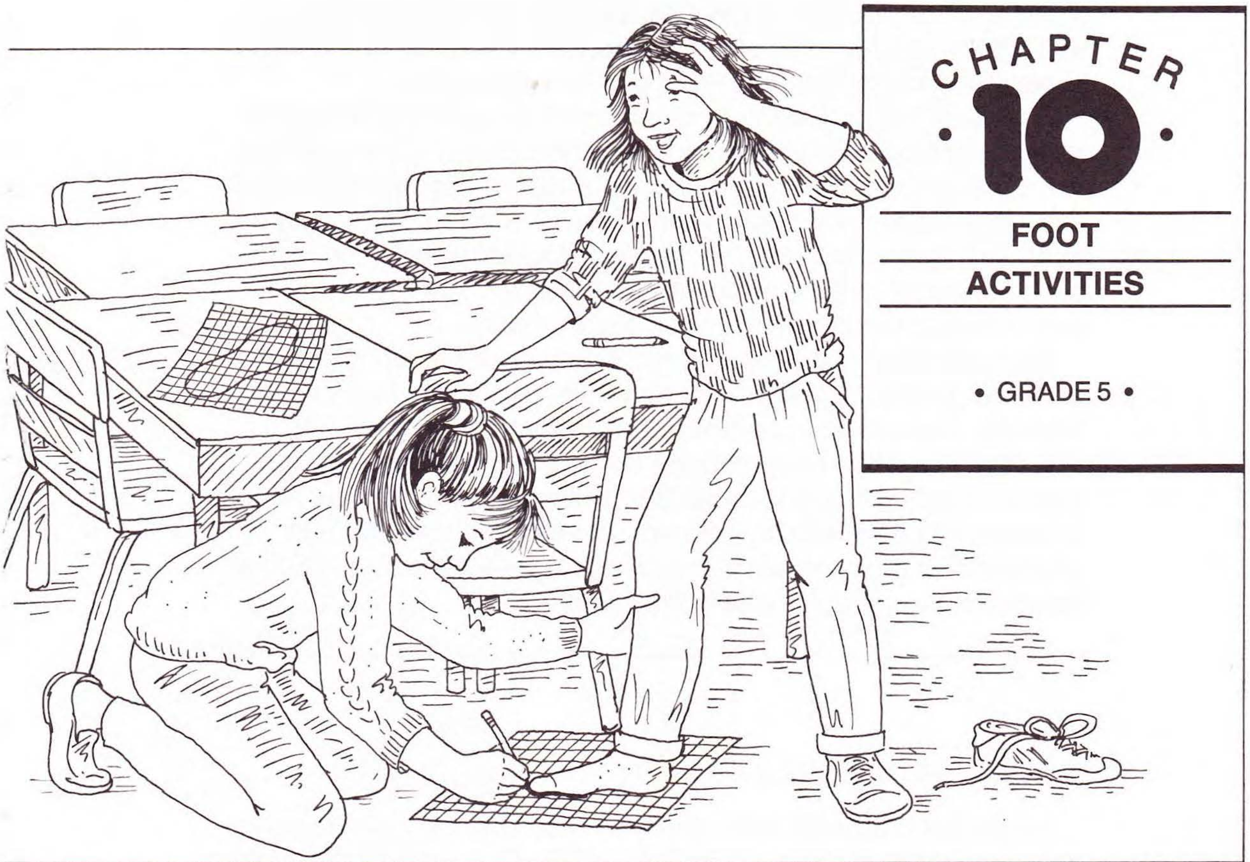
CHAPTER 10

FOOT ACTIVITIES

• GRADE 5 •



Kathy and Melissa work together to trace their foot outlines.

A sequence of lessons is presented in this chapter, each lesson involving the students with measurement activities using their feet. The lessons were conducted in the same fifth-grade classroom on four different days spread over a two-week period.

There were several purposes to the activities. One was to give students experience with area in ways that differed from their usual focus on applying formulas to regular shapes. A second purpose was for students to study the concepts of area and perimeter in relationship to each other rather than as separate topics. A third was to provide a context in which students could investigate finding averages, using the data they generated from their foot areas. And all the students' learning was to occur through problem-solving experiences in which the students were expected to think and reason.

Between the presentation of the first foot activity and the second, the students explored area and perimeter through four additional activities. Those activities gave the students the opportunity to explore the relationship between the area and perimeter of shapes in several contexts and with several different materials.

