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Measuring Experiences for Young Children

"Are you bigger than my teacher?" four-year-old Jeffery asked his slightly overweight principal on his way to the bus.

Responding optimistically, Mrs. Hix said, "Do you mean taller?"

"No, no. . . . More numbers!" Jeffery quickly replied.

Mrs. Hix laughed, responded, "Yes," shook her head, and thought, "Children always surprise me. I thought he meant weight, I guessed height, and he meant age! A very different view of 'bigger.' I had no idea that's what he meant!"

Measurement concepts are often a part of children's interactions. "My dad is bigger," "I can jump higher," or "I have more Kool-Aid than you!" are common comparisons that children make. From the child's perspective, these statements compare quantity; however, they provide a nice introduction to measurement.

Unfortunately, measurement is an often-neglected Content Standard in early childhood classrooms. Continuing debates over such topics as the ability of young children to conserve length, volume, or area; the use of standard or nonstandard tools for measuring; and the readiness of young children to measure often mean that teachers postpone the teaching of measurement until later grades or relegate it to a unit at the end of the year.

As prekindergarten and kindergarten teachers, we write this article from a very different approach. Rather than debate *if* and *how* children should measure, we provide our students with a multitude of measuring experiences throughout the year. The purpose of this article is to describe opportunities that we have given our young students to engage in meaningful measurement problem-solving activities. In each of these activities, our goals were to involve young children in experiences that (1) gave them the opportunity to learn the process of measurement; (2) developed their understanding by solving real, contextual problems; and (3) facilitated their understanding of measurement through conversations with peers and teachers.

Young children are natural problem solvers. Based on our experiences, we believe that children's solutions to problems can inform the teacher's practice and the learning that results. In most cases, the teacher did not identify the children's solutions or the process they used to solve the problems as right or wrong; instead, the teacher asked questions that facilitated further exploration and invention. In all cases, the purpose of the ensuing discussion was to promote measurement investigations and an interest in "figuring out."

The classroom illustrations that follow reveal children's developing understanding of the process of measurement as well as their strong desire to measure well. We introduce each vignette with a description of the measurement problem followed by a detailed outline of the children's investigation.

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Edited by **Julie Sarama,** *jsarama@buffalo.edu, and* **Douglas Clements,** *clements@buffalo.edu, State University of New York at Buffalo, Buffalo, NY 14260. This department addresses the early childhood teacher's need to support young children's emerging mathematics understandings and skills in a context that conforms with current knowledge about the way that children in prekindergarten and kindergarten learn mathematics. Readers are encouraged to send manuscripts for this section to "Early Childhood Corner," NCTM, 1906 Association Dr., Reston, VA 20191-1502.*

We then outline excerpts from the conversations that occurred so that the reader can identify children's thinking as well as the teacher's questions that facilitated their learning. Finally, we list specific follow-up activities, then share our thoughts about the activity and connections to pre-K–2 expectations from *Principles and Standards for School Mathematics* (NCTM 2000). The vignettes occurred in prekindergarten or kindergarten classrooms throughout the school year.

Quilt Cover (Area with Emphasis on Length Measurement)

Problem introduction

Four-year-olds in a prekindergarten class decided to decorate their classroom with a beautiful multicolored quilt. The teacher cut construction paper "scrap" pieces into the following sizes: 3" × 3" squares, 3" × 6" rectangles, 6" × 6" squares, 3" × 9" rectangles, and 6" × 9" rectangles. The teacher gave each child a 12" × 18" piece of white paper and told the children to completely cover their white paper with colored paper. Just as in a quilt, the pieces could not overlap. Each child had to order his or her construction paper pieces from the "paper store." The children had to use words to tell what color and size they needed as well as the specific number of each piece.

Observed investigations

The children's words and actions were especially interesting. Only a few children ordered multiple pieces of paper. Most ordered one or two pieces of paper, went back to their seats to place the pieces on their paper, and returned to the "store." Often, they ordered their favorite color, discovered that using only one color was boring, and returned their pieces to get other colors. The words and behaviors that the children used to order also were interesting. "Long ones," "fat squares," "tall pieces," "little rectangles," "big like my hand," and "the same as" were all phrases that children used to describe the piece they wanted. They frequently used their hands to show the size of the piece they were requesting. When the teacher "store clerk" expressed uncertainty about the order, children changed their minds, clarified their responses with phrases such as "more bigger" or "not fat like that one," or moved their hands to indicate longer or shorter lengths.

