I. Overview
   a. Measurement is an extremely important aspect of mathematics
      i. It is a practical activity that is used in everyday life during experiences such as cooking, shopping, building, and constructing
      ii. In the primary curriculum, it is essential to data gathering in science and can also be applied in other areas
      iii. Measurement is a major vehicle for integrating mathematics with other content areas
         1. Also a vehicle for reinforcing other math skills and concepts:
            a. The number line is based on length, a popular multiplication model is much like area, and measurement is an area that lends itself naturally to problem-solving activities
            b. Counting, whole number operations, and fractions are used to arrive at measurements and report the results
   b. NCTM lists several expectations for primary grade children’s accomplishments in measurement
      i. Primary grade children are expected to:
         1. Select an appropriate unit and tool for the attribute being measured
         2. Be able to measure objects that require a repeated use of the same tool
         3. Use a variety of tools for measuring
         4. Be able to make comparisons and estimates of standard unit measurements
   c. During the primary grades, measurement is an important connection from number and operations, algebra and geometry
      i. Grade 1
         1. Measurement is a means for obtaining data to be analyzed in order to solve problems
      ii. Grade 2
         1. Linear measurement is a focal point that connects with geometry
      iii. Grade 3
         1. Children use their knowledge of fractions as they connect to making finer measurements
      iv. Grade 4
         1. Measurement of area is a focal point
      v. Grade 5
         1. Volume of area is a focal point
   d. Five stages in the development of the concept of measurement
      i. During the sensorimotor and preoperational periods, children’s measurement activities center on play and imitation and making comparisons
ii. During the transition period from ages five to seven, children enjoy working with arbitrary units.

iii. During concrete operations (which an individual usually enters at age six or older), they can begin to see the need for standard units (stage four) and begin to develop skills in using them (stage five).

iv. Standard units are not introduced for each concept at the same time.

1. In general, the following guidelines can be observed:

a. Length (linear measure)
   i. The units inch/foot and centimeter/meter are introduced in the beginning of primary and for measurement during second grade

b. Area
   i. Introduced informally with nonstandard units in grade one and ties in with multiplication in grade three

c. Time
   i. Time measurement devices and vocabulary were introduced prior to primary, but it is generally the end of primary before conventional time is clearly understood and a non-digital clock can be read with accuracy

d. Volume (capacity)
   i. Learned informally during pouring activities, and accuracy is stressed during preprimary cooking
   ii. Concept of units of volume is usually introduced in grade two

e. Weight
   i. Standard measurement for weight is usually introduced in third grade

f. Temperature
   i. Temperature units are identified, and children may begin to read thermometers in the second grade, but it is usually beyond primary when children really measure temperature with accuracy and understanding

g. Money
   i. Coins and bills are identified prior to primary, symbols are associated in early primary, but value does not begin to be understood until the end of primary

E. Goal in the primary grades is to introduce:
   i. The meaning of measurement
   ii. Needed terminology
   iii. Important units
   iv. Most common measurement tools

f. Both English units (customary in the United States) and metric units are
introduced during the primary years
i. Although the metric system is much easier to use because it is based on 10s and is used as the principal system in most countries, it has not been adopted as the official measure in the United States
   1. However, children must learn the metric system because it is so widely used around the world as well as in industry and science

II. Assessment
   a. Concrete operational thinking is essential for an understanding of the need for and the use of standard units
   b. In Unit 18, observational assessment guidelines are suggested for finding out what children at the early stages of understanding of measurement know about volume, weight, length, and temperature
   c. Interview tasks for time can be found in Unit 19
   d. Be sure that children can apply nonstandard measure before moving on to standard measure

III. Instruction
   a. The concept of measurement develops through measurement experiences
      i. Lecture and demonstration are not adequate for supporting the development of this concept
      ii. Also important to take a sequenced approach to the introduction of standard units
      iii. Adhere to the following steps.
         1. Do comparisons that do not require numbers
         2. Use nonstandard arbitrary units
            a. Find the number of units by counting
            b. Report the number of units
         3. Compare the thing measured to the units used
         4. Introduce standard units appropriate for the same type of measurement
            a. Find the number of units using standardized measuring instruments
            b. Report the number of units
      iv. Introduction of new standard measurement techniques and instruments should always be preceded by comparisons and nonstandard measurement with arbitrary units
         1. Naturalistic and informal measurement experiences should be encouraged at all levels
   b. The concept of unit
      i. Children’s ability to measure rests on their understanding of the concept of unit
         1. Many children have difficulty perceiving that units can be other than one
      ii. By using nonstandard units of measure first, the concept of unit can be developed
         1. Children learn that measurement can be made with an arbitrary unit, but the arbitrary units must be equal to each other when
making a specific measurement