The benefit of having students interact with a concept through a collection of varied experiences is that the concept doesn't get tied to a specific situation. Instead, students' learning is developed from a broader experience of interacting with the concept in a variety of ways. In this approach students have the opportunity to connect each new experience to what they have already learned, which both cements their understanding and extends it.

Students were asked to write in connection with each of these activities, both to describe what they had done and to explain their thinking. This was not something the students were used to doing in math class. Their usual experience was to complete an assignment and be done with it, rather than reflect and think further about it. Most of their first efforts were not satisfactory. However, with attention and persistence, their writing improved and their thought processes deepened. It was worth the effort.

FIGURING FOOT AREA

For the first experience in this sequence of lessons, I wanted the students to figure the area, in square centimeters, of one of their feet and to write a description of how they did it. I had dittoed a supply of squared centimeter paper and showed a sheet to the class.

"This is squared centimeter paper," I began and asked, "Who can explain why this is called squared centimeter paper?"

Almost half the class volunteered. I called on Lisl. "It's in squares, and the lines are a centimeter apart." Others nodded in agreement. I continued with my introduction.

"For this activity," I explained, "you'll each figure out the area of one of your feet. You'll use a sheet of squared centimeter paper to do this. There are three parts to the activity."

I placed a sheet of the squared paper on a short stool in front of the class, took off my left shoe, and placed my foot on the paper. "For the first part of this activity, you'll need to place one foot, with your shoe off, on the paper and carefully trace around it to get an outline of your foot." As I talked, I outlined my foot with a pencil. "It helps to be careful and to hold the pencil vertically so you get an outline that is as accurate as possible. You might find it easier to work with a partner and trace each other's foot. Any questions so far?"

There weren't any. I added one comment, "This is not hard to do, but it does tickle just a bit if your feet are sensitive." This was to avoid giggly reactions when they got started. (I had already heard several teasing murmurs about taking their shoes off, which I chose to ignore.)

I continued, "For the second part of this activity, you have to figure out the area of your foot, which means to find out how many square centimeters your foot covers. You'll notice that there will be bits and pieces to think about since your foot doesn't totally cover all squares, and you'll need to decide how to account for them. Your answer won't be completely accurate. That would be very difficult, even impossible, with a shape as irregular as your foot. But I'd like you to come to as close an approximation as you can. What questions do you have about this part before I tell you the last part?"

Mark raised his hand. "Can we mark on our feet?" There was a burst of laughter in response from the class. Mark went on, "I didn't mean on my feet. I meant on the drawing of my foot."

"Yes," I answered, "you can mark on your foot drawing any way that is helpful for you."

I called on Melissa. "Can we work together on this?" she asked.

"You can work with a partner to get a tracing of your foot if you like," I responded, "but I want you to work independently to figure your area. I'm interested in your individual thinking and work on this problem."

"Does it matter which foot we outline?" David asked.

"Either foot is fine," I answered.

There were no further questions, so I explained the third part of the activity to them. "When you have figured the area of your foot, I want you to write an explanation that describes how you did it. Write on the lined paper and hand it in with your foot. Be sure to write your name on each sheet."

Before having them get started, I decided it was a good idea to write the three parts of the activity on the board, as it was a lot for some of them to remember. A written reference is essential for some students and helpful for all. It also gave me the chance to show them how to write an abbreviation for square centimeters. I wrote:

1. Trace around one foot (shoe off) on squared centimeter paper.
2. Figure the area of your foot in sq. cm.
3. Write a description of how you did this.

My final direction was that those who completed the task before the others were to continue on their social studies project after they had handed in their work.

The students got busy. As I circulated and observed, I noticed that students were working basically in two different ways, though with some variations. Some were partitioning their feet into squares and rectangles, finding the areas of those, then dealing with the leftover pieces. Others were counting all the whole squares inside their foot outlines one by one, some numbering each one as they counted, some coloring in all the whole squares, some marking them with an X or other mark. One child drew a rectangle that enclosed her foot, figured its area, then worked to figure out how much she needed to subtract.

Tracy was one of the few students who raised their hands for help. Her question was a usual one for her and no surprise to me. "Am I doing this right?" she asked.

"Tell me what you're doing," I responded.

"I'm counting the whole squares first, and then I'm matching up the extra pieces to see which fit together to make more wholes," Tracy explained.