Problem conversations

As children worked to cover their paper, many of their conversations were between peers as well as with the teacher. Peer interactions were generally commands such as "Move that fat one," "Take that one off," or "Go get a tall one." The teacher-child interactions, however, involved questions and responses such as "I wonder how they could all fit," "What pieces would fit here?" and "How many more do you think you will need to cover the whole piece?"

Follow-up activities

Children placed all their 12" × 18" rectangles on a large piece of butcher paper so that they could be displayed as one large rectangular quilt made by the class. Initially, they placed the eighteen rectangles as five rectangles in each row; they made three full rows and left three rectangles in an incomplete row. The class agreed with one child who said, "Good thing we didn't glue it!" After discussion and several variations, the children placed the eighteen rectangles in three rows with six rectangles per row. Later, the children did a similar activity using triangles of equal size.

Connections to the Standards

The four-year-olds in this activity used language to communicate the lengths of paper that they wanted to order from the store. When children were required to "order" their quilt pieces from the storekeeper, they were encouraged to use words to compare and "recognize the attributes of length" (NCTM 2000, p. 102). After they selected the pieces, they had to fit them together and completely cover the area of their quilt pieces. That task required children to relate the lengths of the individual pieces to the area of the quilt piece and "recognize the attributes of area" (NCTM 2000, p. 102).

Buildings and the Runaway Gerbil (Length, Height, and Area)

Problem introduction

The prekindergarten class had a problem that was initiated by an actual event. With the addition of new blocks in the construction center, many children had been intensely involved in building a new city. Their creation indicated creativity and persistence. Unfortunately, when the class went outside, one of the classroom gerbils escaped and destroyed or rearranged much of their creation. After tears were

dried and the gerbil was returned to his home, the children decided to make "building plans" to help them remember what their creation looked like. They drew the plans and measured how tall and fat the blocks were. The problem was expanded when a builder loaned plans to the class. The teacher provided pieces of rolled butcher paper and wax pencils to the young architects.

Observed investigations

Children's representations were unique and, in most cases, identifiable. They eagerly drew their constructions, elicited the assistance of fifth-grade helpers to record their words and numbers, signed their names to their plans, and stored the rolled plans in the "plan bin." In some cases, they added digital photos of the creations to their plans. On following days, children selected their peers' plans and created constructions that matched the plan, at least in their eyes. They often consulted each other about their specific plans to make sure they "did them right."

Problem conversations

Many peer interactions consisted of directions ("Put the big ones on top" or "No, not the pointy one—the tall block!") or comparison phrases ("Mine was bigger. It was up to here" or "Yours goes more this way"). In addition, communications occurred between the children and their fifth-grade scribes. Children described their constructions as "5 pounds tall," "20 zillion big," or "7 fat." The scribes recorded exactly what the children stated and questioned their answers only if they could not hear them. Later, the children shared the drawings, and their classmates and the teacher asked for clarification of their representations. The children added words or pictures as directed.

Follow-up activities

The teacher added commercially purchased task cards for different types of block constructions to the plan bin. The cards included height measurements such as a picture of a cube tower with a length of five paper clips. The teacher challenged children to make constructions that matched the cards.

Connections to the Standards

The opportunity for children to use measurement in a realistic way was a primary focus of this activity. Representation is an important Standard; children represented their construction to solve the initial problem and then used the created representations to rebuild constructions. In addition, some children began to "understand how to measure using nonstandard and standard units" and to "use tools to measure," expectations listed in the Measurement Standard (NCTM 2000, p. 102).

Totem-Pole Teddy Bears (Height)

Problem introduction

At the beginning of the school year, kindergartners created pages for a class book titled "When We Were Five." To record their heights, the children measured how tall they were in "teddy bears." Three different totem poles made from paper teddy bears stacked head to toe were taped to the wall over three consecutive days. On day one, each paper bear was five inches in height; on day two, each bear was three inches in height; and on day three, each bear was ten inches in height. The teacher asked the children to record their height three times, using each of the totem poles.

