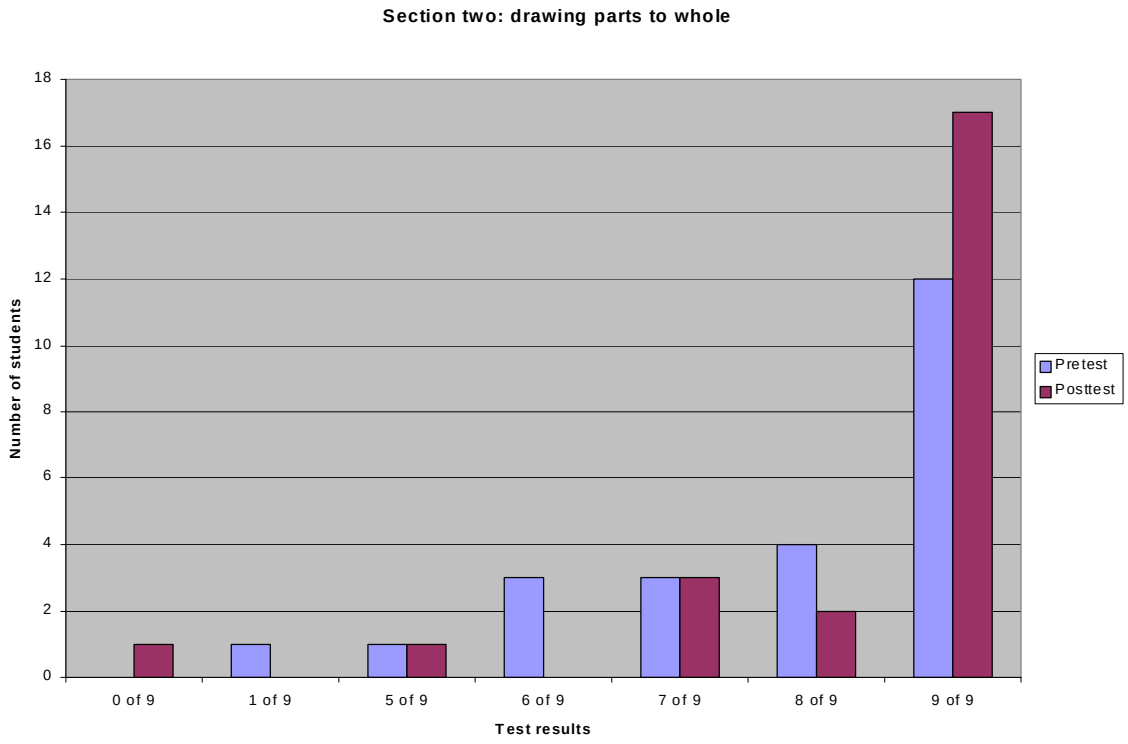
Figure 1



The pretest found five students gave a total of eight wrong answers. The five students were given homework packets. All homework packets were completed and returned. The posttest found only one student giving a total of one wrong answer.

Section two: drawing parts to whole Section two was subdivided into three subsections and was done without using a ruler. Subsection one asked the student to divide the box into equal pieces, subsection two asked the student to divide the box into equal pieces and lightly shading the number of parts requested, and subsection three asked the student to divide the rectangle into equal sized boxes and lightly shading the number of boxes required by the fraction. Each subsection had three questions. Figure 2 depicts the results for section two.

Figure 2



The pretest found twelve students gave a total of thirty-one wrong answers. Twelve students received homework packets. Ten students completed and returned the packets. The posttest found six students gave a total of twelve wrong answers. One student skipped the entire section. Those answers were marked missing. One student commented that the homework helped him to understand section two.

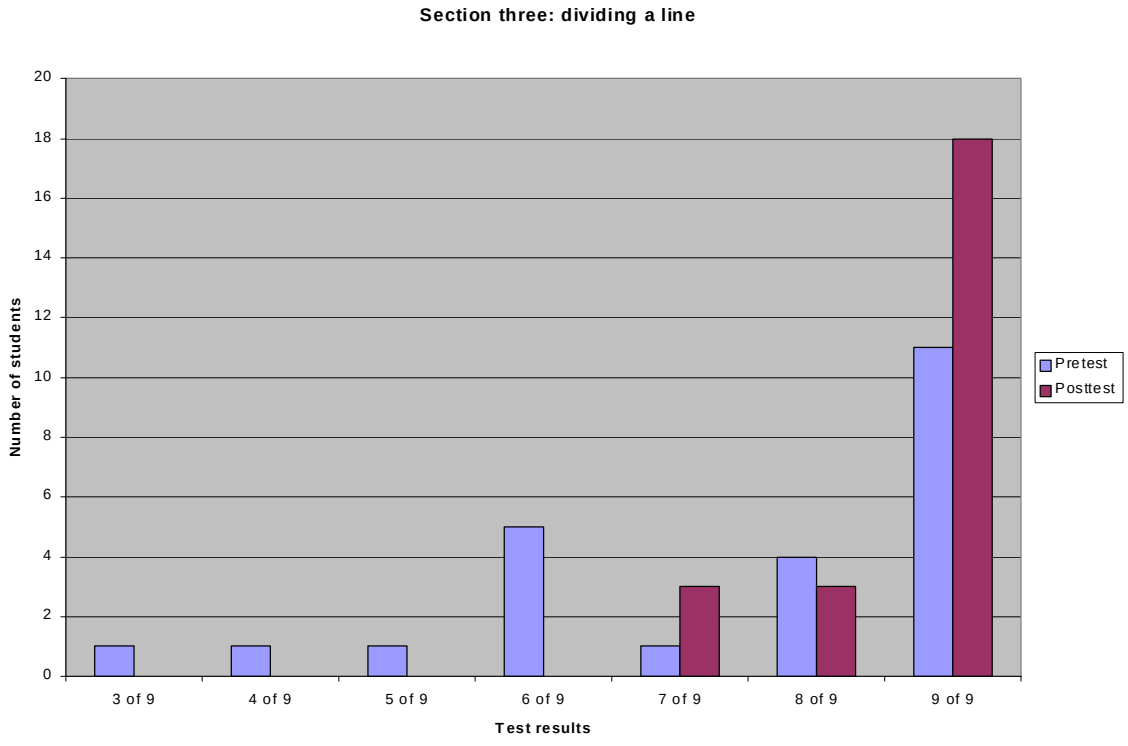
All of the students who made errors, made them in dividing the rectangle into the correct number of pieces. The literature review did not address this problem. This problem occurred in the pilot study and was addressed in the packets, but continued in the tests.

Item 5 in this section was the only item on the entire test that had a negative result when comparing the pretest/posttest. The pretest asked that the student illustrate one

shaded part of four parts and the posttest asked the student to illustrate three shaded parts of four parts. All the students got the item correct in the pretest. One student got the item incorrect on the posttest and one student skipped the question. This resulted in a –2 change between the pretest and the posttest for this question.

Section three: dividing a line Section three was subdivided into three subsections. Subsection one asked the student into how many parts were each line divided, subsection two asked the student to express as a fraction the number of shaded parts to the total number of parts on this line, and subsection three asked the student to divide the line into equal sized pieces and lightly shade that number of pieces indicated by the fraction. Each subdivision had three questions. Figure 3 depicts the results for section three.

Figure 3



The pretest found thirteen students gave a total of thirty-six wrong answers. Thirteen students were given homework packets. Twelve students completed and returned the packets. The posttest found six students gave a total of nine wrong answers. One student commented that it was difficult to understand the answers.

An error occurred in the posttest subsection three questions 7 and 9. The question was the same. Upon realizing this, the researcher changed question 9 to 7/8 from 5/8. Each student was individually notified of the change. However, several students were beyond that point in the test. As a result, some students changed the answer and other did not. In scoring, both answers were accepted.

The errors that occurred in posttest were a repeat of section two. The students did not divide the line into the correct number of parts. In addition, students did not divide the whole line. They did not divide the line into reasonable equal sections nor did they mark the beginning and end of the line. The following example was marked wrong.

5/8

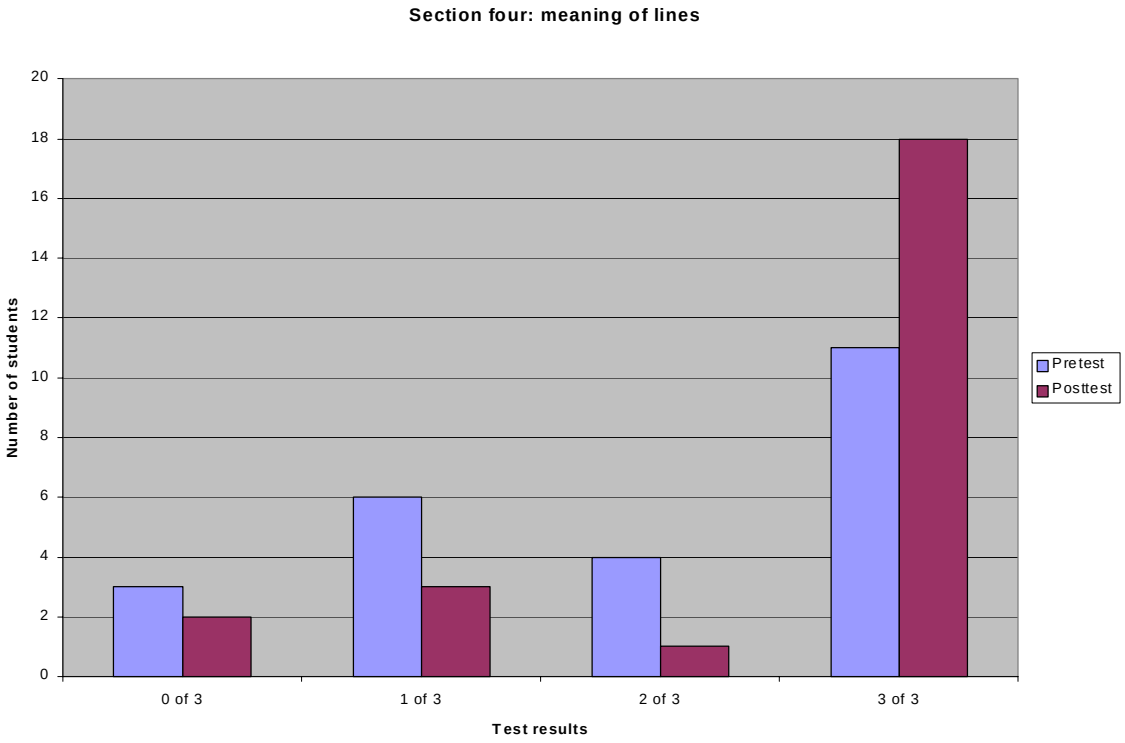
Other students shaded the wrong number of parts. Of the six students that had errors on this posttest section, four also had errors on section two

Section four: meaning of lines Section four had three questions, which asked the student to match a line of the ruler with a unit. Section four was done without using a ruler. Figure 4 depicts the results for section four.

The pretest found twelve students gave a total of twenty-five wrong answers. Twelve students received homework packets. Six students completed and returned the packets. The posttest found six students gave a total of thirteen wrong answers.

Comments on this section were that the information was confusing and that it was hard until you got the hang of it.

Figure 4

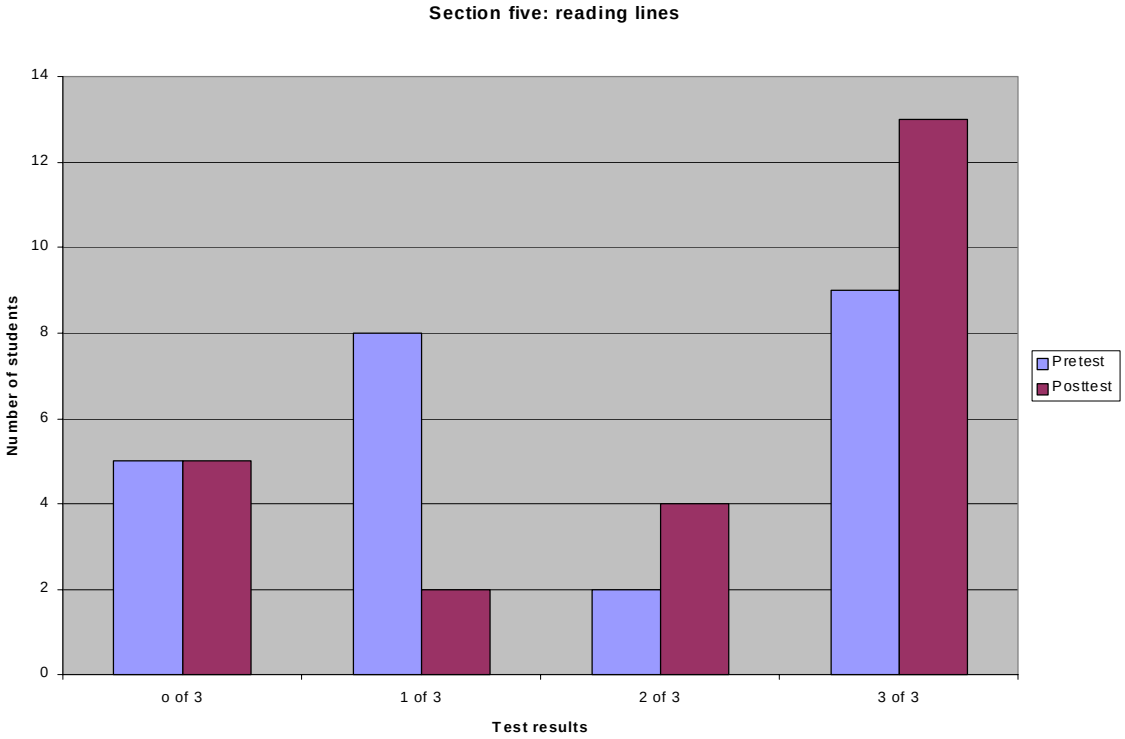


Section five: reading lines Section five had three questions, which asked the student to read the length of a line that was located above a provided ruler. Section five was done without using a ruler. Figure 5 depicts the results for section five.

The pretest found fifteen students gave a total of thirty-two wrong answers. In the pretest of section five, one student did not complete the test due to time. When this happened, the answers were marked as missing (Appendix E) not errors. The number of students not completing the test steady rose to eleven with the pretest. All students were able to complete this section on the posttest. Fifteen students received homework packets. Eleven students completed and returned the packets. The posttest found eleven

students gave a total of twenty-three wrong answers. One student commented that did not get it at first.

