A sequence of early childhood learning experiences designed to teach concepts of measurement

by Julie Diamond

Introduction

This paper describes methods for promoting young children's understanding of measurement in Kindergarten and late in the preschool year. My focus is on measurement of a *continuous* dimension like an object's length, as opposed to the *number* of discrete objects, as in the case of marbles or cookies. I base my pedagogical suggestions on experiences in my own Kindergarten classroom (Diamond, 2011).

Direct comparison of objects as to equivalence, more, and less

Materials that teachers put out on shelves, at the beginning of the term, can set the stage for the development of measurement concepts. In preschools, children often play with blocks and connecting cubes. Exploring these objects, children spontaneously make trains of cubes and blocks, compare the lengths, and vie with each other to make longer and longer trains. They may also want to know whether two trains are exactly the same length or "same size." They may make towers of blocks, again comparing them to see if they are the same height or whether one is taller than the other. These kinds of activities provide a basis for children's developing understanding of measurement. Block and cube play also gives children an opportunity to develop appropriate vocabulary—like *length*, *height*, *taller*, *shorter, and same as*—that helps to organize these concepts and describe them to others. Extensive exploration with connecting cubes and blocks is a necessary base for later targeted and meaningful use of these materials for measurement.

Using paper tape and other materials to create "as long as"

At the beginning of kindergarten (or even late in the preschool year), children can begin to make focused and rigorous comparisons of properties like length and height. To promote basic measurement, the teacher can introduce materials like ribbons, string, and strips of paper (e.g., adding machine tape) that children can use to create a length that is "as long as" something else. Adding machine tape (easily available in office supply or education materials stores) is particularly well suited to this purpose. It can be used to measure a variety of objects, and can be drawn or written on so that it becomes personalized. It can be labeled ("Height of ---'s building"). The tape can be protected (for example, by laminating or covering with clear contact paper), saved and compared with other tapes. The paper tape functions as an intermediary material, object, or "tool": the tape is easy for children to handle, and establishes in a concrete manner that something can be created that is "as long" as something else. Also, the tape can eventually be used to promote more precise measurement.

One early experience has children marking off strips of paper that are “as long as” their bodies. Children lie down on a piece of adding machine tape. They work in pairs to mark off where the lying-down child “begins” and “ends.” The partner draws a line marking the feet and a line marking the top of the head. The child cuts the tape along the marks to create a piece of paper that is the child’s height: “As long (or tall) as me.” Children write their names on the tapes and decorate them, as shown in this picture.

The tapes are then put up along a wall, for example, in the hallway outside the classroom, as shown in this picture of tapes arranged in order of height, from shortest to longest. Some tapes have pictures of the children, and other tapes have names and decorations. The display provides “data”—a simple bar graph—that can be discussed in terms of increasing size.

Using paper tapes to compare lengths

To continue developing the concept of "as long as," as well as "longer" and "shorter," children can measure other objects with adding machine tape, working with partners to create tapes as long as their heads, the length of arms and legs, the height of a table, etc. (They may, alternatively, measure with string, yarn, or ribbon.) These tapes can be used to make comparisons and order lengths: who has the longest arm or leg? Is this table longer than that one? Children can use tapes in different areas of the room, like the block area, to measure the height of block buildings. As this work continues, with children working in pairs or small groups, the teacher can reinforce the vocabulary of length, height, width, etc.

As children work, the teacher can observe how children use this simple measuring tool (the strip of paper tape). Does a child seem to understand the concept of "as long as"? What does a child actually do in order to compare two different lengths of tape? These observations, supplemented by questions ("Tell me what you're doing now." "Why did you do that?" "Tell me what you notice about that."), can help the teacher assess children's understanding of measurement. For example, the teacher can determine whether children understand that one end of the measuring tape must be lined up with one edge of the object. Worksheets on which children record their findings can also provide information on children's thinking. Teachers can also take dictation about work as children proceed, and photograph children as they work. Teachers can examine this documentation to decide on future work and questions, and the worksheets, dictated texts, and photos can be shared with the class, and discussed, as well as used for classroom displays.

Introducing connecting cubes for measurement

Connecting cubes are excellent as first measuring *units* because they fit together, so that units cannot overlap. The straight edges make it relatively simple to ensure that the cubes begin at the beginning of the object or tape and end at the end. Cube trains also lend themselves to comparing the difference, in number of cubes, between one train and another. "Which train is longer?" "Which train is shorter?" "How many more cubes does this train have? Let's count." From a theoretical perspective, connecting cubes' power as a measuring tool lies in their being discrete (countable) units while, at the same time, when connected as trains, they can be apprehended as a continuous entity. Thus they are bridges between the continuous attribute being measured (length), and the discrete measurement units (the number of cubes) being counted to determine the total length. Thus, the guinea pig is 12 connecting cubes long.