Observed investigations

During center time, children worked with partners and directly compared their heights. In most cases, they accurately counted how tall they were on days one and two. Because of the smaller size of the unit on day two, all the children were "more" teddy bears tall on the second day. On the third day, all the children went to the center and appeared to measure their heights, but few recorded the number of teddy bears. Often, their pages contained erasures or blank spaces for the third required measurement.

Problem conversations

Children explained their seemingly increased heights between days one and two with great delight: "I growed!" "My brother has been stretching me!" "I eat lots of vegetables!" Only two of the forty children mentioned the difference in bear size as a reason for the increase. When the teacher asked children why they did not record their third height, they generally refused to believe their own data. "It's not a good one," "You need other bears," or "I don't like it!" were the usual responses.

Follow-up activities

The teacher introduced other unit differences (for example, small cubes and big cubes to measure volume) in centers throughout the year. By the end of the year, many children could identify the unit that they wanted to use and note the reason for the difference in measurements.

Connections to the Standards

Generally, young children have not developed an awareness of the need for standard units. Because this activity directly connected to their heights, children easily believed that the second set of smaller bears accurately measured a rather amazing growth. When the third set of bears produced a much smaller number and one that they did not like, however, most children ignored the result. This beginning activity provided an initial experience and an impetus for the expectation to "measure with multiple copies of units of the same size" (NCTM 2000, p. 102).

Big Bill and Little Larry (Length)

Problem introduction

Halfway through the year, a teacher introduced a kindergarten class to a pretend measuring problem. In the problem, Big Bill, a tall man with very large feet, and Little Larry, a short man with very tiny feet, came to the classroom to measure the length of the classroom for a new rug. Unfortunately, their answers were quite different. Little Larry's answer of twenty feet was twice as long as Big Bill's measurement of ten feet. The teacher asked the children to offer suggestions about the rug's length as well as why differences existed in the measurements. Later, the teacher asked them to actually measure the room using whatever tools they required.

Observed investigations

Children's ideas were humorous and generally indicated only a surface understanding of length measurement. Most children attributed the differences to counting errors and "not good" measuring: "Big Bill just forgot how to count his numbers past ten. I do sometimes!" "I think Little Larry was counting too fast and skipped numbers." "Big Bill forgot what to measure and so he went up the wall instead of long-ways!"

The five-year-olds measured the length of the classroom by using a variety of methods with some commonalities. Surmising that length had a beginning and an ending point, all the children began counting from one end of the room and ended their counting at some point on the other side. In addition, they used a type of measuring unit such as their own foot, a measuring tape, a ruler, a piece of yarn, their finger, or their hand span. The differences in their measuring processes, however, provided evidence of their partial notions of measuring. Children counted feet by walking toe to heel "like a tightrope walker." They walked sideways by opening and closing their legs, counting the number of leg openings. Children in one partnership even measured by jumping while keeping their feet together, a process that they said was "really, really hard!" Sometimes, children combined different methods. Several children counted their footsteps while holding a ruler " 'cause you're supposed to," they said. Others spread tape measurers across the room, looked at the last number on the tape measure, and reported either 1 or 150 as the measurement, depending on the orientation of the tape. Still others ran out of rulers and decided to use pencils for measuring tools because "they kinda fit."

Problem conversations

After the measuring experiences, children shared their results. To their surprise, the answers were all different. Children explained the differences by stating that some people "did it more better" or that "we need to do it more to find out the real answer." Perhaps the most interesting conversation occurred when children were prompted by the teacher's "confusion" about Big Bill and Little Larry. She stated, "Big Bill is big and he has big feet, so he should have a big number. Little Larry is little and he has little feet, so he should have a little number. But that is not how it worked. Big Bill has a little number and Little Larry has a big number. I wonder why." An animated conversation ensued as children explained to the teacher how big feet "take up lots of room" and how they "spread out more." They explained Larry's measurement by saying that Larry takes "baby steps so they are real close together." The conversation continued even after the class was dismissed, and children suggested many solutions over the next few days.

Follow-up activities

Children did not want to leave this problem. They continued to persist until they recorded all their answers using both standard and nonstandard units as well as a variety of tools. This investigation prompted even more interest among some children

when school district personnel were measuring the building for new tiling. Several conversations about the size of the men's feet and their measuring methods were overheard, and the investigation continued.