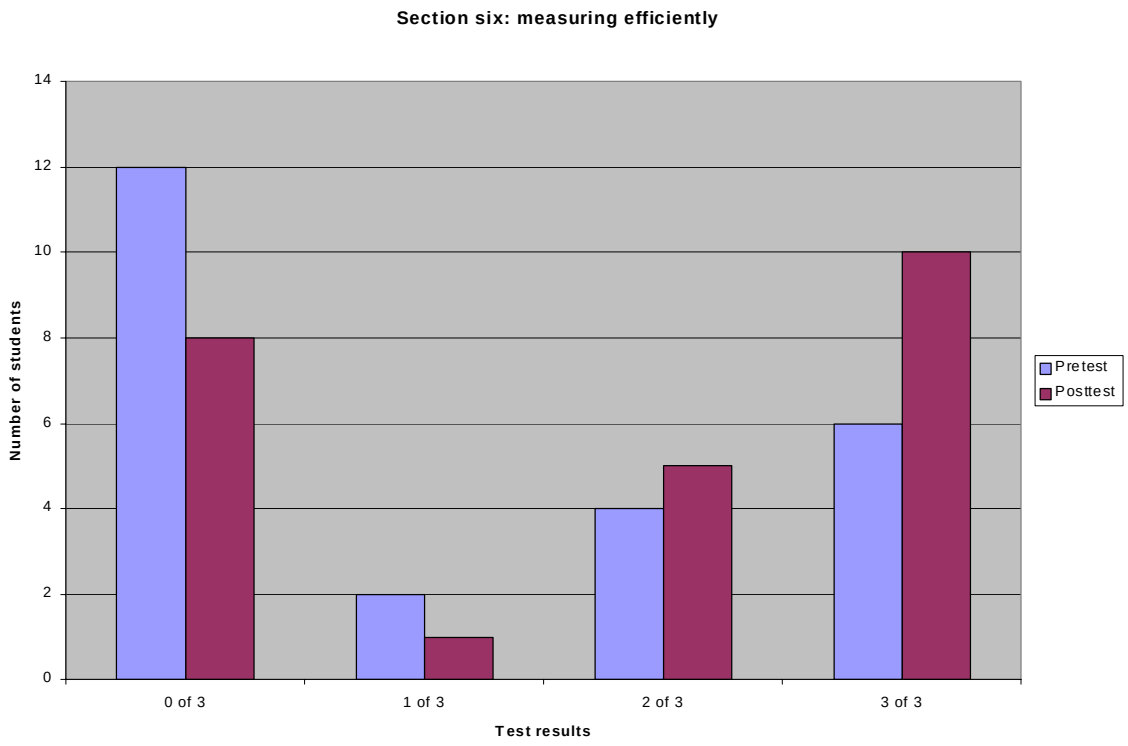
Figure 5



Section six: measuring efficiently This section had three questions, which asked the student to measure the length of the line using pictures of rulers where some of the lines were missing. Figure 6 depicts the results for section six.

The pretest found eighteen students gave a total of thirty-eight wrong answers. Two students had missing answers. Eighteen students received homework packets. Thirteen students completed and returned the packets. The posttest found thirteen students gave a total of thirty-one wrong answers. In this section almost half of the students missed 2/3 questions on the posttest.

Figure 6



In looking over the tests, the following observations were made:

1. Six students on the pretest and ten students on the posttest completed all three items correctly; five students completed the items correctly on the both tests
2. Eight students on the pretest and one student on the posttest omitted answers to at least one of the questions
3. Two students on the pretest and eight students on the posttest did not reduce fractions
4. Eight students on the pretest and four students on the posttest tried to fill in the missing lines on the ruler

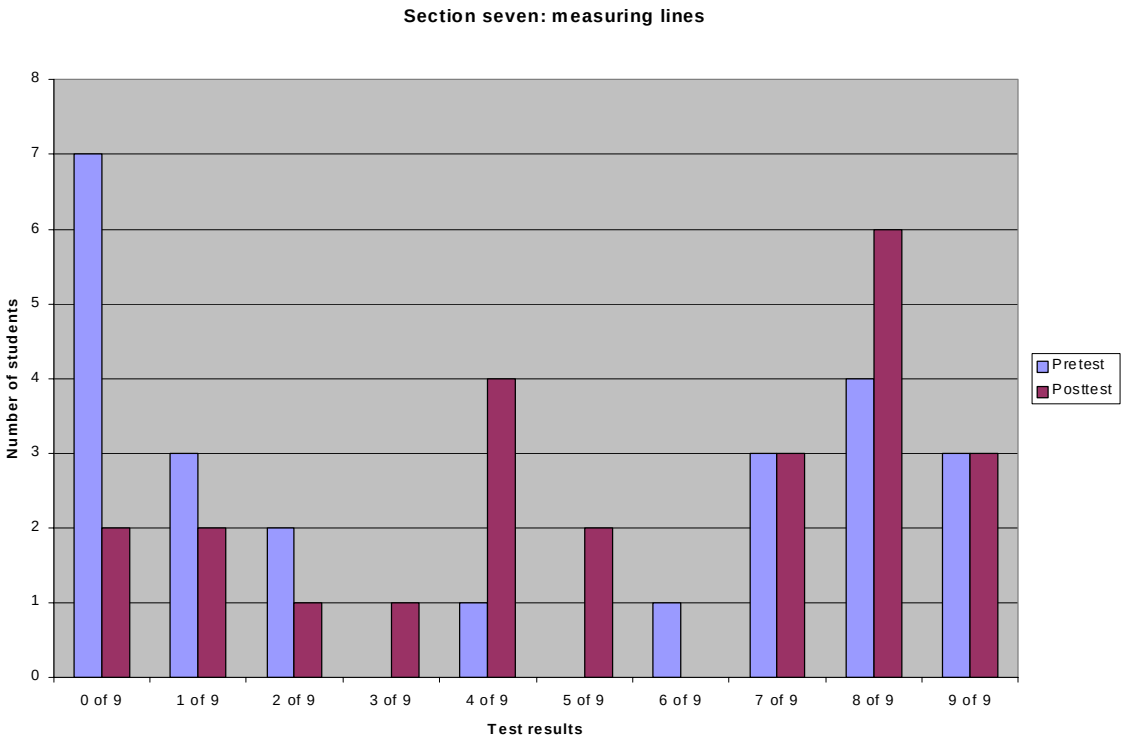
Section seven: measuring lines Section seven was subdivided into three subsections. Subsection one asked the student to measure each line, subsection two

asked the student to draw a line above the ruler the requested length, and subsection three asked the student to draw a line the requested length starting at the dot. The student used the supplied ruler in this section. Figure 7 depicts the results for section seven.

The pretest found twenty-one students gave a total of eight-nine wrong answers. Three students had missing answers in items 1-6 and the four students had missing answers in items 7-9. Twenty-one students received homework packets. Twelve completed and returned the packets. The posttest found twenty students gave a total of eighty-four wrong answers. One student had missing answers in items 7-9.

Errors in this section fell into four areas. The first area was fractions that were not reduced. Fractions that were not reduced were scored as incorrect because it demonstrated that the student was not using the ruler correctly as a tool. This occurred six times on the pretest and eight times on the posttest. The second area included answers with the wrong denominator, decimals, or metric. This occurred fourteen times in the pretest and thirteen times in the posttest. The fourth area included answers that demonstrated that the student did not have any understanding of the questions being asked. Examples were 7/16” for 3/16”, 5/8” for 3/16”, 15/16” for 7/16”, 3/8” for 7/8” 11/16” for 3/8”, 3” for 3/8”, and 15/16” for 3/8”. This area decreased from twenty-six times in the pretest to sixteen times in the posttest. The fourth area included understandable mistake or errors that were close. Examples were 5/16” for 5/8”, 3/8” for 5/8” or answers that were within 1/8”. This area had sixteen examples in the pretest and twenty-two examples in the posttest.

Figure 7

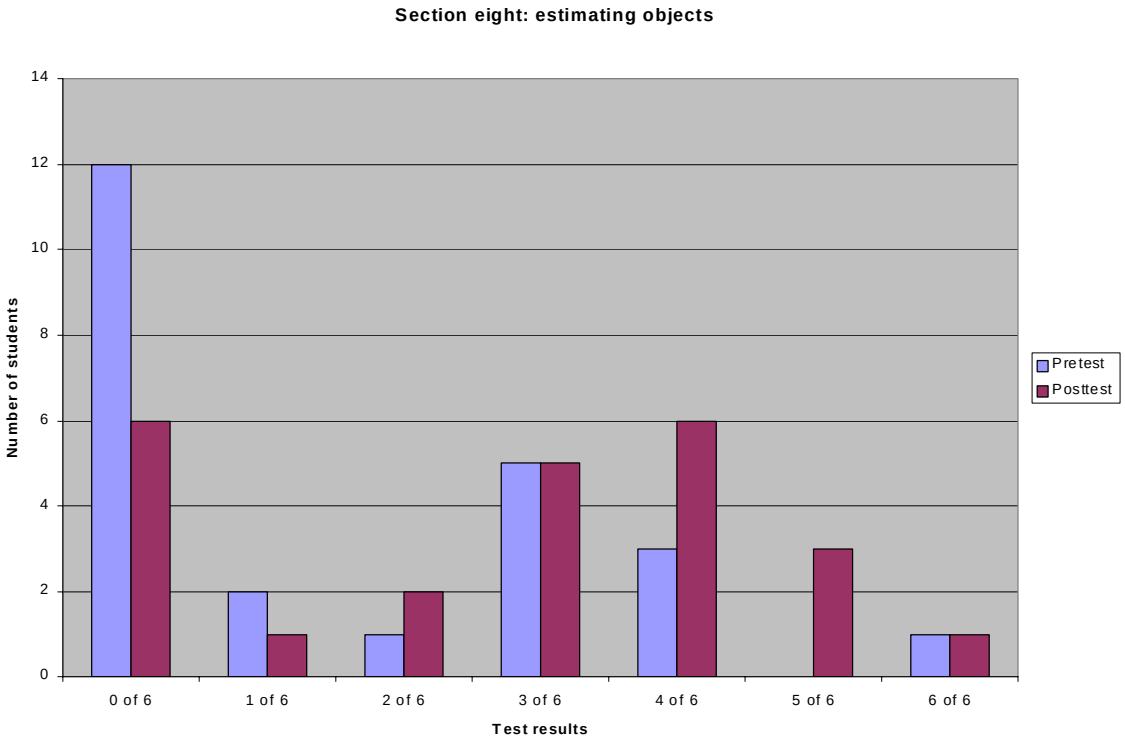


Section eight: estimating and measuring objects This section was subdivided into two subsections. Subsection one asked the student to estimate and subsection two asked the student to measure objects. The items used for estimation included a clothespin, a small playing card, and a package of gum. The items used for measuring objects included a plastic anchor, a large playing card, and an eraser. The clothespin and the plastic anchor were the two items that were used to estimate/measure length. The playing cards were the two items that were used to estimate/measure length and width. The package of gum and the eraser were the two items that were used to estimate/measure length, width, and depth.

Estimation The results of this section were meaningless. The students had used the ruler in section seven and used it again in section 8B. When it was observed that the

students were using the rule for estimating, they stated that they wanted to get the questions correct. Once the students had measured the object, it was not possible for them to estimate the object. This was more of a problem with the posttest than the pretest because more students completed this section on the posttest and the posttest was being used as a test grade in the class. Figure 8A depicts the results for section eight A.

Figure 8A



The estimating was scored with the answer falling in a range. The range was within 1/16" with measurements under one inch and within 1/8" with measurements over one inch.

The pretest questions one and two found fifteen students gave a total of fifty-three wrong answers. The pretest question three found thirteen students gave a total of eighteen wrong answers. Eight students had missing answers for question one and two. Ten students had missing answers for question three. Twenty-four students received

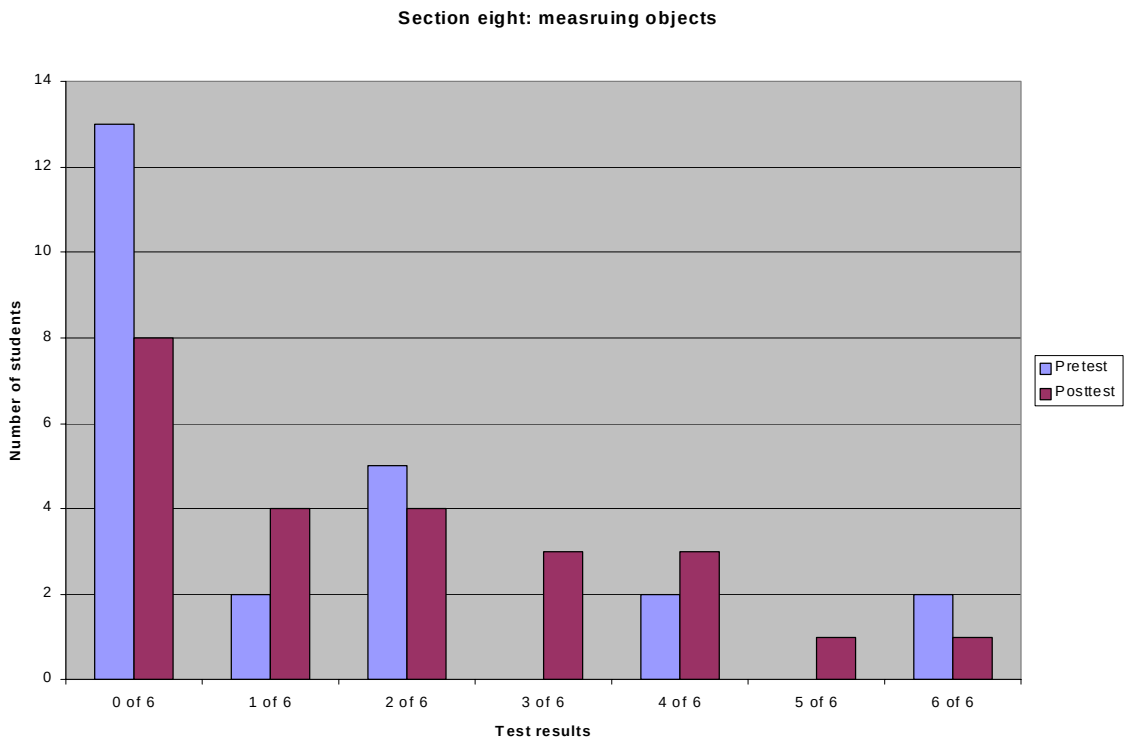
homework packets. Nine students completed and returned the packets. The posttest question one found eleven students gave a total of eleven wrong answers. The posttest question two found fourteen students gave a total of twenty-one wrong answers. The posttest question three found seventeen students gave a total of twenty-eight wrong answers. Two students had missing answers for question one, four students had missing answers for question two, and three students had missing answers for question three.

Measuring objects Section 8B had three questions. The students were asked to measure to the nearest 1/16th" a plastic anchor, a large playing card, and an eraser. The students were asked to measure the length of the anchor, the length and width of the playing card, and the length, width, and depth of the eraser. There were a total of six answers for section 8B. Four of the six answers were greater than one inch. Figure 8B depicts the results for section 8B.

The pretest found eleven students gave a total of forty-seven wrong answers. Eleven students had missing answers. Twenty-three students received homework packets. Nine students completed and returned the packets. The posttest found twenty students gave a total of eighty-two wrong answers. Three students had missing answers.

In the pretest fourteen answers were not reduced and in the posttest thirty answers were not reduced. If these answers were reduced three would have been correct in the pretest and two in the posttest. Two students on the posttest had answers with the correct fraction, but missed the whole number in front of the fraction.

Figure 8B



It looked like the number of wrong answers on section 8B sharply increased. However, if the number of missing answers on the pretest was added to the errors on the pretest, the total was 115. If the number of missing answers on the posttest was added to the errors on the posttest, the total was 101. This indicated a slight gain.

Summary of study

The purpose of the study was to develop and evaluate an instructional unit that would address the ruler reading deficiencies of middle school students. The ruler reading tests and packets were set up to start from materials that the students understood to material they did not understand. Each section was meant to build upon the previous section. When a student did not understand a section, most likely, the student would have difficulty with later section.

The data collected in the study can be presented in many different ways. One can look at the data by an analysis of the questions on the test (Appendix E). This Figure lists the question in each section and presents the results on the pretest and the posttest by showing the number of correct, incorrect, and missing answers for each question. The final column shows the change between the number of correct answers on the pretest and the posttest.

One could look at the data from the standpoint of each individual student (Appendix F). On this Figure, the twenty-four students that participated in the study were shown for each of the section scores and total scores on the pretest and the posttest. One can see by looking at this table that all but two students improved their scores. Eight students improved by ten to fifteen points on a test with a total of fifty-seven points. The two students, who did not improve, decreased their scores by one point and by four points.