"Do you feel your method will help you find out how many square centimeters there are in your foot?" I asked.

"I think so," Tracy said, "but I want to make sure."

"Your method makes sense to me," I told Tracy. "There are other ways as well to do this, and we'll have the chance to find out later what different methods were used by others in the class."

Several other students raised the same sort of question. I try to acknowledge the children's need for reassurance yet still make them responsible for their work and decisions. I feel that it is only after they have had sufficient experiences with success that they will move toward more independence.

When I read the students' papers that night, I found a wide variation in their written descriptions. A few were detailed and explained their thinking clearly. More, however, were vague and unexplanatory. Some were garbled and unclear. The following samples are reproduced with the children's misspellings and other errors.

From Nelson: *I figured it out by counting the whole ones. When I was done I tried to put all the uneven squares together. I put the uneven squares together by putting a big uneven square with a small uneven square. 152 squares can fit in my foot.*

From Kathy: *I counted the squres that were hole then I counted the squres that were not and my foot came out to be 120½.*

From Amy: *To find out the area of my foot I traced my foot on centimeter graph paper. I found out that my foot is 112 square cm.*

My method was to make a rectangle around a large group of whole centimeter squares. Then I multiplied the length times the width.

With small pieces of squares I tried to find two pieces that formed a whole. Then I put the number zero in one and the number one in the other. I would count the piece with the one in it.

From Jerry: *The way I got it was I counted what was in the picture of my foot.*

From Marcie: *This is how I found the area in my foot. I put it in rectangles and squares and counted it that way and then added it.*

From Lisl: *The way I got it was by first coloring the whole squares lighter. Then I added half to half and if there was a square that only needed a little corner I would look for one and add them. My total score is 139 sq. cm.*

From Karine: *I started by coloring and adding the "not whole" boxes blue. There were 55. Next I colored and counted the whole boxes yellow.*

Karine

I started by coloring and adding the "not whole" boxes blue. There were 55. Next I colored and counted the whole boxes yellow. There were 92 I then divided 55 by two since the fraction boxes rounded out would be about half. 27 r1 was my answer. I then added 92 and 27 which was 119. I added the remainder 1 because I shouldn't leave out part of the number and the area of my foot was 120 square cm.

Karine decides that all partial squares could be considered approximately one-half of a square.

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From Jonathan S.: *Step 1 First I colored all of the whole squares brown. I found the number of the brown squares and wrote it down on my paper.*

Step 2 Then I colored the half squares orange. I found the number of half squares and wrote it down.

Step 3 After the halves I did the quarter squares. I colored them green. I wrote down the number and continued.

Step 4 I then colored the three-quarter squares black. I wrote down the number and I added up all of the wholes, halves, quarter, and three quarter squares. My answer was $152\frac{3}{4}$.

From Brian: *I counted them with meshment with a ruler.*

I wrote comments on each paper, giving them suggestions about how they might better describe their work. On most I referred them to the work they showed on their papers with their foot outline.

The next day I discussed what I had observed when they were working in class and my reactions to their writing. "When you were working on figuring the areas of your feet yesterday, I noticed a great deal of thinking going on. You were solving the problem in different ways, and I found your

Jessica Reidel

First, I counted the wholes. Then, I tried to match of the thirds, fourths etc. and counted them as wholes, each time I tried to mark the wholes with crayon so I wouldn't count them again.

Total: 113

Jessica tries to be as accurate as possible by estimating fractional parts of squares.

methods interesting and effective. Except for Jason and Scott, who were absent, you all finished the activity.

"Last night I looked over your work on your foot outlines and read your descriptions. Some of your descriptions told me both what you had done and what you were thinking. Others, however, did not give me very much information about what you did or what you thought. If I hadn't been in class with you, I wouldn't have much of an idea about the thinking and problem solving you were doing.

"Because this is the first time I've asked you to describe your work in writing, it is a good time for us to discuss writing. I think it's important for you to learn to describe your thinking in writing for several reasons. One is that it makes you rethink what you've done, and in that rethinking you strengthen your own understanding and learning. Another is that your writing can help me better understand how you are thinking, so I can know how to help you continue to learn."

I had decided to read aloud some of the papers to help the children understand what I wanted them to do. I explained this to them: "Without reading your names I'm going to read a few of your descriptions. We'll discuss them together. I believe this will help you think about how you can improve your writing. Then I'll return your papers to you, and you'll see what comments and suggestions I have made to you. Then you'll have a chance to rewrite and improve your descriptions."

