CHAPTER 1

"What Color Are Our Feet?"

Empowering Prekindergarteners' Statistical Reasoning through Opportunities to Create, Discuss, and Own Visual Representations

Theodore Chao, *The Ohio State University*
DeAndrea Jones, *Weinland Park Elementary School, Columbus (Ohio) City Schools*

DeAndrea Jones, a veteran prekindergarten teacher at an urban public school serving a low-income and historically African American community, finishes reading Dr. Seuss's *The Foot Book* (1968) to her classroom of fifteen to twenty children, aged four to five. *The Foot Book* details variations in feet through whimsical rhymes: "Left foot, Right foot, Feet, Feet, Feet, How many, many feet you meet" (Seuss 1968, pp. 8–9). Jones asks the children to look at their shoes and the other shoes in class: What do they notice? As children come up with multiple ways to describe their shoes (e.g., laces or no laces, shoe color), Jones steers the conversation toward organizing what they notice in a way everyone can see. After discussion about various ways to organize the feet, one child asks if they can create a poster of all the feet in the classroom.

"I like that idea!" exclaims Jones, taking up this suggestion and rolling out some butcher paper. Jones then elicits ideas about how to create and organize data about classmates' feet onto the butcher paper. Children come up with various solutions, many of them focused on stepping on

the paper. One child suggests stepping in paint first, then walking on the butcher paper. “OK, let’s do it,” says Jones, directing her assistant teachers to prepare paint and help children remove their shoes and socks. As the children excitedly paint their feet, Jones asks, “How will we know whose feet is whose on the paper?” One child suggests that boys paint their feet one color and girls paint their feet another color.

Another child extends this idea, saying, “Boys on one side, and girls on the other side.” Jones takes up these ideas, drawing a line down the middle of the butcher paper. The children line up, paint their feet, and make a footprint onto either side of the butcher paper (with help from the assistant teachers). As the paint dries and children clean off their feet, Jones gathers children around the poster and asks what they notice (see fig. 1.1).

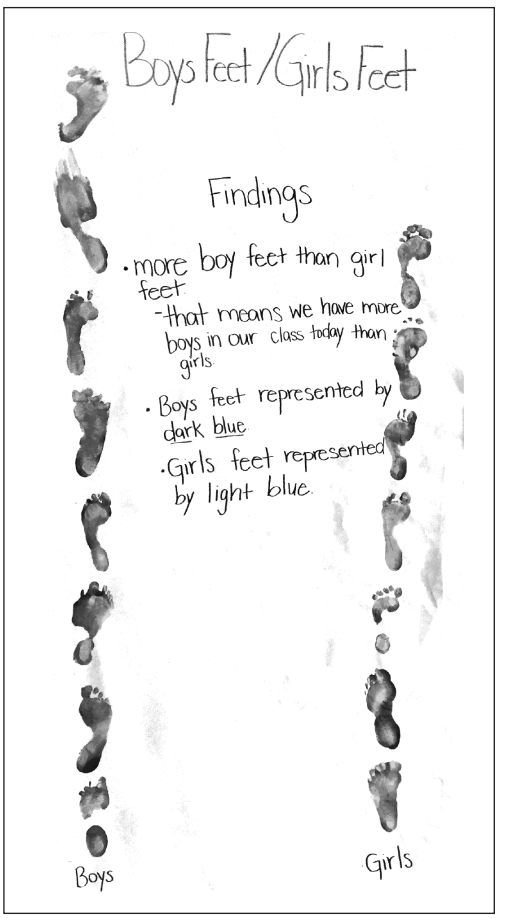

Fig. 1.1. The prekindergarten children’s two-column chart of their feet

One child says, “We can count boys’ feet and girls’ feet.” Jones takes up this contribution, writing, “Findings” in the middle of the poster. She hangs up the poster on the front wall and asks children to count the feet. A child says, “There’s more boys’ feet than girls’ feet.”

“How did you figure that out?” asks Jones.

“The boys’ feet got 8. The girls’ feet got 7,” answers the child. Jones records the students’ findings on the poster.

One week later, when children revisit the chart, a child shares that while the foot chart shows boys and girls, she wished everyone could have chosen their own color. Other children agree; they also wanted to choose the color of their feet. Jones goes to the whiteboard, writing down all the colors children say they would like to paint their feet. The children, eager to paint their feet their chosen color, start removing their shoes and socks. “Freeze,” Jones instructs. “How should we organize our data?”