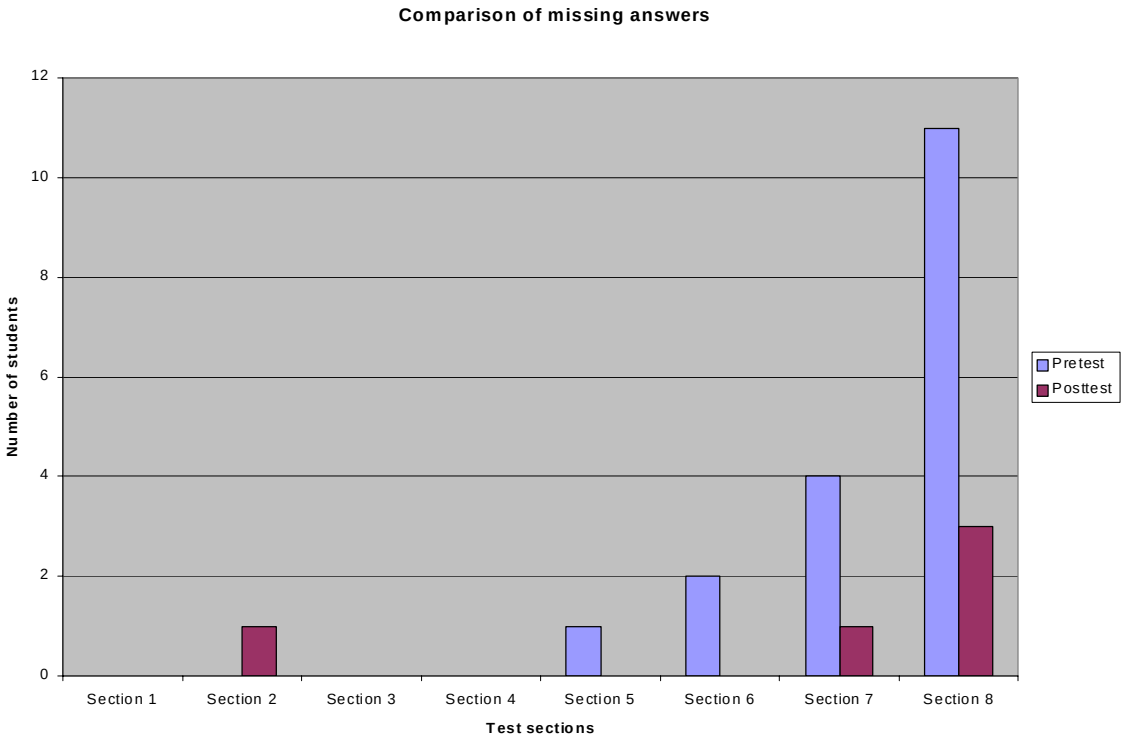
The mean, median and standard deviation for the test results are shown on Appendix G. Of particular interest was the fact that the mean score increased about six points, the median increased nine points, and that the standard deviation decreased about two points between the pretest and the posttest.

Pearson correlations (r) were calculated with a population of 24 (n= 24). The correlation between the total pretest and the posttest were r = .833 with sig. (2-tailed) .000, the correlation between the gain of the total test and the pretest total was r = -.603 with sig. (2-tailed) .002, the correlation between the gain of the total test and the posttest total was r = -.060 with sig. (2-tailed) .780. These statistics moved in the direction one would expect. The scores on the pretest compared to the posttest went up as indicated by the positive r value. The total gain correlated to the total pretest had a negative r-value,

which indicated that the largest gains were from the lowest students or an inverse relationship.

Figure nine illustrated the speed at which the students were able to process the information. One can see by looking at Figure nine, the radical reduction in the number of students with missing answers between the pretest and the posttest. This result indicated that the students processed the information faster when taking the post-test.

Figure 9



Test results were also analyzed by a comparison of correct answers when measuring with 8th's and 16th's, a comparison of reading measurement with and without a ruler, the lower 25% to the upper 25%, and a comparison of the effect the homework had on the test results. Since the number of answers involving 8th's and 16th's was not equal in the test, this data is given in percentages in Table 2.

Table 2

Percent of correct answers with 8^{th}'s and 16^{th}'s

	Pretest		Posttest	
	8^{th}'s	16^{th}'s	8^{th}'s	16^{th}'s
Mean	74.1071	64.583	79.398	81.862
Median	75.0	65.0	86.11	91.176
Std. Deviation	16.825	24.535	17.219	18.756

This table shows that there was improvement in reading $8^{th's}$ and 16^{th}'s between the pretest and the posttest. It also showed that there was a bigger gain in correct answers with the 16^{th}'s than the 8^{th}'s.

The analysis of reading measurements with and without a ruler compared the results between using and reading the supplied ruler as opposed to using and reading the ruler that was printed on the test (Table 3). Issues that were addressed here were eye hand coordination and visual perception.

Table 3

A percent comparison of performance in reading measurements with and without a ruler

	Pretest		Posttest	
	Without	With	Without	With
Mean	48.611	31.597	65.740	42.013
Median	33.333	29.166	88.888	41.666
Std. Deviation	36.896	31.563	33.077	27.526

One can see by this table that the students improved between the pretest and the posttest in both categories, but that they had more success with rulers printed on the page than with the use of a separate ruler.

The t test was applied to the lower 25% and the upper 25% of students, as determined by the pretest, and the gain from the total number of correct answers on the

posttest. This t test was significant for the lower 25% making more gains than the upper 25%.

	t	df	Sig. (2-tailed)
Gain of total number of correct answers	4.551	10	.001

Finally, what was the relationship between the homework packets completed and the learning that occurred with ruler reading? After the pretest was scored and the students identified who would receive the study packets, two to three study packets per week were distributed to these students. A school holiday, no homework on Wednesdays (school policy), and no homework on the weekends determined the packet distribution schedule. Students were reminded about the delinquent homework assignments as packet four and eight were distributed. Table 4 compares the percent of homework completed with the pretest/posttest score changes, the posttest score, and the percent of change between the pretest score and the posttest score.

Table 4
Homework completed compared to pre/posttest score change, posttest score, and percent of change from pretest to posttest

Percent of home-work completed	Frequency	Pre/posttest change	Posttest score	% Change from pretest
0	1	5	30	20
25	1	9	43	26.3
28.57	1	-1	32	-3
33.33	1	11	43	34
40	3	4	47	9.3
		2	35	6
		15	43	53.5
50	2	2	52	4
		2	33	3
60	1	13	54	31
62.5	1	14	39	52
66.67	2	0	50	0
		7	31	29
80	1	10	47	27

83.33	1	5	39	14
85.71	1	4	36	9.3
100	8	7	47	17.5
		14	27	107
		-4	52	-7
		9	36	33
		4	49	8.8
		0	43	0
		11	50	28.2
		12	42	40

Discussion

Almost half of the eighth grade students enrolled in technology education classes have not learned to read a ruler at the level needed for success in high school technology education classes. The National Assessment of Educational Progress as well as other researchers (Bright & Hoeffner, 1993; Carpenter et al., 1980; Lindquist, 1989) and teachers agrees that middle school students are deficient in ruler reading skills. Research shows that the logico-physical abstraction, procedural measurement, and logico-mathematical abstraction should be established in most students by fifth grade. Formalization appears to develop in students slightly later (Kamii, 1991; Heraud, 1989a). Often times there is a discrepancy between the opportunities to learn ruler reading and the actual performance (Bright & Hoeffner). By the time students are in middle school, some students have not acquired ruler-reading skills, while other have forgotten such skills and need the skills to be taught to them again (Bright& Hoeffner, 1993; Hart et al., 1981). Problems that middle school students have with ruler reading include being afraid of fractions, failing to realize that the length of an object does not change when it is moved, failing to understand where the zero is on a ruler, counting the lines rather than the spaces on a ruler, and inability to estimate (Kamii, 1991; Bright & Hoeffner, 1993; Hart et al., 1981; Bright, 1976).

This study found a wide range of ruler reading skills among the students tested. Of the problems mentioned above, realizing that the length of an object does not change when it is moved and not understanding where the zero is on a ruler were not a problem in this study. However, being afraid of fractions, counting the lines rather than the spaces, and inability to estimate were problems with this population of students. The students had a hard time understanding that the ruler was a tool and that if the lines on the ruler were correctly read the answer could then easily be stated in the form of the resulting fraction.

CHAPTER FIVE

Summary, Conclusions, and Recommendations

Summary

Few will argue that measurement is a skill used in many professions. Measurement is an intricate part of manufacturing, construction, communication, agriculture, power, transportation, retail business, art and theater, and food processing to name a few. In our schools measurement is a part of the curriculum in art, science, mathematics, and technology education. National math tests find about half of the eighth grade students unable to measure with a ruler more accurately than one quarter of an inch. Yet, no discipline has taken responsibility for teaching this skill and no discipline has devised a method of teaching the skill successfully to all students.

One hears stories about people who cannot read a ruler. A librarian told a story of a carpenter who came to her looking for information on how to read a ruler because he needed the skill for a test he was going to take. A college graduate and kindergarten teacher was delighted to find self-reading rulers on the market because she could not read a ruler. And pipe fitter at the former Uniroyal plant in Eau Claire, Wisconsin always carried a ball of string on his hip to measure the pipes he needed to cut. He too, could not read a ruler.

Studies done on length and measurement with children over the years have shown that they generally possess the skill necessary to read a ruler by fifth grade. Studies showed that after the students have been taught a method of learning to read a ruler, they performed poorly if the test questions were presented in a different format. This indicated that the students did not understand the concepts in the skill of reading a ruler.

Purpose of the Study

The purpose of the study was to develop and evaluate an instructional unit that would address the ruler reading deficiencies of middle school students. The results of this study would add to the current knowledge of how students learn ruler reading. The results of the study would assist teachers in adapting more effective teaching methods for this essential topic.

Questions

The questions this study answered are as follows:

1. To what extent did the materials that were developed effectively help students recognize parts and whole?
2. To what extent did the materials that were developed effectively help students draw parts to whole?
3. To what extent did the materials that were developed effectively help students divide a line and illustrate a fraction?
4. To what extent did the materials that were developed effectively help students name the lines on the ruler?
5. To what extent did the materials that were developed effectively help student read the lines on a ruler?
6. To what extent did the materials that were developed effectively help students measure efficiently?
7. To what extent did the materials that were developed effectively help students measure lines?

8. To what extent did the materials that were developed effectively help students' estimate and measure objects?

Research Method

Data for this research was gathered from two six grade technology education classes. Twenty-four students participated in the study. The author developed the ruler reading test and homework packets. The test had eight subdivisions which were: 1) recognizing parts to whole 2) drawing parts to whole 3) dividing a line 4) meaning of lines 5) reading lines 6) measuring efficiently 7) measuring lines and 8) estimating and measuring objects. The pretest contained a cover sheet to collect the demographics for the variables. After the pretest was administered and scored, self-paced packets were given to students that were deficient in the subdivisions. Four days after the last packets were distributed, the posttest was administered.

The independent variables in this study were gender, age, elementary school attended, where they study, how quiet it is, who helps them with homework, whether or not they learned to read a ruler, whether or not they remembered how to read a ruler, and homework completion. Of these variables elementary school attended, who helps them with homework, whether or not they learned to read a ruler, and whether or not they remembered how to read a ruler were dropped as the samples were too small. The dependent variable was the students assigned to the researcher for student teaching.

Raw data, percentage, and t test analysis were used on the colleted data in the pretest, posttest, cover page, and homework completion Figure.

Findings

The findings of this study reflected that the students have for the most part studied how to read a ruler and think that they know how to read a ruler, but in fact, most of the students were not proficient with this skill. This study was researched and the pilot test administered with eighth grade students in mind. Although the topic was appropriate for sixth grade students, the developmental skills needed for this task were not as mature in the sixth grade students as in the eighth grade students. When one reviews the findings of this study, one can look at each subsection, the total test, and the variables.

Subsection findings

Section one, recognizing parts to whole, found the students made eight wrong answers on the pretest and one wrong answer on the posttest. The students were at 96.3% on the pretest and at 99.6% on the posttest. One can say that these students understood recognizing parts to whole.

Section two, drawing parts to whole, found the students made thirty-one wrong answers on the pretest and twelve wrong answers and nine missing answers on the posttest. The students were at 85.65% on the pretest and at 94.2% on the posttest with the missing answers not counted with the wrong answers nor in the total possible answers. One can say that these students understood drawing parts to whole.

Section three, dividing a line, found the students made thirty-six wrong answers on the pretest and nine wrong answers on the posttest. The students were at 83.4% on the pretest and at 95.9% on the posttest. One can say that these students understood dividing a line.

Section four, meaning of lines, found the students made twenty-five wrong answers on the pretest and thirteen wrong answers on the posttest. The students were at 65.3% on the pretest and at 85% on the posttest. This shows a significant improvement between the pretest and the posttest, but 16% of the students did not understand this section. Since understanding the meaning of the lines is essential in reading a ruler, teachers should be aware of this stumbling block for students.

Section five, reading lines, found the students made thirty-two wrong answers on the pretest and twenty-three wrong answers on the posttest. The students were at 55.6% on the pretest and at 60.1% on the posttest. In this section, the degree of improvement sharply declined and forty percent of the students had difficulties with this section after completing the homework packet. In this study, this was the point at which the class as a whole needed additional help.

Section six, measuring efficiently, found the students made thirty-eight wrong answers on the pretest and thirty-one on the posttest with six missing answers on the pretest. The students were at 42.5% on the pretest and at 57% on the posttest. Since measuring efficiently was based on an understanding of reading lines, one would expect problems in this section since 40% of the students were unable to read a line. Teachers need to help their students understand the reading lines first. The students need to understand the basics before they can take the short cuts.

Section seven, measuring lines found the students made eighty-nine wrong answers on the pretest and eight-four wrong answers on the posttest with missing answers from both tests. The students were at 52.5% on the pretest and at 60.8% on the posttest. The problems that the students had in section five also influence section seven. In addition

this was the section that introduced the use of the ruler. One now needs to look at how eye-hand coordination and spatial relationships affect this process.

Section eight A, estimating, found the students made fifty-three wrong answers on the pretest and sixty wrong answers on the posttest with missing answers from both tests. The students were at 44.8% on the pretest and at 52.8% on the posttest. This study found that estimation was not easily evaluated with a measurement test. Once the students had access to a ruler, they preferred to use the ruler instead of estimating. Since the students progressed at different rates through the tests, it was not possible to prevent the students from using the ruler for estimating.

Section eight B, measuring objects, found the students made forty-seven wrong answers on the pretest and eight-two wrong answers on the posttest with missing answers from both tests. The students were at 39.8% on the pretest and at 35% on the posttest. In this section, in addition to the problems that mounted from the other sections, the students now had to manipulate the object and the ruler while measuring. This section also had the poorest rate of homework complete at 39%.

Total test

The overview of pretest and the posttest found that most students benefited from the ruler reading packets. Of the twenty-four students in the study, twenty-two improved their score in the posttest from the pretest. The two students that had lower scores were down one and four points. The mean score increased about six points, the median increased up nine points, and that the standard deviation decreased about two points between the pretest and the posttest. Students also improved in their ability to process the

information faster. This study was also able to identify the point at which the students began to have problems with understanding how to read a ruler.

Variables

The variables included gender, elementary school, age, location of homework, noise, who helped with homework, whether or not the students had learned to read a ruler, whether or not the students remembered how to read a ruler, and the number of packets completed and returned. Of these variables, the sample size was too small with the elementary schools, who help the student with the homework, whether or not the students learned to use a ruler in elementary school, and whether or not the students remembered how to use a ruler. No significant data appeared when one looked at the differences between males and females and the amount of noise in ones study area. Two other variables were close to being significant. These two looked at age and location of study area. This found that the younger students did better with the pretest and the older students made more overall gains. It also showed that students who study outside of the bedroom area do better on the posttest. With regards to the number of homework packets completed and the test results, only raw data was obtained.