2. Through the use of arbitrary but equal units used to measure objects, children construct the concept of a unit
   a. The concept is reinforced by using different arbitrary units (one kind at a time) and then comparing the results in terms of the number of units
   b. Soon they realize that measurement with smaller units requires more units than with larger units
   c. When the students move on to standard units, they can compare the number of units needed to measure using teaspoons versus a standard cup measure, inches versus a yardstick, and so on

iii. Children should be aware that when they use units (arbitrary or standard) they must be accurate
   1. Once children are able to measure using as many units as needed to measure the whole length, capacity, and so on, then they can advance to using one or more units that must be moved to make a complete measurement
   2. As children discover these shortcuts to measurement, they will be able to transfer this knowledge over to standard unit measure and understand the rationale behind foot rulers, meter and yardsticks, and quart and liter measures

   c. Measuring instruments
      i. Rulers, scaled instruments (scales, graduated cylinders, thermometers), and clocks are the tools of standard measurement
         1. Children have problems with these instruments unless they understand what they are measuring and what it means to measure
         2. Wise to begin with simple versions of the instruments, which are marked only with the unit being used
         3. Be sure the children understand how units are marked
         4. Children need many experiences measuring objects shorter than their ruler before they move on to longer objects with which they will have to measure, mark, and move the ruler
            a. Also will need to be able to apply their addition skills
            b. To measure to the nearest one-quarter, one-eighth, or one-sixteenth of an inch, they must understand fractions
      ii. Scaled instruments present a problem because every individual unit is not marked
         1. A good way to help children understand this concept is to have them make their own instruments
         2. They can make graphs using different scales or make their own graduated cylinders
      iii. Clocks are one of the most difficult instruments for children to understand
          1. Although there are only three measures (hours, minutes, and
seconds), the circular movement of the hands makes reading the face difficult

2. Children vary greatly as to when they are finally able to read a clock face accurately
   a. Skills needed to tell time must be learned over many years and through practice with clock faces with movable hands
   b. Digital clocks are easier to read but do not provide the child with the visual picture of the relationship between time units

iv. Money also offers difficulties because the sizes of the coins do not coincide with their value
   1. Bills provide no size cues but do have numerical designations that relate one bill to the other
   2. Relating the coins to the bills is a difficult task for young children

IV. Measurement Activities
   a. Refer to this section in your textbook for information on activities that will help children construct the measurement concepts of:
      i. Linear measurement
      ii. Volume
      iii. Area
      iv. Weight
      v. Temperature
      vi. Time
      vii. Money

V. Ideas for Children with Special Needs
   a. Autism spectrum disorders (ASD)
      i. Awareness of the prevalence of these disorders has increased greatly in recent years
      ii. Includes:
         1. Autistic disorder
         2. Pervasive developmental disorder
         3. Asperger’s syndrome
      iii. Symptoms of these disorders vary, but commonly these children have social and communication disorders and may display challenging behaviors
      iv. Focus for teaching ASD children is getting them socially involved
      v. May range intellectually from gifted to severely challenged
      vi. According to Lewis, communication with these children must be clear and simple
         1. Tasks need to be broken down into small steps
         2. Most common instructional methods are:
            a. Applied behavioral analysis
            b. Applied verbal analysis
            c. Floortime
         3. Each of these methods requires constant attention to the child
b. Some typical children may have difficulties with mathematics that can be identified in the early grades
   i. Mathematics Recovery (MR) is a program for helping struggling first graders (6-or 7-year-olds) in mathematics
   ii. Instruction is individualized and one-on-one and problem based
   iii. Wright et al present a detailed plan for working with difficult students

VI. Evaluation
a. Evaluation of children’s progress with measurement should be done with concrete tasks
   i. Examples:
      1. Give the children a list of three items in the classroom to measure
      2. Arrange a set of measuring cups, material to measure, and a container to measure into, and have each child turn in his answer
      3. Set up a scale with three items of known weight, have each child weigh each item individually, and record the amount
      4. Put out three model thermometers with different temperatures and have each child in turn tell you the readings and whether they indicate hot, comfortable, or cold
      5. Show the child the time on a model clock and ask him to tell you the time and explain how he knows
      6. Have each child identify coins and then put them together to make various amounts, making the amounts appropriate to the child’s level at the time