A first use of connecting cubes to measure lengths might involve the measurement of children's shoes. Each child would remove one shoe and trace around it on a worksheet. Working with partners, children make a connecting cube train that is as long as the shoe, heel to toe. Children fill in a sentence on the worksheet: "My shoe is --- cubes long." Children illustrate these worksheets, and may draw the cubes on the shoe outline, as shown below. Papers would be shared with the class, compared ("How many people have shoes that are 9 cubes long?"), and finally put up as a wall display, which in effect is a collection of data.

Children also measure other objects in the room with connecting cubes. Again, they are asked to illustrate work-papers, and share what they are finding out. Children usually enjoy the challenge of measuring very large or tall objects: the rug, classroom door, etc. If children have had experience making single-color trains (of two cubes, five cubes, ten cubes), and counting by those numbers, the trains can aid the counting of cubes when children have measured an especially long object. Children can work, first, to create many trains of the size that they want to use, for example, trains of 10, and then count by 10s instead of ones to figure out the length of the object in cubes. Again, the concrete materials aid children in conceptualizing the equivalence between the attribute of the object itself (the length) and the measuring units, even when dealing with big objects and large numbers of units. Children can see and feel the relationship in this form more easily than if they were looking at unit notches on a ruler.

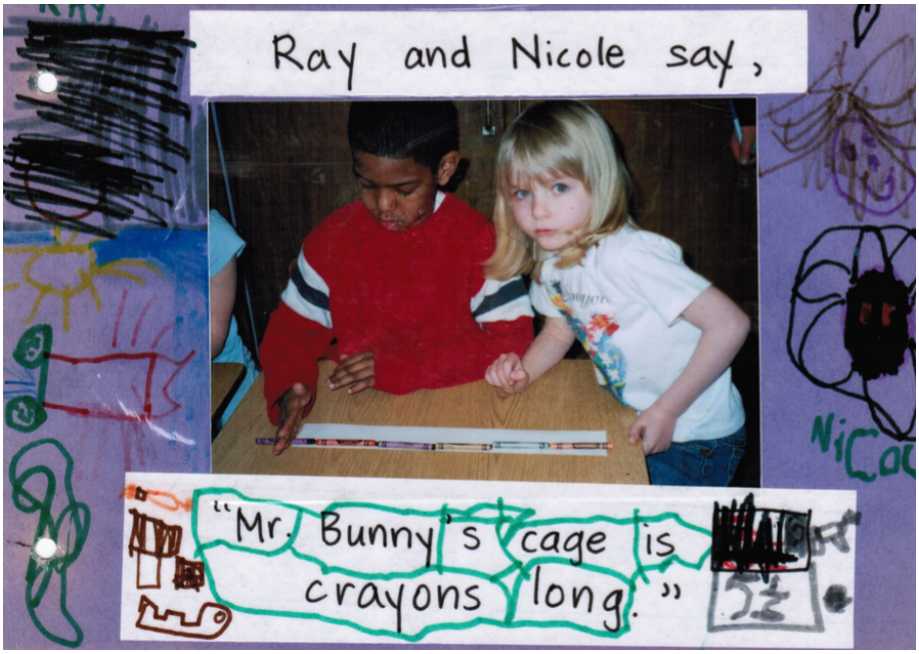
As one of the experiences using connecting cubes as non-standard units of measurement, children might measure their height tapes with connecting cubes and record the results on index cards: “I am 54 connecting cubes tall.” The cards can be affixed to the adding machine tapes. Late in the spring term, children might measure themselves again, standing in front of

the tapes, to compare heights over a period of time, or might measure themselves using inch or centimeter measuring tapes, which I describe below.

Introducing different non-standard measures

Children's work with non-standard measures can help to reinforce several core concepts about length: that units must be uniform in length, placed end to end, one by one, without overlap or spaces between them, to create a line *as long as* something else. Like connecting cubes, these non-standard units are three-dimensional objects that can be easily handled, and give children practice in lining units up correctly, and practice in counting the units. They help solidify children's knowledge that when they have lined up these units, and counted them, they can tell the length, in these units, of the measured object. And children also learn the necessity for units to be *uniform* in length, so that the same object counted twice cannot be both 20 crayons long and also 15 crayons long, a discrepancy which might result from using crayons of uneven length.