One child says they should make lines like the boys vs. girls chart. Another child says they should make a table. One child asks if they can do a circle of colors. Other children agree with the circle idea, and Jones solicits more information: “What do you mean by a circle? Can you show me?” One child draws a circle with her hands, showing different pieces with different colors, which Jones revoices as a “pie chart.”

At this point, Theodore Chao, who was observing this lesson as a mathematics education researcher, steps in to suggest that creating a pie chart by hand might be too complicated for prekindergarteners because of the circular angle measurements and percentages involved. Chao suggests a histogram representation. Jones agrees—a pie chart might be too complex. But the children keep insisting on circle graph. So Jones shrugs her shoulders and says, “I guess we’re making a pie chart.”

The assistant teachers help children paint their feet while Jones labels the butcher paper “Pie Chart” and draws a big circle. Children, one a time, make a footprint in the circle. Jones organizes all sixteen children as Yellow, Green, Dark Blue, Pink, Blue, and Black, asking children choosing the same color to step in the same section of the pie chart (see fig. 1.2). As children clean up, Jones asks children what conclusions they can make from their pie chart. One child notices that pink is the most popular color and yellow is the least popular color. Jones asks the children to verify this observation, then writes it on the chart. Jones hangs the chart on the wall for children to examine over the next week.

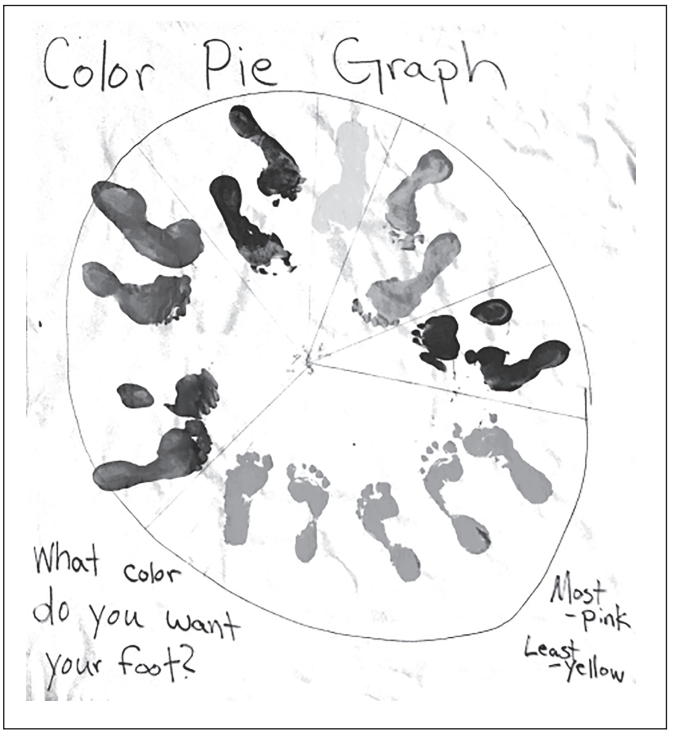

Fig. 1.2. The pie chart children made to organize and analyze the color of their feet

Making a Commitment to Access and Equity

In *Principles to Actions: Ensuring Mathematical Success for All* (NCTM 2014), NCTM explicitly frames Access and Equity as the first principle for successful mathematics teaching and learning. In the vignette that opens this chapter, Jones centers her children's explorations on this principle, helping "all students have access to a high-quality mathematics curriculum, effective teaching and learning, high expectations, and the support and resources needed to maximize their learning potential" (NCTM 2014, p. 5). During these evolving activities, Jones and Chao watched as prekindergarteners took ownership of their mathematical discussions around organizing and creating graphical representations of the data they generated. Jones routinely gave her children the power to steer the conversation or activity, positioning herself along the learning experience with her children. This approach also meant sometimes abandoning learning goals (i.e., children would create histograms) so the activities would go where children wanted. Jones was able to make these activities meaningful because of the ways she incorporated principles of access and equity.