Recommendations

Based on the findings of this study, the following recommendations are made.

1. The study needs to be repeated with a larger population at the eighth grade level. This study was designed primarily for the eighth grade student instead of the sixth grade students that it was given too. The eighth grade students has had a little more exposure to reading a ruler, are at an age where they realize that they do not know this information, and have improved eye-hand coordination.

2. The estimation section should be done separate from the remaining ruler reading test. The literature review and research has shown that students have difficulty estimating length. By improving ones ability to estimate well, one is able to recognize when measurements are likely wrong. However, the experience of this study found that it would be easier to administer an estimating test one day and a measurement test another day.
3. The material used in this study can be valuable to sixth grade students by putting the emphasis on halves, quarters, and eighths and not sixteenth. The sixth grade teacher should use the packets and tests for sections one through three as is. Section four, the meaning of lines, needs to be supplemented with additional materials. Section five needs to be presented with more emphasis on quarters and eighths. Drawing lines and measuring lines and objects with quarters and eights should be added. One would suggest that the ruler selected for use with these students have the length of the lines (half, quarter, eighth, sixteenth) clearly distinguishable
4. The students need more practice with measuring objects.

Recommendations for Further Research

Based on the findings of this study, the following items are recommended for further research.

1. Use the same pretest and posttest so one knows that one is measuring the same thing.
2. Correct the answer in homework packet section three n and the question on the posttest section three question nine.

3. Use a larger population or a sample of eighth grade students or rewrite the tests and homework packets for a sixth grade level.
4. Review the homework packets in sections four, five, six, seven, and eight B.
5. Develop a separate estimating test.
6. Workout a way to statistically measure the influence of homework packets completed with posttest and gain results.

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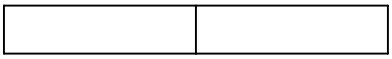
Appendix A

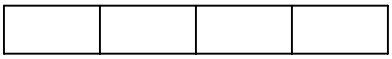
Pilot Test

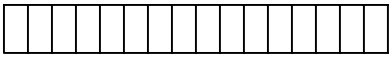
Ruler Reading

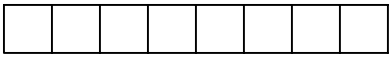
Section one

Into how many parts is each rectangle divided?

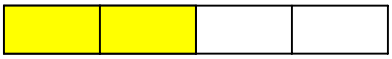
Example:  answer_2___

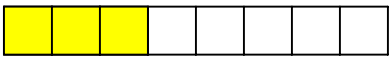
1.  answer_____

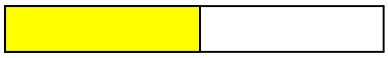
2.  answer _____

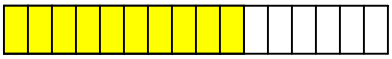
3.  answer _____

How many parts are shaded in each rectangle?

Example:  answer_2___

1.  answer _____

2.  answer _____

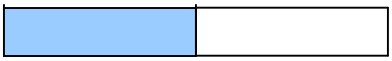
3.  answer _____

What is the number of parts shaded compared to the total number of parts?

Example:  answer_5/8___

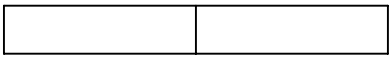
1.  answer _____

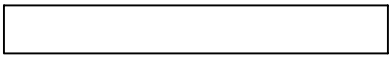
2.  answer _____

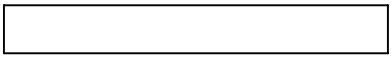
3.  answer _____

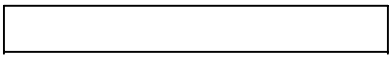
Section two

Without using the ruler, divide the boxes into equal pieces.

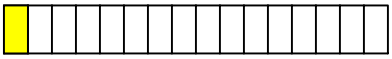
Example:  2 pieces

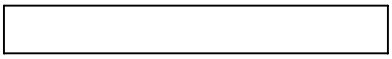
1.  16 pieces

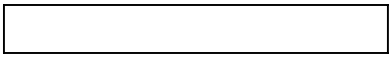
2.  4 pieces

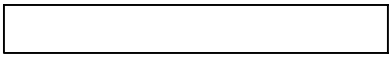
3.  8 pieces

Without using the ruler, divide the box into equal pieces and lightly shade in the numbers of parts requested. *Lightly shade the boxes so the scorer can count the number of boxes shaded.*

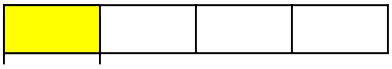
Example:  1 shaded part of 16 parts

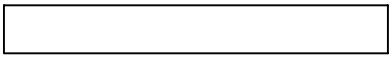
1.  7 shaded parts of 8 parts

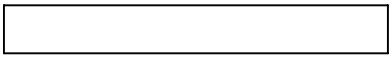
2.  1 shaded part of 4 parts

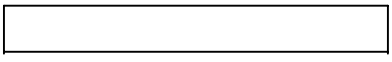
3.  3 shaded parts of 16 parts

Without using the ruler, divide the rectangle into equal sized boxes and lightly shade the number of boxes required by the fraction.

Example:  1/4

1.  1/8

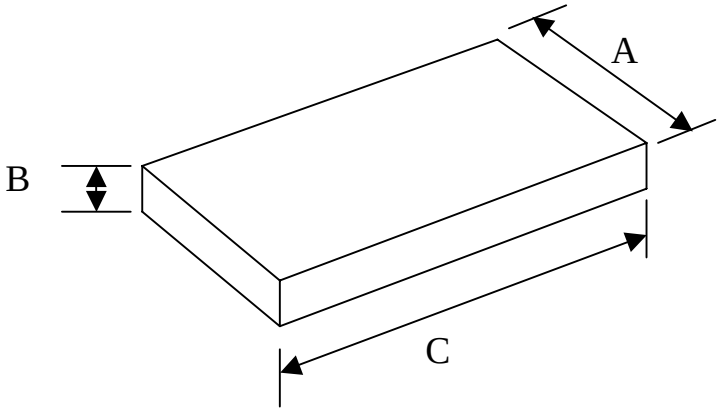
2.  15/16

3.  3/4

Section three

Letters identifies the terms length, width, and depth. Match the letters in the diagram with the terms. Then place the correct letter in the spaces provided.

1. Length = _____
2. Width = _____
3. Depth = _____



Section four

Estimate how many little boxes will fit into the big box?

Example: answer _5____

1. answer _____

2. answer _____

3. answer _____

Without using a ruler, shade the requested fraction in the box.

Example: ¾

1. 1/8

2. 7/16

3. 3/8

1. Take the clothespin out of the bag. Estimate its length. Record the length in the space below and return the clothespin to the bag.

Clothes pin length:_____inches

2. Take the **small** playing card out of the bag. Estimate its length and width. Record the length and width below. Return the card to the bag.

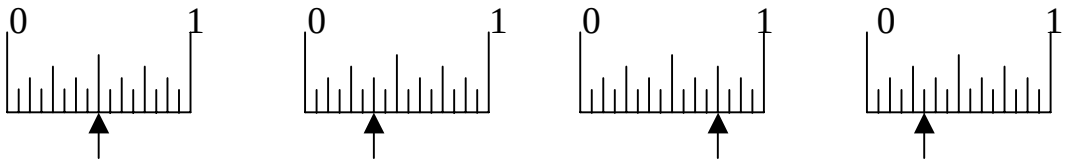
Small playing card length:_____inches width:_____inches

3. Take the package of gum out of the bag. Estimate its length, width, and depth. Record the estimates below. Return the gum to the bag.

Package of gum length:_____inches width:_____ inches depth:_____inches

Section five

The arrow is pointing to a mark on the ruler. Underline what division of an inch the mark represents.



Example:

1. sixteenth	1 sixteenth	1. sixteenth	1. sixteenth
2. eighth	2. eighth	2. eighth	2. eighth
3. quarter	3. quarter	3. quarter	3. quarter
4. half	4. half	4. half	4. half
5. whole	5. whole	5. whole	5. whole

Section six

Into how many parts is each ruler divided?

Example:  answer_2___

1.  answer_____

2.  answer_____

3.  answer_____

Express as a fraction the number of shaded parts to the total number of parts on this ruler.

Example:  answer 4/8 or ½

1.  answer _____

2.  answer _____

3.  answer _____

Without using the ruler, divide the line into equal sized pieces and lightly shade that number of pieces indicated by the fraction.

Example: ¾ 

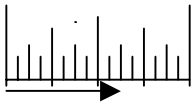
1. 5/8 

2. 1/16 

3. 3/8 

Section seven

How long is the arrow below the ruler? Measure to the tip on the arrow.

Example: 

answer __5/8__

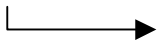
  

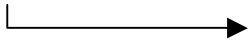
answer _____ answer _____ answer _____

Section eight

Using the supplied ruler, measure each arrow to its tip very carefully.

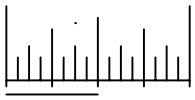
1.  answer:_____

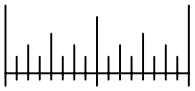
2.  answer:_____

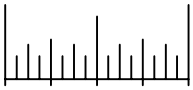
3.  answer:_____

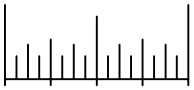
Using the supplied ruler as a straight edge, draw a line below the ruler of the requested length.

Example: 1/2”









1. 7/16” 2. 1/8” 3. 3/16”

Using the supplied ruler, draw a line the requested length starting at the dot. Draw carefully and accurately!

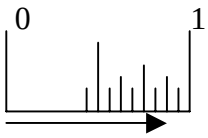
1. 15/16” .

2. 5/8” .

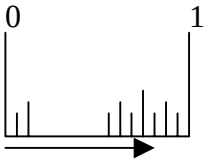
3. 3/16” .

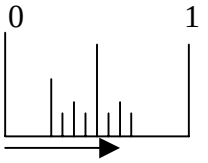
Section nine

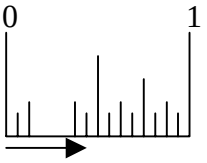
Can you figure out the length of the line using the pictures of the rulers where some of the lines are missing?

Example: 

answer _7/8__







1. answer:_____ 2. answer:_____ 3. answer:_____

Section ten

1. Take the blue plastic anchor out of the bag. Using the ruler supplied, measure the anchor's length to the nearest 1/16th of an inch. Record the length below and replace the anchor in the bag.

Plastic anchor length:_____inches

2. Take the **large** playing card out of the bag. Using the ruler supplied, measure the playing card's length and width to the nearest 1/16th of an inch. Record the length and width below and replace the playing card in the bag

Large playing card length:_____inches width:_____inches

3. Take the eraser out of the bag. Using the ruler supplied, measure the eraser's length, width, and depth to the nearest 1/16th of an inch. Record the length below and replace the eraser in the bag.

Eraser length:_____inches width:_____inches depth:_____inches

Appendix B

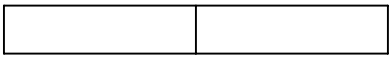
Pretest

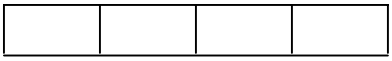
Teacher to complete Number: _____

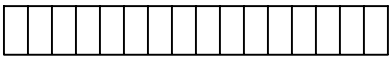
Ruler Reading

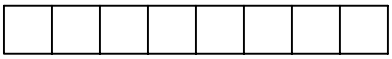
Section one: recognizing parts to whole

Into how many parts is each rectangle divided?

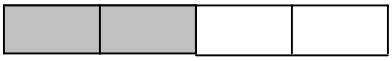
Example:  answer_2___

1.  answer_____

2.  answer _____

3.  answer _____

How many parts are shaded in each rectangle?

Example:  answer_2___

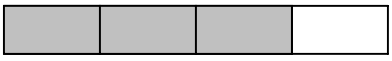
1.  answer _____

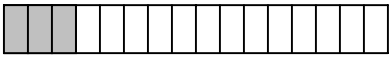
2.  answer _____

3.  answer _____

What is the number of parts shaded compared to the total number of parts?

Example:  answer_5/8___

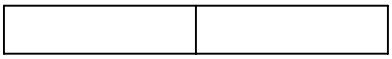
1.  answer _____

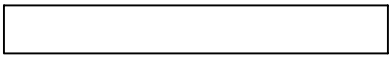
2.  answer _____

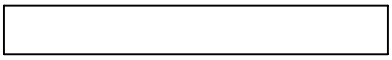
3.  answer _____

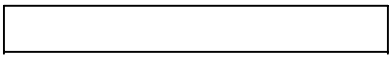
Section two: drawing parts to whole

Without using the ruler, divide the boxes into equal pieces.

Example:  2 pieces

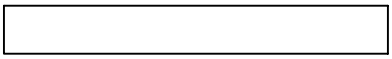
1.  16 pieces

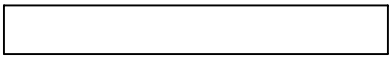
2.  4 pieces

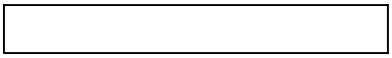
3.  8 pieces

Without using the ruler, divide the box into equal pieces and lightly shade in the numbers of parts requested. *Lightly shade the boxes so the scorer can count the number of boxes shaded.*

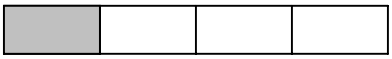
Example:  1 shaded part of 16 parts

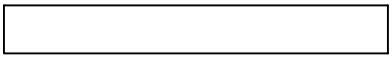
1.  7 shaded parts of 8 parts

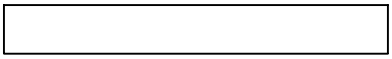
2.  1 shaded part of 4 parts

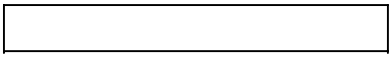
3.  3 shaded parts of 16 parts

Without using the ruler, divide the rectangle into equal sized boxes and lightly shade the number of boxes required by the fraction.

Example:  1/4

1.  1/8

2.  15/16

3.  3/4

Section three: dividing a line

Into how many parts is each line divided?

Example:  answer_2___

1.  answer_____

2.  answer_____

3.  answer_____

Express as a fraction the number of shaded parts to the total number of parts on this line.

Example:  answer 3/8___

1.  answer _____

2.  answer _____

3.  answer _____

Without using the ruler, divide the line into equal sized pieces and lightly shade that number of pieces indicated by the fraction.

Example: ¾ 

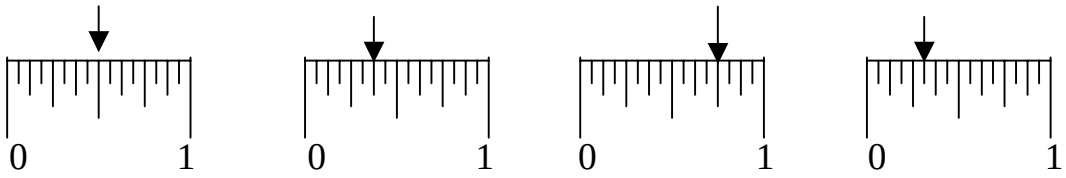
1. 5/8

2. 1/16

3. 3/8

Section four: meaning of lines

The arrow is pointing to a mark on the ruler. Underline what division of an inch the mark represents.

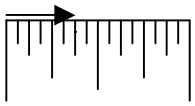


Example:			
1. sixteenth	1 sixteenth	1. sixteenth	1. sixteenth
2. eighth	2. eighth	2. eighth	2. eighth
3. quarter	3. quarter	3. quarter	3. quarter
4. half	4. half	4. half	4. half
5. whole	5. whole	5. whole	5. whole

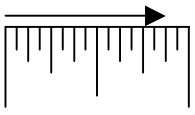
Section five: reading lines

How long is the arrow above the ruler? Measure to the tip on the arrow.