I continued, giving them some guidelines for listening when I read. "When you hear the description, I want you to decide whether you get a picture of what the writer is really doing and understand the method used.

When it isn't clear, I'll ask you to think about what could be added to help make it clear. I'll share my thoughts as well."

I began with Nelson's paper. They thought it was a clear description, and I agreed. I then read Kathy's as a contrast, and we talked about the similarity in their methods. I told them that though I understood how the smaller bits of squares were put together in the first description, I didn't have that information in the second. I told them that I needed details in order to understand their thinking. I reinforced how important it was for me to be able to understand how they thought.

I then read Amy's description, and they thought it was very clear. I followed hers with Jerry's and Marcie's papers, and again we discussed what was missing; then I asked them for suggestions.

"Remember," I told them, "that this was just the first time I've asked you to write in math class. I hope you look at this as a learning experience. Because what you think is important to me, I'll be giving you more practice describing your thinking in writing. I think you'll find it will get easier for you."

I concluded the discussion with one more direction. I posted a class list on a large piece of chart paper and asked that they record the area of their feet on it.

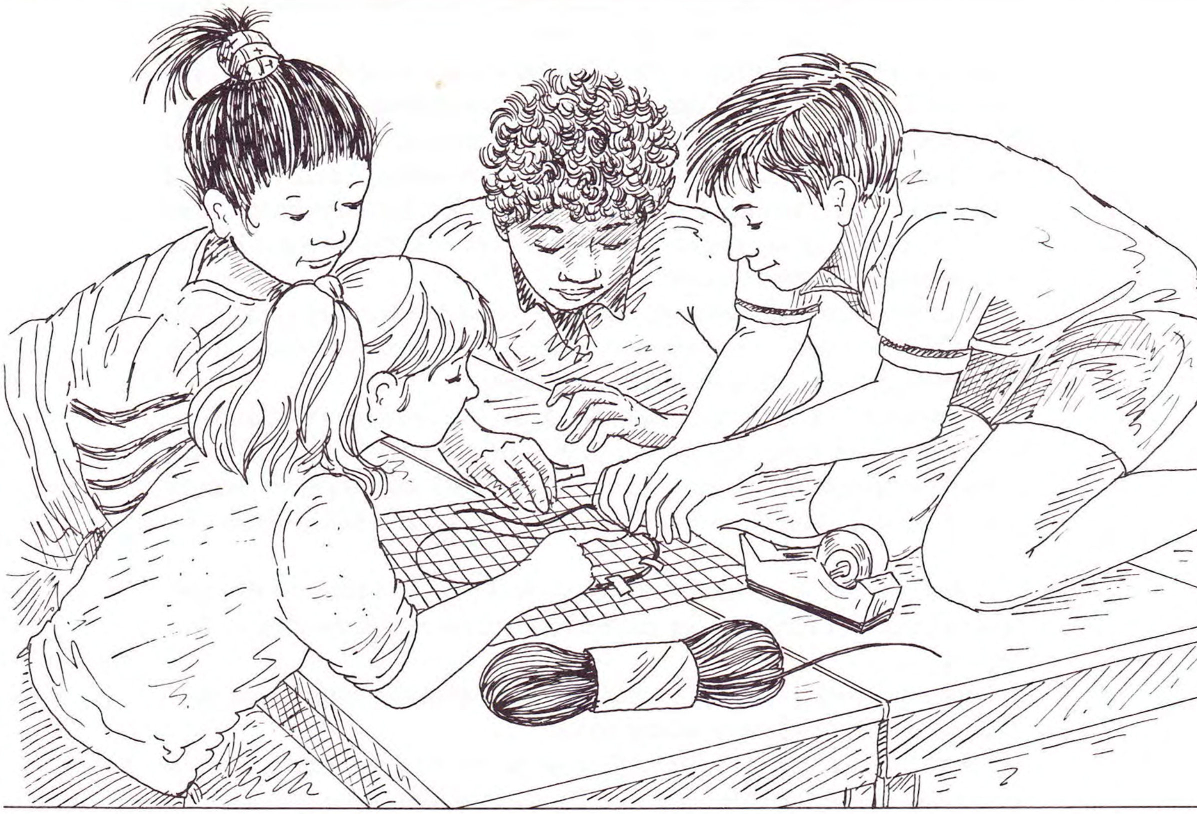
I collected their rewrites the next day and found that for most of them their second attempts were indeed better.