First, Jones positioned all her children as capable of mathematical thinking, echoing that "mathematics ability is a function of opportunity, experience, and

effort—not of innate intelligence. Mathematics teaching and learning cultivate mathematics abilities. All students are capable of participating and achieving in mathematics, and all deserve support to achieve at the highest levels" (NCTM 2014, p. 63). The classroom discussions were open to each of Jones's children, and the norms of the classroom made each child feel welcome to participate and explore mathematics as valid contributors (see chapter 3). Jones trusted her students to guide her through creating the boys vs. girls foot chart and the foot color pie chart; every child in her class participated in thinking about and physically took part in creating the charts. Through Jones's interactions, each child, regardless of background, felt capable of sophisticated mathematical thinking:

> All students are capable of making sense of and persevering in solving challenging mathematics problems and should be expected to do so. Many more students, regardless of gender, ethnicity, and socioeconomic status, need to be given the support, confidence, and opportunities to reach much higher levels of mathematical success and interest. (NCTM 2014, p. 64)

Second, Jones expected her children to engage in challenging mathematical tasks: "Effective teaching practices (e.g., engaging students with challenging tasks, discourse, and open-ended problem solving) have the potential to open up greater opportunities for higher-order thinking and for raising the mathematics achievement of all students, including poor and low-income students" (NCTM 2014, p. 63). Jones expected her children to problem solve and figure out a way to represent their data without telling them or modeling for them what to do, opening up opportunities for higher-order thinking, something not often expected of prekindergarteners. When the children chose the circle graph representation, Jones knew this might be too challenging, yet she allowed it because it was an opportunity to engage her students with a challenging task.

Third, Jones's teaching espouses the belief that "persistent and unacceptable gaps narrow and ultimately disappear when all students have access to rigorous, high-quality mathematics, taught by teachers who not only understand mathematics but also understand and appreciate learners' social and cultural contexts in meaningful ways" (NCTM 2014, p. 65). Jones treats her classroom as a community in which social and cultural knowledge is built over time. In this example, Jones used *The Foot Book* (Seuss 1968), a class favorite, as a social context to orchestrate an open-ended mathematics activity. Jones also routinely builds her activities off books, songs, and stories that children share from their families, homes, and communities (see chapters 8 and 10). This vignette showcases Jones's commitment to access and equity for her children through high-quality and challenging mathematics teaching.

Advancing Access and Equity

Advancing access and equity in the prekindergarten and early elementary classroom involves adhering to a number of teaching beliefs and practices connecting to *Principles to Actions* (NCTM 2014). Holding children to high standards of mathematical achievement and challenging children with open-ended tasks are part of what makes Jones a dynamic prekindergarten teacher. But beyond these expectations sit a number of subtle teaching dispositions that Jones uses to create opportunities for her prekindergarteners to learn, engage, and "do" mathematics that comes from their own experiences. In Jones's classroom, the concept of "access and equity" involves the following dispositions toward learning:

- Play. Young children learn and reason mathematically through play (Parks 2015; see chapters 2 and 7). Creating opportunities for all children to play and to create mathematical meaning through their play allows children to notice and construct mathematical ideas as they interact with multiple representations.
- Community. Young children need to feel that they belong, that they are supported, and that they are safe (Aguirre, Mayfield-Ingram, and Martin 2013). These assurances open up opportunities for them to engage in mathematics, suggest creative ideas, and ask questions that their curiosity prompts.
- Voice. All children should have a voice in which they can say or talk about what they notice, knowing someone will listen intently to what they are saying (Gutstein 2007; Turner et al. 2016).

Jones's Approach to Access and Equity

First, Jones's classroom focuses heavily on children's collaboration; the class is a community where all voices are heard. This approach connects to the community tenets of the Access and Equity Principle:

> Classroom environments that foster a sense of community that allows students to express their mathematical ideas—together with norms that expect students to communicate their mathematical thinking to their peers and teacher, both orally and in writing, using the language of mathematics—positively affect participation and engagement among all students. (NCTM 2014, p. 66)

In previous years, Jones had children create individual histograms based on sorting and counting different colors from a random sample of multicolored cereal (such as Kellogg's Froot Loops.) Using a pre-created chart, the children

colored one appropriate box for each cereal piece to create a histogram of the sample (see fig. 1.3). Children seemed to enjoy this activity because they could eat the cereal. This task came from an activity in the district's prekindergarten curriculum that covered the Common Core standard K.MD.B.3: Classify objects into given categories; count the numbers of objects in each category and sort the categories by count. But after doing this activity for multiple years, Jones became dissatisfied with it. She did not like the way the activity focused only on individual counting and sorting, nor did she think any of her children cared about the number of different colors in a handful of cereal. The activity did not allow opportunity to collaborate or come together in community. So Jones abandoned this activity in favor of charting and counting tasks that organically came out of her class discussions. In this way, her children could see that mathematics was a community endeavor as they learned to count, classify, and organize the data they generated.