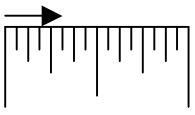
Example:



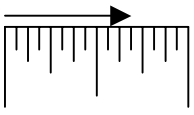
answer __3/8__



answer _____



answer _____

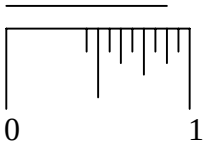


answer _____

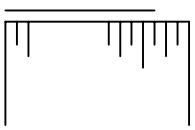
Section six: measuring efficiently

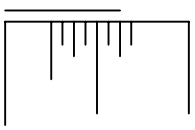
Can you figure out the length of the line using the pictures of the rulers where some of the lines are missing?

Example:



answer _7/8__





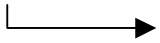
0 1 0 1 0 1

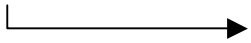
1. answer:_____ 2. answer:_____ 3. answer:_____

Section seven: measuring lines

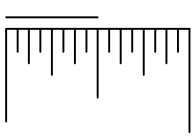
Using the supplied ruler, measure each arrow to its tip very carefully.

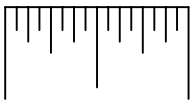
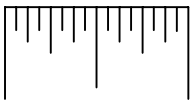
1.  answer:_____

2.  answer:_____

3.  answer:_____

Using the supplied ruler as a straight edge, draw a line above the ruler of the requested length.

Example: ½” 

1. 7/16” 2. 1/8” 3. 3/16”

Using the supplied ruler, draw a line the requested length starting at the dot. Draw carefully and accurately!

1. 15/16” .

2. 5/8” .

3. 3/16” .

Section eight: estimating and measuring objects

Using the objects in the supplied bag, estimate the following items to the nearest 1/16".

1. Take the clothespin out of the bag. Estimate its length. Record the length in the space below and return the clothespin to the bag.

Clothes pin length:_____inches

2. Take the **small** playing card out of the bag. Estimate its length and width. Record the length and width below. Return the card to the bag.

Small playing card length:_____inches width:_____inches

3. Take the package of gum out of the bag. Estimate its length, width, and depth. Record the estimates below. Return the gum to the bag.

Package of gum length:_____inches width:_____ inches depth:_____inches

Using the objects in the supplied bag, measure the following items to the nearest 1/16th"

1. Take the blue plastic anchor out of the bag. Using the ruler supplied, measure the anchor's length to the nearest 1/16th of an inch. Record the length below and replace the anchor in the bag.

Plastic anchor length:_____inches

2. Take the **large** playing card out of the bag. Using the ruler supplied, measure the playing card's length and width to the nearest 1/16th of an inch. Record the length and width below and replace the playing card in the bag

Large playing card length:_____inches width:_____inches

3. Take the eraser out of the bag. Using the ruler supplied, measure the eraser's length, width, and depth to the nearest 1/16th of an inch. Record the length below and replace the eraser in the bag.

Eraser length:_____inches width:_____inches depth:_____inches

Appendix C

Cover Sheet

Ruler Reading Study

Teacher to complete:
Number: _____
Permission given
Yes _____ No _____

Name: _____

Information about the participates:

1. Male _____ Female _____

2. Age: _____ years _____months

3. What elementary school did you attend?
   School name: _____
   City: _____

4. Where do you generally do your homework?
   Kitchen table _____
   Bedroom _____
   Living room _____
   Computer desk _____
   Other (name) _____

5. How quiet is it in the area that you do your homework?
   Quiet _____
   Occasionally noisy _____
   Noisy _____

6. Who helps you with your homework?
   Parent _____
   Sister/Brother _____
   Friend _____
   Homework hotline _____
   Other (name) _____

7. I have learned to read a ruler in elementary school?
   Yes _____
   No _____

8. I remember how to read a ruler?
   Yes _____
   No _____

Appendix D

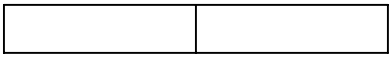
Posttest

Ruler Reading

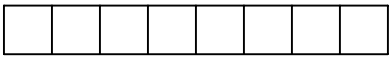
Posttest

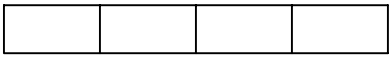
Section one: recognizing parts to whole

Into how many parts is each rectangle divided?

Example:  answer_2___

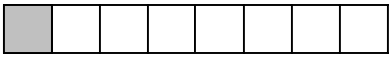
1.  answer_____

2.  answer _____

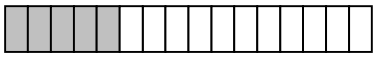
3.  answer _____

How many parts are shaded in each rectangle?

Example:  answer_2___

1.  answer _____

2.  answer _____

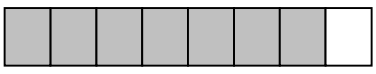
3.  answer _____

What is the number of parts shaded compared to the total number of parts?

Example:  answer_5/8___

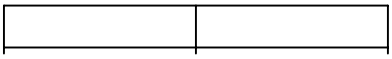
1.  answer _____

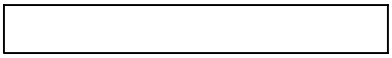
2.  answer _____

3.  answer _____

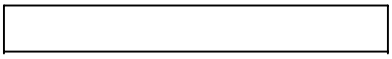
Section two: drawing parts to whole

Without using the ruler, divide the boxes into equal pieces.

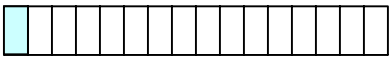
Example:  2 pieces

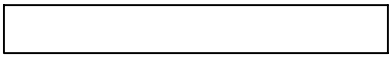
1.  8 pieces

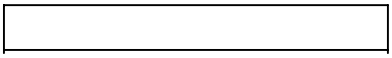
2.  16 pieces

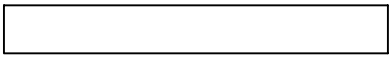
3.  4 pieces

Without using the ruler, divide the box into equal pieces and lightly shade in the numbers of parts requested. *Lightly shade the boxes so the scorer can count the number of boxes shaded.*

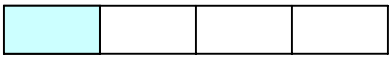
Example:  1 shaded part of 16 parts

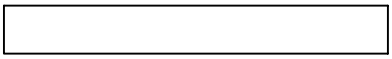
1.  5 shaded parts of 8 parts

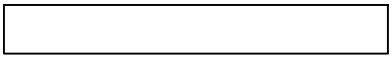
2.  3 shaded part of 4 parts

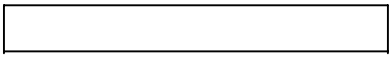
3.  7 shaded parts of 16 parts

Without using the ruler, divide the rectangle into equal sized boxes and lightly shade the number of boxes required by the fraction.

Example:  1/4

1.  7/8

2.  3/16

3.  1/2

Section three: dividing a line

Into how many parts is each line divided?

Example:  answer_2___

1.  answer_____

2.  answer_____

3.  answer_____

Express as a fraction the number of shaded parts to the total number of parts on this line.

Example:  answer *3/8*__

1.  answer _____

2.  answer _____

3.  answer _____

Without using the ruler, divide the line into equal sized pieces and lightly shade that number of pieces indicated by the fraction.

Example: ¾ 

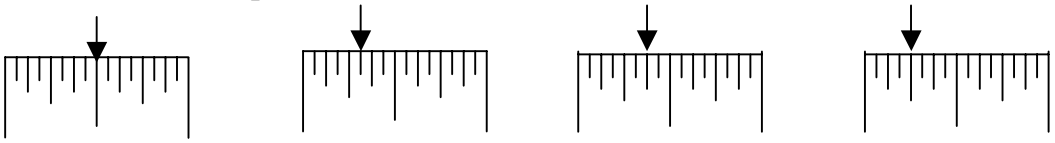
1. 5/8

2. 9/16

3. 5/8

Section four: meaning of lines

The arrow is pointing to a mark on the ruler. Underline what division of an inch the mark represents.

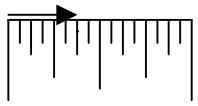


0	1	0	1	0	1	0	1
Example:							
1. sixteenth		1 sixteenth		1. sixteenth		1. sixteenth	
2. eighth		2. eighth		2. eighth		2. eighth	
3. quarter		3. quarter		3. quarter		3. quarter	
4. half		4. half		4. half		4. half	
5. whole		5. whole		5. whole		5. whole	

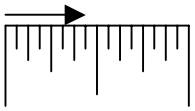
Section five: reading lines

How long is the arrow above the ruler? Measure to the tip on the arrow.

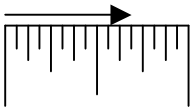
Example:



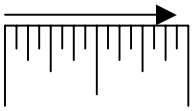
answer __3/8__



answer _____



answer _____

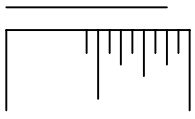


answer _____

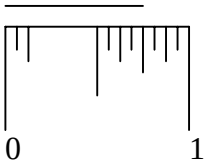
Section six: measuring efficiently

Can you figure out the length of the line using the pictures of the rulers where some of the lines are missing?

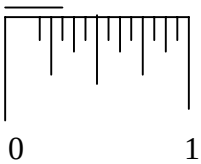
Example:



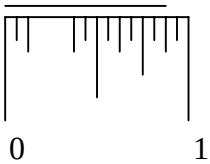
answer _7/8__



1. answer:_____



2. answer:_____



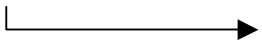
3. answer:_____

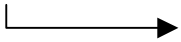
Section seven: measuring lines

Using the supplied ruler, measure each arrow to its tip very carefully.

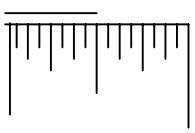
1.

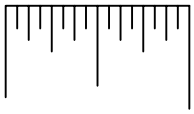
answer:_____

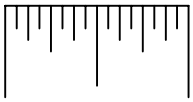
2.  answer:_____

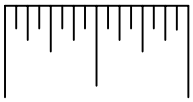
3.  answer:_____

Using the supplied ruler as a straight edge, draw a line above the ruler of the requested length.

Example: ½” 







1. 7/8” 2. 3/8” 3. 11/16”

Using the supplied ruler, draw a line the requested length starting at the dot. Draw carefully and accurately!

1. 3/8” .

2. 5/8” .

3. 7/16” .

Using the objects in the supplied bag, estimate the following items to the nearest 1/16th".

1. Take the clothespin out of the bag. Estimate its length. Record the length in the space below and return the clothespin to the bag.

Clothes pin length:_____inches

2. Take the **small** playing card out of the bag. Estimate its length and width. Record the length and width below. Return the card to the bag.

Small playing card length:_____inches width:_____inches

3. Take the package of gum out of the bag. Estimate its length, width, and depth. Record the estimates below. You may have the package of gum.

Package of gum length:_____inches width:_____ inches depth:_____inches

Using the objects in the supplied bag, measure the following items to the nearest 1/16th"

1. Take the blue plastic anchor out of the bag. Using the ruler supplied, measure the anchor's length to the nearest 1/16th of an inch. Record the length below and replace the anchor in the bag.

Plastic anchor length:_____inches

2. Take the **large** playing card out of the bag. Using the ruler supplied, measure the playing card's length and width to the nearest 1/16th of an inch. Record the length and width below and replace the playing card in the bag

Large playing card length:_____inches width:_____inches

3. Take the eraser out of the bag. Using the ruler supplied, measure the eraser's length, width, and depth to the nearest 1/16th of an inch. Record the length below and replace the eraser in the bag.

Eraser length: _____inches Width: _____inches depth: _____inches

Appendix E

Analysis of Individual Items on the Test

Analysis of individual items on test

	Pretest correct	Pretest incorrect	Pretest missing	Posttest correct	Posttest Incorrect	Posttest missing	Pretest/Posttest change
Section 1: item 1	24	0	0	24	0	0	0
Section 1: item 2	23	1	0	24	0	0	1
Section 1: item 3	24	0	0	24	0	0	0
Section 1: item 4	23	1	0	24	0	0	1
Section 1: item 5	23	1	0	23	1	0	0
Section 1: item 6	23	1	0	24	0	0	1
Section 1: item 7	24	0	0	24	0	0	0
Section 1: item 8	21	3	0	24	0	0	3
Section 1: item 9	23	1	0	24	0	0	1
Section 2: item 1	21	3	0	22	1	1	1
Section 2: item 2	22	2	0	22	1	1	0
Section 2: item 3	20	4	0	23	1	0	3
Section 2: item 4	18	6	0	21	2	1	3
Section 2: item 5	24	0	0	22	1	1	-2
Section 2: item 6	17	7	0	19	4	1	2
Section 2: item 7	21	3	0	22	1	1	1
Section 2: item 8	19	5	0	21	2	1	2
Section 2: item 9	23	1	0	23	0	1	0
Section 3: item 1	21	3	0	24	0	0	3
Section 3: item 2	22	2	0	24	0	0	2
Section 3: item 3	23	1	0	24	0	0	1
Section 3: item 4	21	3	0	24	0	0	3
Section 3: item 5	20	4	0	24	0	0	4
Section 3: item 6	23	1	0	24	0	0	1
Section 3: item 7	18	6	0	19	5	0	1
Section 3: item 8	16	8	0	23	1	0	7
Section 3: item 9	16	8	0	21	3	0	5
Section 4: item 1	17	7	0	20	4	0	3
Section 4: item 2	14	10	0	20	4	0	6
Section 4: item 3	16	8	0	19	5	0	3
Section 5: item 1	15	9	0	16	8	0	1
Section 5: item 2	10	14	0	16	8	0	6
Section 5: item 3	14	9	1	17	7	0	3
Section 6: item 1	7	15	2	12	12	0	5
Section 6: item 2	11	11	2	15	9	0	4
Section 6: item 3	10	12	2	14	10	0	4
Section 7: item 1	10	11	3	10	14	0	0
Section 7: item 2	10	11	3	10	14	0	0
Section 7: item 3	3	18	3	14	10	0	11
Section 7: item 4	12	9	3	18	6	0	6
Section 7: item 5	14	7	3	17	7	0	3
Section 7: item 6	12	9	3	17	7	0	5
Section 7: item 7	13	7	4	16	7	1	3
Section 7: item 8	11	9	4	13	10	1	2
Section 7: item 9	12	8	4	14	9	1	2
Section 8: item 1	7	9	8	11	11	2	4
Section 8: item 2L	3	13	8	12	8	4	9

Section 8: item 2W	3	13	8	7	13	4	4
Section 8: item 3L	11	3	10	15	6	3	4
Section 8: item 3W	8	6	10	11	10	3	3
Section 8: item 3D	5	9	10	9	12	3	4
Section 8: item 4	4	9	11	5	16	3	1
Section 8: item 5L	4	9	11	6	15	3	1
Section 8: item 5W	4	9	11	5	16	3	1
Section 8: item 6L	7	6	11	13	8	3	6
Section 8: item 6W	7	6	11	8	13	3	1
Section 8: item 6D	6	7	11	7	14	3	1

Appendix F

Correct Responses for Pretest and Posttest by Students

Correct responses for pretest and posttest by student
Posttest results are in parenthesis.