Connections to the Standards

This activity connects to the Problem Solving Standard as well as the Measurement Standard expectations referring to the application of "appropriate techniques, tools . . . to determine measurements" (NCTM 2000, p. 102). When the teacher expressed confusion over the "big feet, small number" dilemma, she created yet another opportunity for peer discussion and a beginning understanding of the processes of measurement.

Car Races (Distance)

Problem introduction

As part of a thematic unit on moving objects, children experimented to find out which toy car would travel the farthest distance after traveling down a ramp. By design, only one car could be on the ramp at a time, so children somehow needed to remember how far their favorite cars went.

Observed investigations

Children used counters to mark the ending points that showed how far the cars went. They also remembered the distances by stating the relative positions of the cars: "My car went all the way to the block center" or "The blue car was best. It almost went out the door!" Children quite naturally used comparison terms such as "longer," "more farther," and "went bigger" as they talked about the distances that the best cars traveled.

Problem conversations

The conversations about this problem centered on a car-race contest between the teacher's best car and the class's best selection. After a vote, the children released their favorite car on the ramp. To help them remember how far the car went, the teacher suggested measuring with a licorice stick, a nonstandard device this class often used. The number of sticks was counted and recorded so everyone could see the result. Then the teacher introduced her car, a rather puny vehicle. In fact, the teacher had selected her car because her tests had shown that the vehicle would not travel a great distance. After excessive bragging by the teacher ("My car is going farther than your car!"), she released the car. As expected, the car traveled a short distance. As children cheered, the teacher reminded them that they must measure the distance traveled for her car as well. This time, however, the teacher had eaten the licorice stick so that the remaining section was about one-fourth of the original piece. As a result, the recorded number created the appearance that the teacher's car traveled farthest. Immediately, a lively conversation erupted. Shouts of "That's not fair!" and "That's not right!" progressed to more general reasoning: "You didn't do it right" and "Do it again." The conversation further progressed to more specific justifications: "Use the same licorice sticks to count" and "The stick's gotta be the same size!"

Follow-up activities

The teacher introduced many similar situations throughout the year. Children measured distances that balloon rockets traveled with differing lengths of Unifix-cube trains. They weighed objects with small and large teddy-bear counters. They poured glasses of orange drink using different cup measures. By the end of the year, children were frequently reminding the teacher to "do it fair!"

Connections to the Standards

The expectations of "use repetition of a single unit to measure something larger than the unit" and "measure with multiple copies of units of the same size" (NCTM 2000, p. 102) are both essential to understanding the car-race problem. The teacher's introduction of the element of competition in an appropriate way for young children initiated the idea of fair measurement. Although most children did not understand why the measurements were

incorrect, they did understand that something about the process was unfair.

Summary

We have learned a great deal about children's understanding of measurement concepts by providing these initial experiences for young children and facilitating their development throughout the year. Do these measurement experiences represent a cohesive measurement curriculum? No. Did every child learn the processes of measuring distance, height, or area correctly? Of course not. Could each child verbally explain his or her understanding of the measurement principles of unit, iteration, or conservation? Absolutely not. What did these young children learn about the process of measurement? The Measurement Standard for pre-K–2 (NCTM 2000) lists several expectations; we observed that children began to meet many of these expectations during the year. Many children began to place objects end to end to measure length, and side by side to cover an area. Many children began to use the process of iteration and required only one licorice stick or one ruler to measure a length. Most children began to use the same unit to measure distance "to be fair," or they could remind the teacher to do so. Most children began to use mathematical measurement words to talk about the attributes of length, weight, and area. Are these four- and five-years-olds making a good beginning in their understanding of measurement? The answer is yes—and so are their teachers.

Reference

National Council of Teachers of Mathematics (NCTM). *Principles and Standards for School Mathematics.* Reston, Va.: NCTM, 2000.

The events and quotes in these vignettes are from lessons taught in public school classrooms that are part of the Early Childhood Collaborative supported by the College of Education at the University of Houston. The authors thank the teachers and children of Chancellor Elementary School in Alief Independent School District, Lawhon Elementary School in Pearland Independent School District, Herod Elementary School in Houston Independent School District, Challenger Elementary School in Pearland Independent School District, Post Elementary School in Cypress-Fairbanks Independent School District, and Bammel Elementary School in Spring Independent School District. ▲