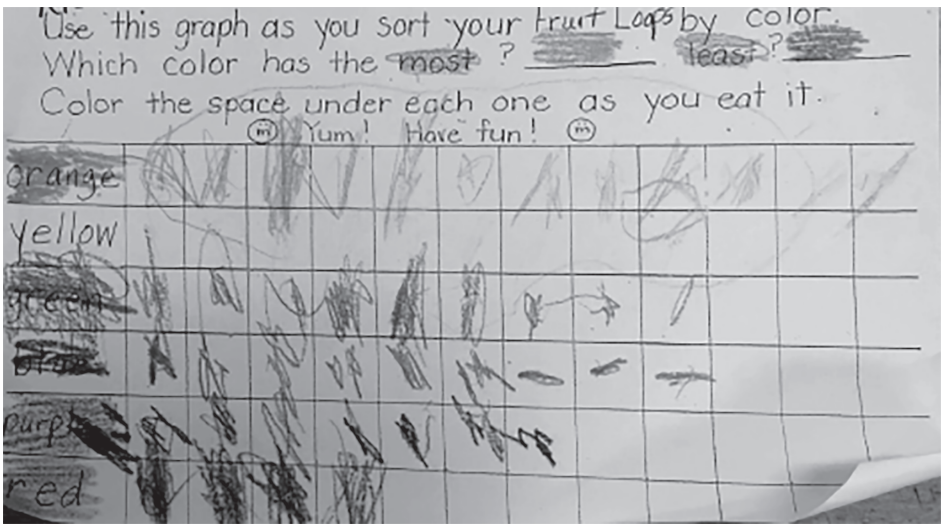

Fig 1.3. The abandoned sorting, counting, and coloring activity involving orange, yellow, green, blue, purple, and red cereal pieces

Second, in Jones's classroom, children's curiosity drives the lesson. Jones constantly takes up and connects children's ideas, utterances, and observations to help children feel ownership in whatever tasks they are doing. This approach leads to collaborative and engaging mathematical discussions that do not dismiss children's mathematical thinking but rather elicit and extend children's ideas, no matter what these may be. For instance, Jones knew that her children loved *The Foot Book* (Seuss 1968) and wanted to create an activity involving measuring the children's feet. Prior to the activity described in the vignette, Jones had children classify their own shoes as either having laces or not having laces. Each child was given a laminated cutout of shoes with laces or without laces; and one at a time, the

children placed their "shoes" on a two-column chart (see fig. 1.4). Collectively, the class then counted the number of children in the class who had shoes with laces and the number of children in the class who had shoes without laces. This activity still covers CCSSM K.MD.B.3 as did the activity with the colored cereal, but it also allows children to stand up, place a shoe on a chart, count the number of shoes, and compare which side of the chart has more shoes and which side of the chart has fewer. This activity starts with discrete data—laces vs. no laces—and introduces children to how they can generate data themselves.

Fig. 1.4. Laces vs. no laces laminated "shoes" for children to select

However, Jones still felt this activity was too procedural and did not actively engage children in play as they explored mathematics, a crucial element in prekindergarten teaching (Parks 2015). So when a child suggested tracing feet on the butcher paper, and another child added the suggestion of painting feet, then stepping on butcher paper, Jones took up these ideas and let them drive the lesson. Jones focused the conversation on creating a visual representation of the classroom community but still allowed the children to dictate how they wanted to create and represent the data themselves.

Third, in Jones's classroom, the children worked with data and created mathematical representations meaningful to them. In comparison with the colored cereal (see fig. 1.3) or the Laces vs. No Laces (see fig. 1.4) activities, the foot color circle graph was child-generated, communal, and came from children's ideas.

Fourth, Jones practices responsive teaching by readjusting her own goals for the lesson and being open-ended about where children take a mathematical activity. Jones listened to her children, which led to them representing their data in a circle. Jones and Chao were not sure this approach would work—they thought it would be difficult for the children to create the circle graph—but Jones heard the children's ideas of creating a circular representation and made their ideas happen.

Jones's confidence in the children, as well as her supervision, helped ensure that this representation actually worked to represent the data the children generated.

Fifth, Jones not only fostered a community of mathematics inside her classroom but also connected to the outside community knowledge that children brought with them from home, families, and experiences outside of school. Jones's teaching makes strong connections with her community; parents regularly help out in her classroom, jumping into mathematical tasks and being playful with the children. This connection bridges her children's school experience with family life. Jones reaches out in particular to children who might feel shy or isolated, such as her emerging bilingual children. Additionally, the classroom community atmosphere is constantly negotiated by children, who made *The Foot Book* (Seuss 1968) part of the community landscape by continually requesting it for reading time.