To begin measuring with non-standard units, the teacher could provide children strips of adding machine tape as long as an object (for example, the bunny cage). The pairs of children then use different objects to measure these (equally long) strips of paper: paper clips, crayons (of uniform length), pencils (also uniformly long), markers, blocks, etc. (Other uniformly long objects can be used as well.) Work would be documented with photos.



Children would also produce worksheets that illustrate their work and record their results, including a sentence indicating the number and type of units used. As the picture shows, these two children found that the strip of paper corresponding to the bunny cage is 5 crayons and a

little bit extra long. In subsequent discussion, children would report on their results, and reflect on the reason for the differences that occur. If some children measure the paper strip (which represents the length of the bunny cage) as around 5 crayons long while other children show that the strip is 42 paperclips long, why are the measurements different? What would you expect if you use something that's much smaller than the paper clip or something much longer than the crayon? It takes lots of small paper clips to get the same length as a few crayons. This sets the foundation for learning, much later in the course of schooling, the ratio of clips to crayons—that there are around 8 paper clips per crayon unit.

Introducing standard, conventional measures: centimeter and inch blocks

When children have had practice using a variety of non-standard units, they can measure with units that are standard sizes, for example, one-centimeter rods (metric units), and wooden one-inch cubes (traditional units). Children can measure and record objects in both metric and inch units, comparing the lengths in these different systems of measurement. Because the rods and cubes are concrete, children can line up single units, and count them. Once again, the paper strips used to measure various objects can provide material for measurements with standard units.

As children engage in these experiences with metric or inch measures, record their work, and discuss it and the work of others, they have opportunities to gain fluency in the concepts related to measurement of length: that the measuring tool must be at least as long as the thing being measured; that if they want to compare the length of two objects, they must use the same units; that measurement must begin where the object begins and end where the object ends; and that the mark where measuring begins is equivalent to zero. They will also undoubtedly note that in some cases there may be a bit "left over" that is smaller than the measuring unit or they might say that the object is, for example, longer than two cubes but shorter than three.

Introducing the ruler

These experiences lead naturally to use of the ruler, a more complicated and abstract tool. The initial use of the ruler should be, ideally, an integral part of a study that children are undertaking. The object being measured should be of considerable interest to the children, so that the measuring activity will have a purpose, and the result will be meaningful. For example, if the class is studying dinosaurs and learns that a certain dinosaur is thirty-five feet long, a small group of children might go out to the hall with masking tape, pens, and rulers, to mark off thirty-five feet, placing tape on the floor to mark off each ruler, and writing the appropriate numerals (beginning with zero). Children might, for another example, use measuring tapes to measure the height of a bean plant as it grows taller. They could use tapes that show measurements in centimeters as well as tapes that show inches, and record results for both. They could, alternatively, use a piece of string, which could then be set out along an inch or centimeter ruler, to measure the plant's height in inches or centimeters. These kinds of

experiences are excellent in reinforcing the idea that the measurement starts at zero and that students can employ both standard inch and centimeter units to determine length.

When children begin to systematically use rulers (either inch or centimeter), their challenge is to recognize that the base of the ruler is zero units. In other words, when counting units on a ruler, it's necessary to count 'one' to indicate the length up to the first notch rather than at the base; and that the total length is the number of unit lengths between zero and the number indicated by the last notch. Thus, the length of a pencil might be the distance, in inches, between zero and 5 as indicated on the ruler.

Teachers can perhaps clarify these principles and ease the transition to the systematic use of rulers, by crafting an activity in which children measure objects using wooden inch cubes and/or centimeter rods, and then line up cubes or rods on top of rulers to gain concrete knowledge of the correspondence between these units and the units on rulers. They could also be asked to make their own rulers. The experience would reinforce the knowledge that notches on the ruler indicate the beginning or end of a unit of length.

Conclusion

Extensive and focused experience with relevant concrete materials can provide a foundation for correct and deep understanding of units of measurement. The corollary is also true: a child's inability to use abstract tools may well indicate insufficient earlier experience with concrete materials. An important conclusion, then, is that focused exposure to concrete materials can carry over into children's understanding of more abstract tools and ideas. Having children record and discuss their work, in a variety of ways, including pictures, words, and numerals, promotes verbal expression and understanding. Producing and discussing these records aids children in moving towards abstract representation, and is a necessary component of a sequence of activities directed towards meaningful use of abstract measuring tools.

Reference

Diamond, J. (2011). *Kindergarten: A Teacher, Her Students, and a Year of Learning*. New York: The New Press.