Subject Number	Pre/Post Section 1	Pre/Post Section 2	Pre/Post Section 3	Pre/Post Section 4	Pre/Post Section 5	Pre/Post Section 6	Pre/Post Section 7	Pre/Post Section 8A	Pre/Post Section 8B	Total
101	9 (9)	9 (9)	8 (9)	3 (2)	1 (3)	0 (2)	7 (8)	2 (3)	1 (2)	40(47)
102	9 (9)	9 (9)	9 (9)	3 (3)	3 (3)	3 (3)	8 (8)	4 (2)	2 (6)	50(52)
104	9 (9)	9 (9)	6 (9)	1 (3)	1 (3)	3 (3)	7 (8)	3 (2)	4 (1)	43(47)
105	8 (9)	1 (8)	3 (7)	0 (3)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	13(27)
106	9 (9)	8 (9)	6 (9)	3 (3)	3 (3)	3 (3)	9 (8)	3 (3)	6 (3)	50(50)
108	9 (9)	6 (8)	4 (7)	2 (1)	3 (2)	0 (0)	0 (0)	0 (3)	0 (1)	24(31)
109	9 (9)	5 (7)	9 (8)	3 (3)	0 (1)	0 (2)	7 (1)	0 (4)	0 (0)	33(35)
110	9 (9)	9 (9)	9 (9)	1 (3)	0 (3)	0 (0)	0 (4)	0 (4)	0 (2)	28(43)
111	8 (9)	6 (9)	6 (9)	1 (3)	1 (0)	1 (1)	1 (7)	1 (1)	0 (0)	25(39)
112	9 (9)	9 (9)	9 (9)	3 (3)	1 (2)	0 (0)	1 (1)	0 (0)	0 (0)	32(33)
113	9 (9)	9 (9)	9 (9)	3 (3)	3 (3)	3 (3)	8 (9)	6 (4)	6 (3)	56(52)
115	9 (9)	8 (9)	9 (8)	3 (3)	3 (3)	2 (3)	0 (8)	0 (0)	0 (0)	34(43)
116	9 (9)	9 (9)	9 (9)	0 (0)	0 (3)	0 (2)	0 (4)	0 (0)	0 (0)	27(36)
117	9 (9)	8 (9)	8 (9)	3 (3)	3 (3)	3 (2)	9 (9)	0 (3)	2 (2)	45(49)
118	6 (9)	7 (5)	5 (9)	3 (3)	3 (2)	2 (3)	9 (7)	0 (5)	2 (4)	37(47)
119	9 (9)	7 (0)	8 (9)	1 (3)	1 (0)	1 (3)	2 (4)	4 (4)	2 (4)	35(36)
120	9 (9)	9 (7)	8 (9)	2 (3)	1 (0)	0 (0)	2 (4)	3 (4)	0 (3)	34(39)
121	9 (9)	9 (9)	9 (9)	2 (3)	2 (3)	2 (3)	8 (8)	0 (6)	0 (4)	41(54)
122	8 (9)	9 (9)	7 (7)	1 (1)	3 (2)	0 (3)	0 (5)	3 (5)	1 (2)	32(43)
123	9 (9)	9 (9)	6 (9)	3 (3)	3 (3)	3 (3)	6 (5)	4 (5)	4 (1)	47(47)
124	9 (9)	7 (9)	6 (9)	1 (1)	1 (1)	0 (0)	4 (3)	3 (0)	2 (0)	33(32)
125	9 (9)	6 (7)	9 (8)	0 (0)	0 (0)	0 (0)	0 (2)	1 (3)	0 (1)	25(30)
126	7 (8)	8 (9)	9 (9)	3 (3)	2 (3)	2 (2)	8 (7)	0 (4)	0 (5)	39(50)
127	9 (9)	9 (9)	9 (9)	2 (3)	0 (3)	0 (0)	1 (9)	0 (0)	0 (0)	30(42)

Appendix G

Mean, Median, Standard Deviation for Pretest/Posttest

	Mean	Median	Standard deviation
Pretest section 1	8.67	9	0.76
Posttest section 1	8.96	9	0.2
Pretest section 2	7.71	8.5	1.9
Posttest section2	8.13	9	2.01
Pretest section 3	7.5	8	1.82
Posttest section 3	8.63	9	0.71
Pretest section 4	1.96	2	1.12
Posttest section 4	2.46	3	1.12
Pretest section 5	1.63	1	1.21
Posttest section 5	2.04	3	1.23
Pretest section 6	1.17	.5	1.31
Posttest section 6	1.71	2	1.33
Pretest section 7	4.04	3	3.71
Posttest section 7	5.38	6	3.02
Pretest section 8A	1.54	.5	1.84
Posttest section 8A	1.83	1.5	1.81
Pretest section 8B	1.33	0	1.9
Posttest section 8B	1.83	1.5	1.81
Total pretest	35.54	34	9.88
Total posttest	41.83	43	7.89

Appendix H

Ruler Reading Section One:

Recognizing Parts to Whole

Ruler Reading

Section one: recognizing parts to whole Name: _____

OBJECTIVES:
Upon completion of this packet you will be able to:

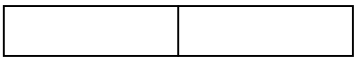
- Count the number of parts in each rectangle
- Count the number of parts in each rectangle that are shaded
- Write a fraction that is illustrated by a picture
- Draw a picture of a fraction using a box when given the fraction

Most errors made in this section are silly mistakes. Examples of errors would include counting the white boxes instead of the shaded boxes or counting the boxes incorrectly.

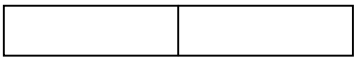
Read carefully!! Think!!

Complete the worksheet. Correct each section as you complete it. The answers are at the end of the packet.

Part A. Into how many parts is each rectangle divided?

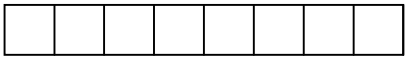
Example:  answer: 2

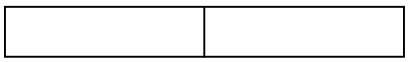
One is asked to count the boxes. The above example with the answer 2 is arrived at as follows:

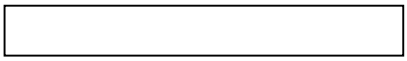


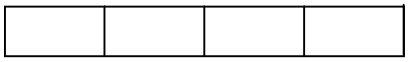
1 box + 1 box = 2 boxes

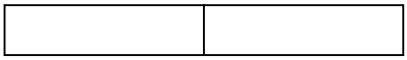
Try these examples on your own. Put your answer next to the box. The correct answers are at the end of the packet under Part A.

a.  answers _____

b.  answers _____

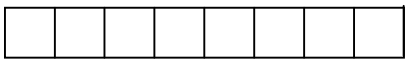
c.  ____

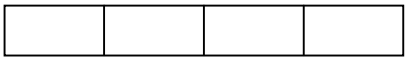
d.  _____

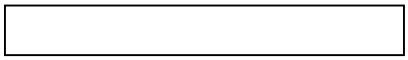
e.  _____

f.  _____

g.  _____

h.  _____

i.  _____

j.  _____

Part B. How many parts are shaded in each rectangle?
Here one is asked how many parts are shaded, not how many parts in the large rectangle or how many white boxes.

Answer: 3

One is asked to count the number of shaded boxes. The above example with the answer 3 is arrived at as follows:

1 shaded box + 1 shaded box + 1 shaded box = 3 shaded boxes

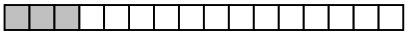
Try these examples on your own. The answers are at the end of the packet under Part B.

k. 

answer _____

l. 

answer _____

m. 

answer _____

n. 

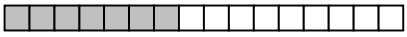
answer _____

o. 

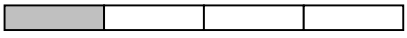
answer _____

p. 

answer _____

q. 

answer _____

r. 

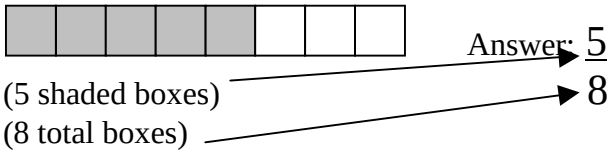
answer _____

s.  answer _____

t.  answer _____

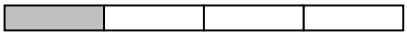
Part C. What is the number of parts shaded compared to the total number of parts?

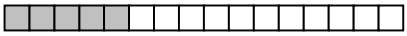
NOTE: The question asks for shaded boxes to total boxes therefore, the **shaded boxes** will be the TOP number in the fraction and the **total number of boxes** will be the BOTTOM number in the fraction.



The answers to this section of questions will always be a fraction. In the above example the number of shaded boxes is 5 and the total number of boxes is 8. The most common error in this section will be putting the incorrect total number of boxes in the fraction.

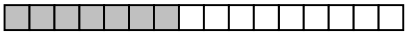
Try these examples on your own. The answers are at the end of the packet under Part C.

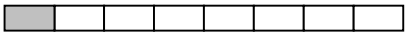
u.  answer _____

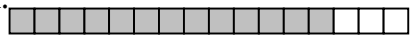
v.  answer _____

w.  answer _____

x.  answer _____

y.  answer _____

z.  answer _____

aa.  answer _____

bb.  answer _____

cc.  answer _____

dd.  answer _____

Answers for Part A

a. 8 b. 2 c. 1 d. 4 e. 2

f. 16 g. 16 h. 8 i. 4 j. 1

Answers for Part B

k. 3 l. 1 m. 3 n. 5 o. 11

p. 4 q. 7 r. 1 s. 6 t. 15

Answers for Part C

u. 1/4 v. 5/16 w.7/8 x. 5/8 y. 7/16

z. 1/8 aa. 13/16 bb. 1/2 cc. 3/4 dd. 9/16

Appendix I

Ruler Reading Section Two:

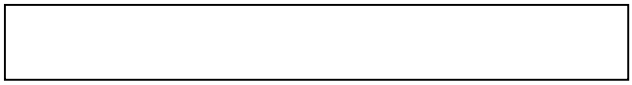
Drawing Parts to Whole

Ruler Reading

Section two: drawing parts to whole

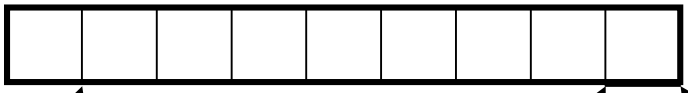
OBJECTIVES:
Upon completion of this packet you will be able to divide the boxes into the correct number of parts.

Divide this box into 16 parts.



Count the number of boxes. How many do you have? _____
Most of the errors on this section happen because the rectangle was not divided into the correct number of boxes. When one draws a line in a rectangle, that line forms the end of the box. But the end line of the **large** rectangle forms the last end of a box.

LOOK at this box, which is divided into 8 equal pieces.



This line represents the end of box one

This line represents the end of a box, box 9

This line represents the eighth line drawn inside the large rectangle. It is the end of box eight.

HINT: How to ALWAYS get this RIGHT
With a customary ruler (standard ruler divided into 16ths) every dimension or finer level is ½ the size of the level before it. Train yourself to divide the box following these directions. To practice you will need one piece of paper approximately 1 5/8" x 11" which is in the packet, a pencil, and the sample box below.

DIRECTIONS:
Dividing a box into **two** pieces:
1. Divide the rectangular piece of paper in half by putting the short ends together and folding in the middle.
2. Draw a pencil line on the fold.
3. Count the number of boxes.
4. Place a pencil line in the practice box in the same place that the pencil line is on the rectangular piece of paper. Number the boxes.

Practice box

Example:

1	2

Dividing a box into **four** pieces:
1. Divide the rectangular piece of paper in half as done above and then in half again.
2. Draw pencil lines on the new lines.
3. Count the number of boxes. Is it twice as many as before? _____
4. Place the pencil lines in the practice box in the same order that they were placed on the rectangular piece of paper. Draw the centerline first because you folded the centerline first. Then draw the lines that are on each side of the centerline because they were folded second. Number the boxes.

Practice box

Dividing a box into **eight** pieces:
1. Divide the rectangular piece of paper in half and then half again as was done above and then in half again.
2. Draw pencil lines on the new lines.
3. Count the number of boxes. Is it twice as many as before? _____
4. Place the pencil lines in the practice box in the same order that they were placed on the rectangular piece of paper. Draw the center line first, then the lines that make four boxes and finally the lines that make the eight boxes. Number the boxes.

Practice box

Dividing a box into **sixteen** pieces:
1. Divide the rectangular piece of paper in half, half again, half again, and finally half again.
2. Draw pencil lines on the new lines
3. Count the number of boxes. Is it twice as many as before? _____
4. Place the pencil lines in the practice box in the same order that they were placed on the rectangular piece of paper. Draw the centerline first, the lines that make four boxes, then eight boxes, and finally the lines that make the sixteen boxes. Number the boxes.

Practice box

Dividing the practice box into 16 pieces again. Notice that every time new lines are added, the existing boxes are divided in half.

Practice

Appendix J

Ruler Reading Section Three:

Dividing a Line

Ruler Reading

Section three: dividing a line Name: _____

OBJECTIVES:
Upon completion of this packet you will be able to:

- Count the number of parts into which each line is divided
- Write a fraction that is illustrated by a picture
- Draw a picture of a fraction using a line when given the fraction

The main problems students have with this section are silly mistakes. The mistakes include being in a hurry and not answering the questions or writing a fraction like 5/5 when the answer is 5/8. The other problem, which is more serious, is not being able to divide the lines into the correct number of units.

Below are some exercises. Think! The answers are at the end of the packet.

Part A. Into how many parts is each line divided?

Example:  answer: 2

Try these examples on your own. Put your answer next to the box. The correct answers are at the end of the packet under Part A.

a.  answer: _____

b.  answer: _____

c.  answer: _____

d.  answer: _____

Part B. Express as a fraction the number of shaded parts to the total number of parts on this ruler.

Example:  answer: 7/16

Seven divisions are colored which represents the top number of the fraction and the total number of divisions represents the bottom number of the fraction.
Try these examples on your own. Put your answer next to the box. The correct answers are at the end of the packet under Part B.

e.  answer: _____

f.  answer: _____

g.  answer: _____

h.  answer: _____

i.  answer _____

j.  answer _____

Part C: Without using the ruler, divide the unit into equal sized pieces and lightly shade that number of pieces indicated by the fraction.

Example: 3/4 

This exercise is just the opposite of the one above. Here you need to be concerned with the bottom number of the fraction first and then the top number. First divide the line into equal pieces indicated by the bottom number of the fraction (4). Then shade the number of pieces indicated by the top number (3).
Try these examples on your own.

k. 11/16 

l. ¼ 

m. 7/8 

n. 3/16 

o. 1/2 

This section needs to be corrected by you. Carefully count the spaces you have made. Item "k" should have 16 spaces between the lines. Do you have 16 spaces? Are 11 of the spaces shaded? Does your answer look like this?

Continue correcting with item "l". Do you have four spaces? Is one of the spaces shaded? Does your answer look like this?

Continue correcting with item "m". Do you have eight spaces? Are seven of the spaces shaded? Does your answer look like this?

Continue correcting with item "n". Do you have sixteen spaces? Are seven of the spaces shaded? Does your answer look like this?

Continue correcting with item "o". Do you have two spaces? Is one of the spaces shaded? Does your answer look like this?

If you have marked one of the problems wrong, you need to bring this paper to your teacher and explain how you figured out your answer. If you completed these problems without error, you are done with this section.

Answers for Part A

a. 16 b. 4 c. 8 d. 2

Answers for Part B.

e. 3/4 f. 5/8 g. 9/16 h. 11/16
i. 3/16 j. 3/8

Comments on this homework:

Appendix K

Ruler Reading Section Four:

Meaning of Lines

Ruler Reading

Section four: meaning of lines Name: _____

OBJECTIVES:
Upon completion of this packet you will be able to name the value represented by the length of lines on the ruler.