The Evolution of Children's Reasoning on Data and Measurement

Over the years, Jones has embraced different ways to think about data, measurement, and graphing within her prekindergarten classroom. She uses the ideas from the Access and Equity Principle to guide her analysis of how to structure an activity and whether it allows all of her children to engage in mathematical thinking. Here we detail the evolution of the activities that Jones used, rewrote, abandoned, and continues to work on in order to build a level of access and equity into her prekindergarteners' learning of statistical reasoning. Jones wants her children to count, categorize, and sort data into visual representation, such as charts, tables, and graphs, in order to document and analyze mathematical concepts from their everyday life.

First, we have already mentioned how the colored cereal activity (see fig. 1.3) was a classroom staple for many years, mainly because it seemed to be a fun, age-appropriate activity that came directly from the district's model prekindergarten curriculum. However, upon reflection, Jones thought it was too individualistic and inauthentic, because children had little ownership over the data. So this year, Jones decided not to do that activity.

Second, Jones implemented a different activity when reading another Dr. Seuss book, *Green Eggs and Ham* (Seuss 1960). After Jones read the book to the children, they voted on whether they "liked" or "didn't like" green eggs and ham. Jones took a photograph of each child and place it onto a laminated cutout of a green sunny-side-up egg. Then, each child placed his or her green egg on either the "like" side or the "don't like" side of a butcher paper chart. Jones liked how children made observations about which side had more eggs and which side had fewer, helping her see that her children were capable of interpreting data presented in charts. She also liked how children actively placed their cut-out "eggs" onto the graph, showing

how engaged children were when physically interacting with the chart. This activity also introduced her children to creating a two-column chart. While Jones noted that children enjoyed this Green Eggs and Ham activity, she felt that voting on "liking" or "not liking" green eggs and ham only introduced the power of using and understanding data. Jones hopes both to expand upon these ideas by using data that are meaningful to children and to engage her children in more generative discussions about representing data.

Third, when discussing an upcoming family night, the children started a conversation about what kind of thank-you gift they should give to each family who attends. In the discussion, children mentioned three ideas of ways to show their gratitude (a word they were learning that day): a thank-you note, a thank-you picture, and thank-you food. Jones built upon this idea and created a three-column chart to organize children's votes. First, she clarified exactly what each category meant by asking children to elaborate on the gifts. The thank-you note would be a card that each child would sign and give to his or her family. The thank-you picture would be a photograph of the child with a short thank-you message written on the back of it. Jones reminded the children that food would already be available at family night—so what did they imagine the thank-you food would be like? One child suggested giving each family a bag of thank-you chips. Other children agreed with this idea. So on the chart, Jones filled in the last column as thank-you chips. Then Jones went through each column and asked children to raise their hand based on which thank-you gift they wanted to give. For each child, she wrote down a tally mark on the chart.

After Jones recorded all the tally marks and counted up the totals, a boy named Brian (a pseudonym) raised his hand and said, "It's not fair. Most people chose all three choices." Jones took up this comment on fairness and asked every child who voted on all three choices to stand up. Only three children stood up. Jones counted, "1, 2, 3. OK, so how many people said all three?" The children responded in unison, "3." Jones asked, "So did most people choose all three?" Brian responded, "A lot of people didn't choose all three. They chose one or two."

Jones asked the class how they could make the voting more fair. Brian then asked, "How many people voted just for one?" Jones responded by asking all the children who voted on just one choice to stand up and move to a corner of the rug. Eight children stood up and moved to the corner of the rug. Jones then asked the children who voted for all three choices to move to the opposite corner of the rug. She then had the children count, together, the number of children in each of the three groups: three children voted for three choices, five children voted for two choices, and eight children voted for just one choice. Jones asked if the voting was fair if five children voted for two choices and three children voted for all three choices. The class came to a consensus that a fair vote meant that each child voted

for just one choice. In taking up Brian's comment that the voting was not fair, Jones orchestrated a discussion focused, not on the data, but on how the data were generated and whether these data represented the whole class. Jones focused the conversation around Brian's idea of "it's not fair" and how to ensure that the voting would be fair next time. As the conversation ended, the children decided that the next day, in order to find a clear winner, each child would vote for only one thank-you gift.

Another activity Jones mathematizes in her classroom is something she calls the body parts song. Jones's children love singing the classic song "Heads, Shoulders, Knees, and Toes" and adding their own parts to the song, so it is not just about heads, shoulders, knees, and toes but can incorporate elbows, chins, bellies, shins, ears, whatever the child wants. Jones started a discussion about whether the class should create their own class song as a version of the body parts song. First, she took suggestions from the children about which body parts to include in the song. The discussion was lively as the children laughed at almost every body part, showcasing how Jones tried to keep every activity and discussion playful. Then Jones created a five-column table. In the first column, she wrote every body part mentioned. The successive columns represented the order of the body part in the song. Jones went through each column, having children vote about which body part they wanted to sing about. Jones reminded the children about the idea of fairness that Brian had brought up when they voted on the thank-you gifts. Jones led a discussion about how the class would make sure everyone voted for only one body part. The children decided that, to make sure everyone voted only once, they would all move to different parts of the rug to represent their vote. For instance, to vote for "hair," a child would go to one corner of the rug; to vote for "cheeks," a child would go to another corner; to vote for "shins," a child would go to the table. This method of moving to a different part of the room ensured that each child would vote for only one choice. After Jones ran through four iterations of voting for the four body parts in the song, the class counted up the number of votes for each body part. Jones asked the children which body part in each column had the most votes, circling that particular part of the table. Through this voting and visual data representation, all children created and voted on their new class body parts song. Over the next few weeks, the children sang their new class body parts song, eventually recording it as a video to send to their families. Through this body parts song activity, the children experienced creating, organizing, and voting on which body parts to sing about as a class. In reflection, this was one of the few activities that actually went according to how Jones planned it. But if it had not, she would have followed the children's discussion.

Overall, principles of access and equity play into the evolution of this series of activities. Every week, Jones would try to think of another way to incorporate

statistical reasoning into a classroom activity. Jones and Chao would chat briefly, and Jones would try the activity with her children. These activities are about more than boys' vs. girls' feet or a foot color pie chart; they are about the entire process that helps children develop their reasoning over time.

Through these activities, Jones's prekindergarteners engaged in mathematical thinking that went above the content standards for their grade. For instance, these lessons connect with CCSS.1.MD.C.4: Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another; and CCSS.K.MD.A.2: Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter.

Challenges

Teaching prekindergarteners about data and measurement using an access and equity perspective has challenges. For instance, even though Jones wanted children to feel ownership of their data, she sometimes had to interfere with data generation so that the data would be simple enough for children to interpret. In the body parts song activity, for example, Jones casually asked assistants and parents in the room to also vote, in order to ensure one body part would have the "most" votes and to avoid ties.

Additionally, the children often took the discussion in different directions than Jones had planned. In the discussion about thank-you gifts, for example, Brian moved the conversation from deciding on a gift to a conversation about fairness in voting and whether it was fair for children to vote for more than one thank-you gift. Jones orchestrated this conversation to focus on how they could vote so that each child voted only once, leading children to come up with a technique of physically moving to a different part of the rug to vote.

Reflecting and Taking Action

Through this journey, Jones felt that her children engaged much more with mathematics, particularly her children from households that did not have English as their primary language or who started the school year shy and reticent about interacting with peers. A big turning point, in terms of children's empowerment through mathematics, was the body parts song, in which children collectively crafted a song to share with their families. This sense of ownership of data and their representations led to children's confidence to later build their own circle graph when measuring the different feet colors in the class.

Adapting These Activities

Jones used the principles of access and equity so that data, the representation of data, and the creation of the data became meaningful, playful, and fun for all her children. We invite you to adapt these materials for your own classroom so that your children will feel ownership of their own data. While Dr. Seuss's *The Foot Book* (Seuss 1968) played an important part of this classroom's shared knowledge, we invite you to use books and knowledge meaningful to your own children's interest to facilitate playfulness in measurement and data. We end with some reflection questions to help you and the teachers you work with build equitable and accessible measurement and data activities.

Reflection Questions

1. What are meaningful topics or ideas your children can take ownership of and organize in terms of data representation? How can you create spaces for children to share or take ownership of these topics or ideas?
2. How can you allow for children to create and organize their own representations of data, emphasizing the process of creating and analyzing the world around them numerically, rather than creating a predetermined graph? How can you allow for the representation to belong to the children rather than having it be your own?
3. How can you evolve an activity you do in your classroom to focus specifically on your children's agency, equity, and access?
4. How does this activity incorporate elements of children's play, community, and voice?

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