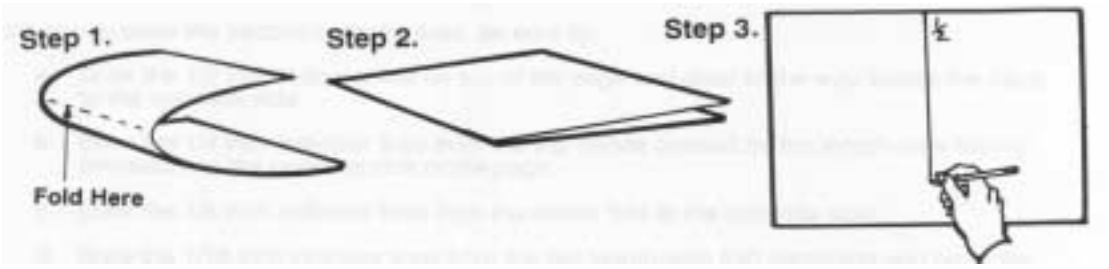
The ruler will help you measure if you know how to use the tool. Understanding and using the lines on a ruler correctly is essential.

What do those lines mean? One can figure this out by making a paper inch. To make your inch you will use the 5 pieces of paper (approximately 1 ¾" x 11") that are in your packet. Follow the directions below to make the inch. You will use it as a reference later in this lesson.

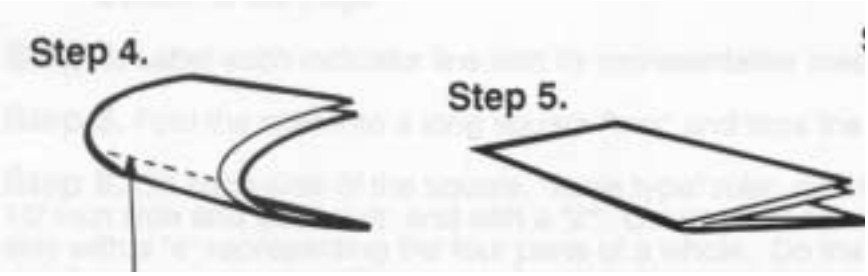
Make an inch

Step 1. The first strip of paper will represent the full inch. Lay it at the bottom of your desk.

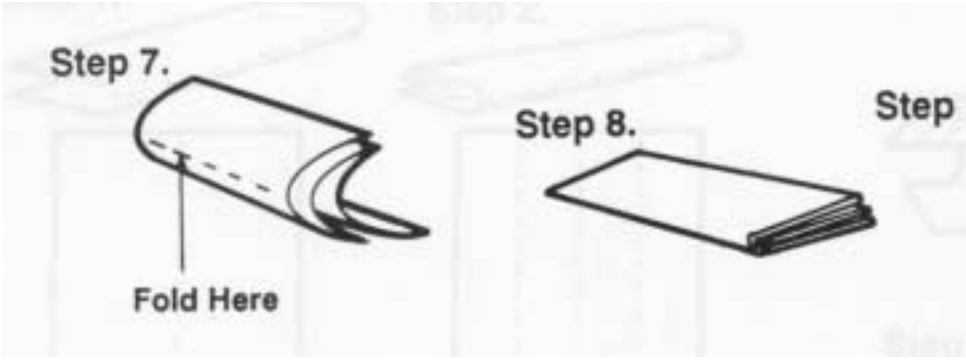
Step 2. Using a second strip of paper, fold the paper in half. Draw a line on the fold and mark that line ½. Place this second strip of paper above the first strip of paper.



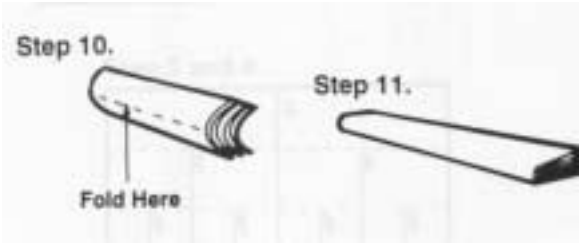
Step 3. Using a third strip of paper, fold the paper in half and then half again. The strip should have four sections. Draw a line on each fold. Since the paper is divided into four sections, the denominator (bottom number) is 4 and the numerator (top number) is the number of boxes it represents. Mark the folds ¼, 2/4, and ¾. Place this third strip of paper above the second strip of paper.



Step 4. Using a fourth strip of paper, fold the paper in halves until you have 8 sections. Draw a line on each fold. Mark the folds 1/8, 2/8, 3/8, 4/8, 5/8, 6/8, and 7/8. Place this fourth strip of paper above the third strip of paper.



Step 5. Using a fifth strip of paper, fold the paper in halves until you have 16 sections. Draw a line on each fold. Mark the folds 1/16, 2/16, 3/16, 4/16, 5/16, 6/16, 7/16, 8/16, 9/16, 10/16, 11/16, 12/16, 13/16, 14/16, and 15/16. Place this strip above the last strip.



At this point, you may want to tape the sections together so you can look at them later.

NOTE: The fractions 2/2, 4/4, 8/8, and 16/16 have not been marked on the ruler, as they are a whole inch.

Now look at the ruler. Pretend that all the strips are attached to one another. You will note that some lines continue from one strip of paper to another. Consider these lines unbroken. What observations can you make about the ruler you made? Write down any observations about the length of the lines and the divisions of the inch.

1. _____
2. _____
3. _____
4. _____
5. _____

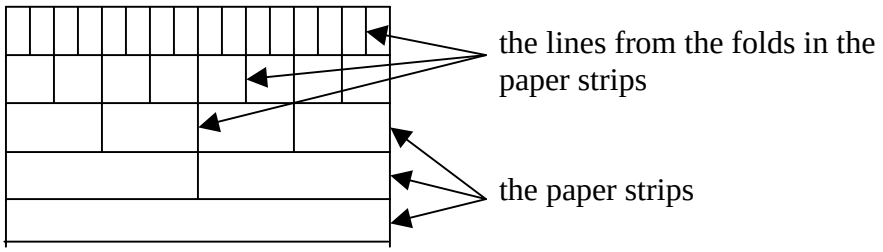
These are some observations that can be made. See how they compare to your observations. Do you understand these observations? Talk to a parent, friend, or teacher about the observations you do not understand.

OBSERVATIONS:
1. There are four different lengths of lines.
2. The same length of line is always on the same level.
3. The shorter line, the more lines on the ruler.
4. Each strip of paper can represent one level.
5. Each level has twice as many boxes as the level above.
6. The number of boxes represented on each level is 2, 4, 8, and 16.
7. The lines on the ruler represent the end of the box.
8. The fraction on the top of the line is always the reduced fraction.
9. The edges of the paper inch represent full inches.

VERY, VERY IMPORTANT POINT!! When reading a ruler that is divided into sixteenths, the **only** numbers that can be in the denominator (bottom number of the fraction) are **2, 4, 8, or 16.**

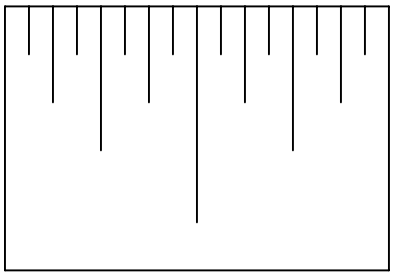
Below are illustrated the changes that occur in the change between the inch you made and a ruler.

1. This is ruler you made without the fractions. .



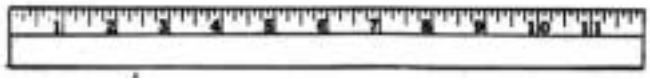
2. This is the ruler you made without the lines that represent the strips.

.

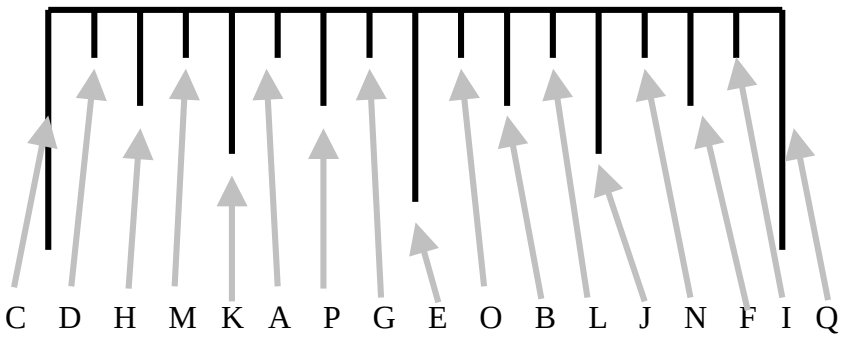


1 2

3. This is a twelve-inch ruler, which is 12 inches put together.



The lines tell the ruler reader into how many parts that level is divided. With that in mind, now identify what the length of the line on a ruler means.



Underline the correct answer.
Example:
What does line A represent? whole half quarter eighth <u>sixteenth</u>

What does line B represent? whole half quarter eighth sixteenth
What does line C represent? whole half quarter eighth sixteenth
What does line D represent? whole half quarter eighth sixteenth
What does line E represent? whole half quarter eighth sixteenth
What does line F represent? whole half quarter eighth sixteenth
What does line G represent? whole half quarter eighth sixteenth
What does line H represent? whole half quarter eighth sixteenth
What does line I represent? whole half quarter eighth sixteenth
What does line J represent? whole half quarter eighth sixteenth
What does line K represent? whole half quarter eighth sixteenth

What does line L represent? whole half quarter eighth sixteenth
What does line M represent? whole half quarter eighth sixteenth
What does line N represent? whole half quarter eighth sixteenth
What does line O represent? whole half quarter eighth sixteenth
What does line P represent? whole half quarter eighth sixteenth
What does line Q represent? whole half quarter eighth sixteenth

The answers are on the back of this sheet. If you had any problems with this section, please ask your parent or teacher to help clarify this for you.

Comments on this homework:

Appendix L

Ruler Reading Section Five:

Reading Lines

Ruler Reading

Section five: reading lines Name: _____

OBJECTIVES:
Upon completion of this packet you will be able to use the lines on a ruler to determine the length of an arrow.

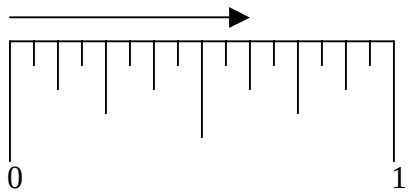
These ruler reading exercises use a ruler. When using a ruler, **let the ruler do the work for you.** If one uses a few simple rules, the answer will always come out correct and the fraction will not need to be reduced.

Rules:
1. Decide what line on the ruler represents the length of the arrow being measured.

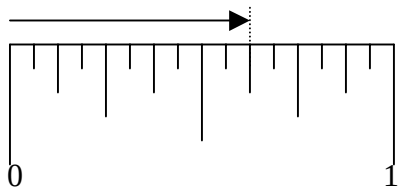
2. The height of the line on the ruler will tell the number of parts into which the inch is divided. The number of parts becomes the bottom number in the fraction. This is called the denominator. **At this point you are no longer concerned with shorter lines on the ruler.** Reminder: a ruler that measures to 1/16" can only be divided into **2, 4, 8, or 16** parts. The denominator represents the number of parts across the whole inch. What will the denominator be?

3. Now count the number of parts to the tip of the arrow being measured. **Reminder:** do not count the shorter lines on the ruler. This number is the numerator or the top number in the fraction. It should always be an odd number. What will the numerator be?

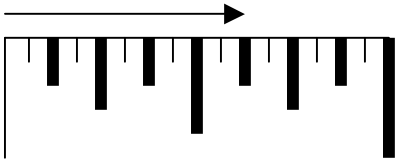
Here is an example. What is the length of the arrow?



Rule 1:
Decide where the arrow ends.

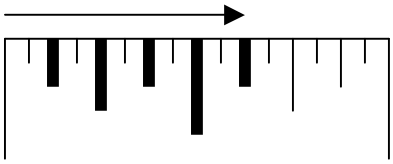


Rule 2:
What will the denominator be? _____



The denominator will be 8 because that length of line (second from the shortest) divided the inch into 8 parts. Do not count the lines on the ruler that are shorter, just the lines on the ruler that are the length of the line being measured or longer.

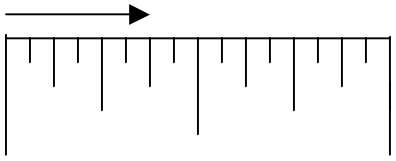
Rule 3:
What will the numerator be? _____



The numerator will be 5 because the arrow being measured covered 5 of the 8 parts in the inch. The fraction is than 5/8. Since there are no whole inches, the line measures 5/8".

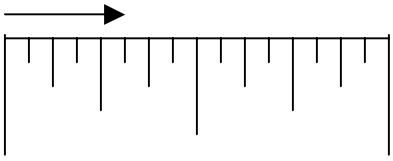
Try reading these lines on your own. The answers are at the end of the packet.

a.



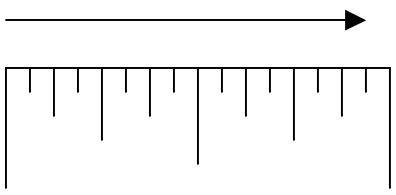
answer: _____

b.



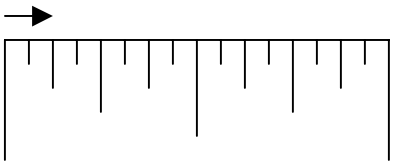
answer: _____

c.

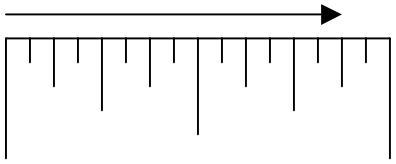


answer: _____

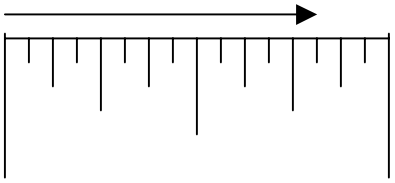
d.



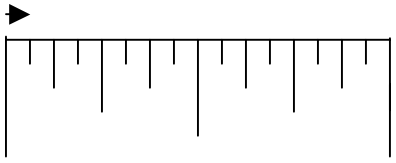
answer: _____

e. 

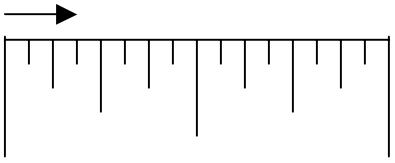
answer: _____

f. 

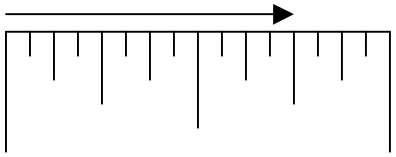
answer: _____

g 

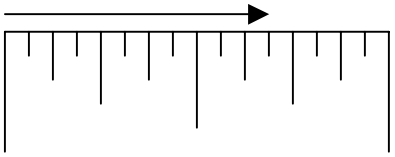
answer: _____

h. 

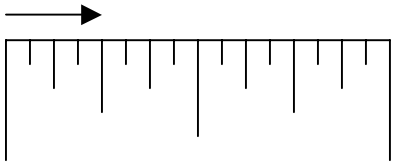
answer: _____

i. 

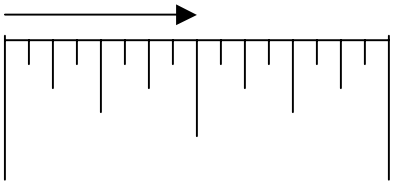
answer: _____

j. 

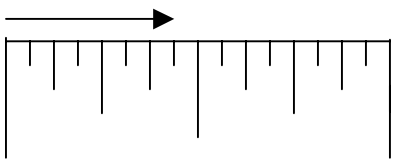
answer: _____

k. 

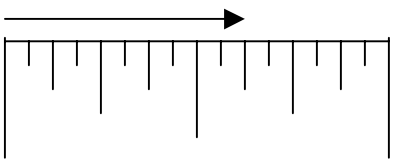
answer: _____

l. 

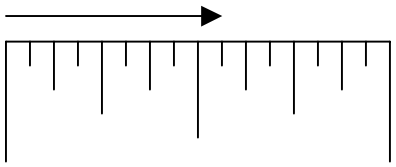
answer: _____

m. 

answer: _____

n. 

answer: _____

o. 

Comments on this homework:

Answers

a. 3/8″ b. 5/16″ c. 15/16″ d. 1/8″
e. 7/8″ f. 13/16″ g. 1/16″ h. 3/16″
i. 3/4″ j. 11/16″ k. 1/4″ l. 1/2″
m. 7/16″ n. 5/8″ o. 9/16″

Appendix M

Ruler Reading Section Six:

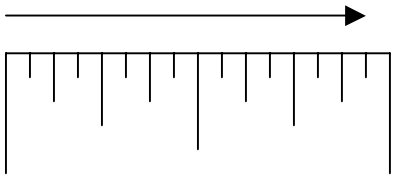
Measuring Efficiently

Ruler Reading

Section six: measuring efficiently Name: _____

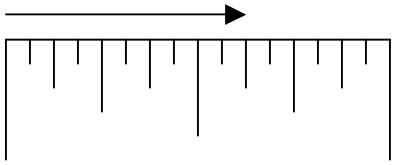
OBJECTIVES:
Upon completion of this packet you will be able to use short cuts to make reading a ruler more efficient.

Reading a ruler needs to be done in an efficient manner. Look at the following example.



This arrow measures 15/16". One knows that the shortest line represents the 16ths and that if you count from the left edge, the arrow covers 15 spaces. It would, however, be faster if one realized that the shortest line represents the 16ths and that a full inch has 16/16ths. When looking at the above example, the arrow does not cover one of 16ths. 16 – 1 = 15. The arrow covers fifteen sections. The arrow therefore is 15/16".

Look at this example:

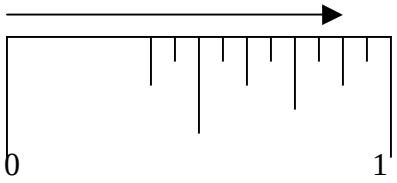


This arrow measures 5/8". One knows that the line at the end of the arrow represents eights and that the arrow covers 5 spaces therefore the arrow is 5/8" long. It would be faster if one realized that the line at the end of the arrow represents eighths, that ½ inch represents 4/8, and that the arrow goes past the ½ line by one eighth space. Therefore, 4/8 + 1/8= 5/8".

Think of these exercises as challenging puzzles.

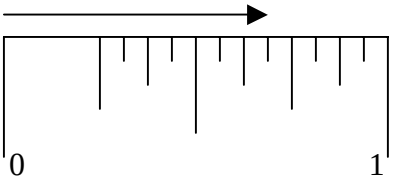
Some of the lines are erased from the ruler to force you to read the ruler using other cues. This exercise will help you learn to read the ruler more efficiently. Try these exercises. With some practice, it will be come automatic. Clues are included after the first four eight and twelve exercises. You are on your own for the last four. The answers are at the end of the packet.

a.



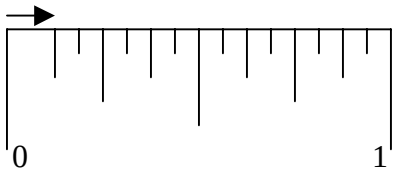
answer _____

b.



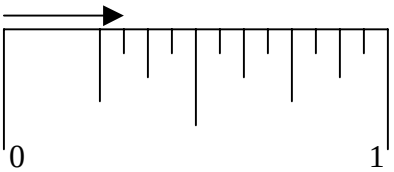
answer _____

c.



answer _____

d.

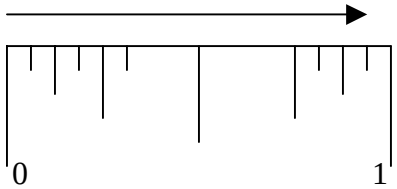


answer _____

CLUES:
Numerator: the top number in a fraction
Denominator: the bottom number in a fraction

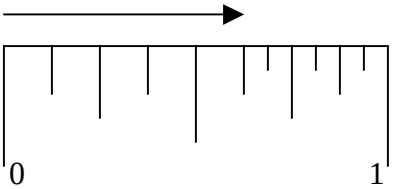
a. Figure the denominator and count back from 1" to figure out the numerator.
b. Start with the number of sixteenths in a half-inch and count forward.
c. Identify the length of the line and count the numerator.
d. Start with the number of sixteenths in a half-inch and count backwards.

e.



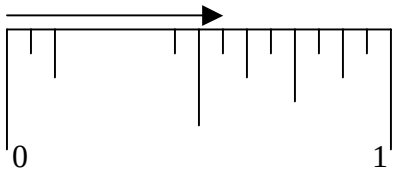
answer _____

f.



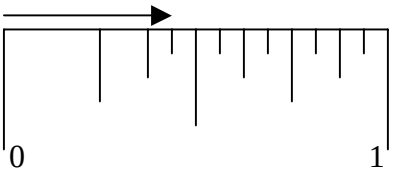
answer _____

g.



answer _____

h.

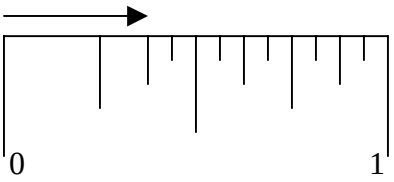


answer _____

CLUES:
Numerator: the top number in a fraction
Denominator: the bottom number in a fraction

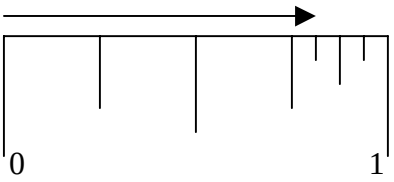
e. Count backwards from the one-inch mark.
f. Start with the number of eighths in a half-inch and count forward.
g. Start with the number of sixteenths in a half-inch and count forward.
h. Start with the number of sixteenths in a half-inch and count backwards.

i.



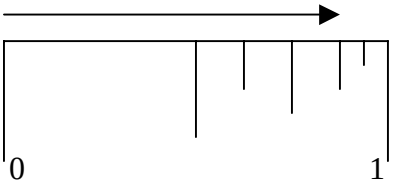
answer _____

j.



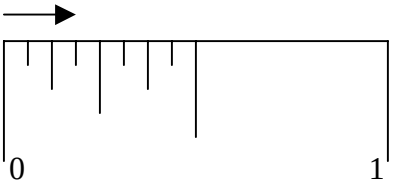
answer _____

k.



answer _____

l.

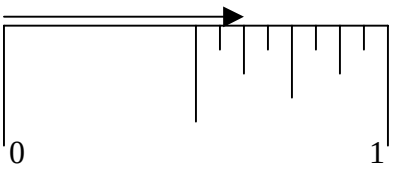


answer _____

CLUES:
Numerator: the top number in a fraction
Denominator: the bottom number in a fraction

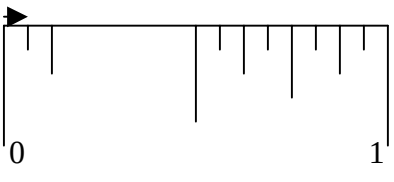
i. Start at the half-inch mark and count backwards.
j. Start at the inch mark and count backwards.
k. Start at the inch mark and count backwards.
l. Identify the length of the line and count the numerator.

m.



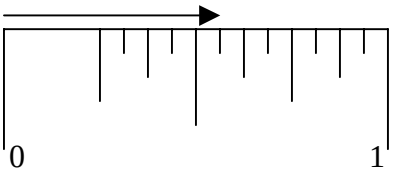
answer _____

n.



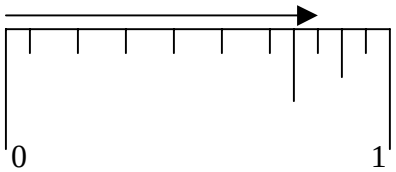
answer _____

o.



answer _____

p.



answer _____

Comments on this homework:

Appendix N

Ruler Reading Section Seven:

Measuring Lines

Ruler Reading

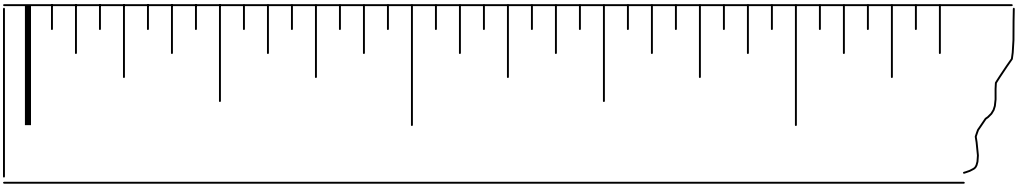
Section seven: measuring lines

OBJECTIVES:
Upon completion of the packet you will be able to:

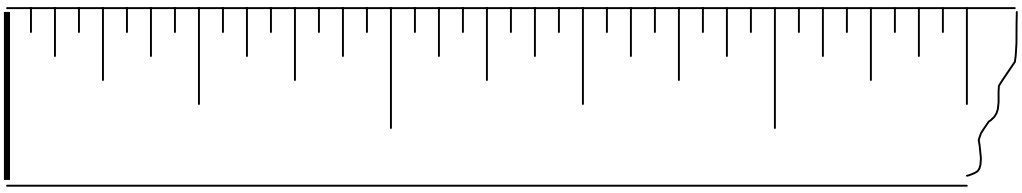
- Estimate the length of straight lines
- Measure lines over one inch
- Draw lines over one inch

Part A

Caution!!
In order to measure accurately, one has to know where "0" is on the ruler. When measuring one starts at "0" which may or may not be at the end of the ruler. Let's look at two examples.



The end of the first complete inch is marked with a "1". The "0" will be the same height line as the one-inch line. On this ruler, the "0" is not indicated with a "0", but is understood to be the first line in from the left hand edge of the ruler.



The end of the first complete inch is marked with a "1" as in the ruler above. In this ruler there is no line on the left hand side of the ruler the same length as the one-inch line. The first line on the ruler is a very short line indicating 1/16". On this ruler the left edge of the ruler is considered to be "0".

To help clarify where the "0" line is on the above rulers, the zero line has been printed in bold.

Part B

Estimating is educated guesses without tools. Try these exercises to see the many different ways to estimate.

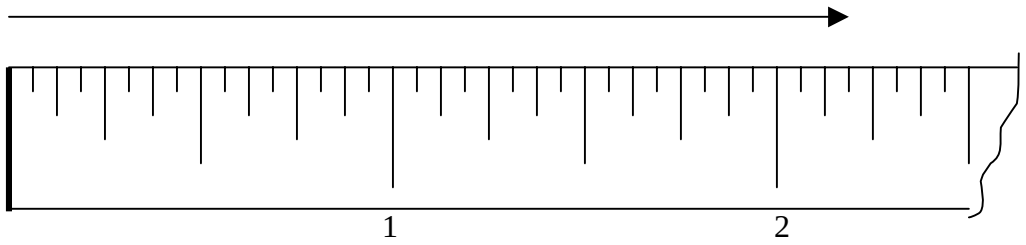
ESTIMATE:

1. How wide can you stretch your fingers from your thumb to your pinkie in inches? _____
2. What is the distance between the floor and your thumb when you are standing up? _____
3. How wide is your locker in inches? _____
4. How long is your house? _____
5. Get a ruler. Which of the following has a measurement closest to 3 feet?
   width of a doorway, height of a kitchen counter, length of your bathtub
6. Which of the following would normally have a length closest to 7 ½"?
   width of a piece of typing paper, length of your shoe, a new pencil
7. Hold a ruler in your hands. Without getting up, find an object in the room that that measures 16".
8. Find an object in the room that is one yard (36").

Part C

The emphasis has been so far has been on using a ruler to measure lines and objects less than one inch. For lines and objects that are more than one inch, the process is almost the same. Start by recording the full inches and then determine the fraction in the usual manner. **Remember** to write down the whole inches. **Do not** count any fractions in the whole inches. This will lead to unreduced fractions and more work. An answer such as 36/8" is not a usable answer. If the fraction was read correctly, it would be 41/2".

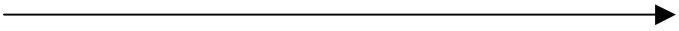
Here is an example:

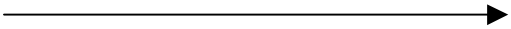


In order to measure this line, start by recording the full inches, in this case 2. Then proceed in the usual manner to determine the fraction. How long is this line? _____

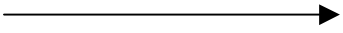
Try some more. This time estimate the length of the line and then measure the line. The answers are at the end of the packet under Part C.

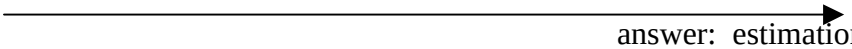
a.  answer: estimation _____
measured _____

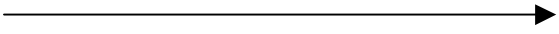
b.  answer: estimation _____
measured _____

c.  answer: estimation _____
measured _____

d. 
answer: estimation _____
measured _____

e. 
answer: estimation _____
measured _____

f. 
answer: estimation _____
measured _____

g.  answer: estimation _____
measured _____

h. 
answer: estimation _____
measured _____

Part D

Now use your ruler to draw a line the requested length starting at the dot. Compare your line to the length of the wooden block indicated in parenthesis. The wooden blocks are in the packet and each one as a different number on it. It should match **exactly!**

i. 3" (#1) **.**

j. 1 ½" (#3) **.**

k. 3 ¼" (#5) **.**

l. 1 7/8" (#7) **.**

m. 1 3/8" (#9) **.**

n. 2 11/16” (#11) .

o. 3 1/16” (#13) .

p. 2 7/16” (#15) .

Comments on this homework:

answers for a-d

a. 7/8 b. 11/16 c. 1/8 d. 5/16

Answers for e-h

e. 15/16 f. 5/8 g. 9/16 h. 7/16

Answers for i-l

i. 3/8 j. 13/16 k. 7/8 l. 3/16

Answers for m-p

m. 5/8 n. 1/16 o. 9/16 p. 13/16

Answer for Part C

measured lines:

a. 2″ b. 3 1/2″ c. 2 5/8″ d. 5 3/8″

e. 1 3/4″ f. 4 3/8″ g. 2 7/8″ h. 4 7/8″

Appendix O

Ruler Reading Section Eight:

Estimating and Measuring Objects

Ruler Reading

Section eight: measuring objects

OBJECTIVES:
Upon completion of this packet you will be able to measure objects successfully to 1/16th of an inch.

Rules for measuring:
1. Decide what line on the ruler represents the length of the object being measured.

2. Measure and write the whole inches first.

3. Determine the denominator (bottom number) of the fraction. The height of the line will tell the denominator of the fraction. Remember: a ruler that measures to 1/16" can only have denominators of **2, 4, 8, or 16.** That denominator represents the number of parts across the whole inch.

4. Determine the numerator (top number) of the fraction. Now count the number of parts up to the line on the ruler being measured. Reminder: do not count the shorter lines on the ruler. This number is the numerator. It should always be an odd number.

To do this exercise, you will need the bag of wooden blocks in the packet and the answer sheet for ruler reading blocks. **Each wooden block has a number on one surface. Use the length (longest distance) and width (shortest distance) on that surface to measure.** Then starting with any block:

1. Estimate the length and width of the block.
2. Record on the answer sheet.
3. Measure the length and the width of the block using your ruler and the above stated rules.
4. Record on the answer sheet.
5. Check the answer with the answer sheet after completing each block.

You have done an excellent job of estimating if your answers are within the fractions on the answer sheet. The **ACTUAL** measurements should be exactly the same.

Continue to practice measuring the blocks until you are confident that you can do it correctly. Two answer sheets are included in the packet.

Refer to prior lessons for help or see your teacher if you still have problems.

Comments on this homework:

Block Number	**Estimation**		**Actual**	
	WIDTH	LENGTH	WIDTH	LENGTH
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				