From Marcie, for example: *I first drew the biggest rectangle that I could that would fit inside my foot. I figgered out how many squares in my rectangle by multipling the length and the width. I combined smaller pieces together to make more wholes. The total number of whole squares were 105.*

From Brian: *I counted the full squares and then I estamated and put the halfs together and the quarters together. I got 111½.*

During the next five class periods, the students worked on a collection of other activities that involved them with the concepts of area and perimeter. For those they worked either individually, with partners, or with their groups. They could work on the tasks in any order. I introduced all the tasks at one time and posted each on a piece of chart paper for their reference. The tasks gave them experiences that related to the additional foot activities I had planned.

One of the tasks was called The Perimeter Stays the Same. It is referred to in one of the group's writing for the next activity. In this activity students were asked to draw five different closed shapes on squared centimeter paper, drawing only on the lines on the paper and drawing shapes of which each had a perimeter of exactly thirty centimeters. They were to find the area of each of their shapes. Then they were to cut out two of them, the one with the greatest area and the one with the least area, and post them. I had designated sections labeled Greatest Area and Least Area. I asked the students to notice the difference between these two sets of shapes as they were posted.



Students carefully place the yarn on the outline of the foot drawing.

The other tasks were variations – making shapes with a loop of yarn for the perimeter and investigating their areas, making shapes using tiles, or cutting paper shapes with fixed areas and seeing what different perimeters resulted. It was after this collection of experiences that I returned to their foot outlines for further investigation.

A GROUP-OF-FOUR INVESTIGATION OF FOOT AREA

I prepared a problem for the students to work on in groups of four. I told them that in their groups they were to evaluate a method used by a student to figure foot area. I told them that this wasn't a method reported by anyone in their class. I explained the problem to them and then gave each group the problem in writing as shown.

Foot Measuring

To do the assignment of figuring out the area of one foot, a student in the class wanted to avoid counting squares and bits of squares. The student reported the following method: "I cut a piece of string equal to the perimeter of my foot. I did this by

As a group we discovered that the students method didn't work.

We took a peice of string equal to the perimeter of Kasara foot. Then made the string into a square on graph-papper and counted the squares inside.

With the first method Kasara used she got 137 cm^2 with the students method she got 170 cm^2.

Amanda, Kasara, Brian and Jerry

This group comes to their conclusion from investigating just one of their group member's foot measurement.

carefully placing string on the outline of my foot. Then I reshaped this string into a square and figured out the area of the square. This is how I got my answer."

As a group, discuss this student's method for figuring foot area. Write a group report (1) stating whether you do or do not think the method is a good one, and (2) explain your reasoning.

I returned their outlined feet to them and put out string, scissors, tape, and more squared centimeter paper. I suggested that they use the tape to anchor their string when shaping it into a square.

This was the first time I had tried this particular activity with a class. I learned from the trial that I should have been specific that the students try the activity with their own feet. Most of the groups tested the method using just one person's foot, which made for too much looking on by some of the group members while others worked with the string. Also, I would rather they make generalizations from more than one specific instance.

Nelson, Karine, Akiko, Kathy

If you have two shapes that are different, but have the same perimeter the area inside both shapes doesn't have to be the same.

After investigating the problem, this group reports a generalization.

Some students were disturbed because their string didn't make a square that exactly enclosed whole centimeter squares. I think I would rewrite that direction to read: Then I reshaped this string as close to a square shape as I could so that it enclosed only whole squares.

Conclusions from three of the groups differed from the conclusions of the other three. Three groups reported that the method wasn't a good one because it didn't work for their one trial. Their explanation was based on their experience, with no further explanation or conjecture.

From Amanda, Kasara, Brian, and Jerry: *As a group we discovered that the students method didn't work. We took a peice of string equal to the perimeter of Kasara foot. Then made the string into a square on graph-papper and counted the squares inside. With the first method Kasara used she got 137 cm² with the students method she got 170 cm².*

From Peter, Jason, and Jon W.: *No, because we counted the area of the foot and it was 128, so that's the right answer. But, using this new method, we got 192, and that is obviously way off.*

From Doug, Lisl, Mark, and Tracy: *We think it is a bad method. For one thing it is hard to get a perfect square. We think it comes out wrong or at least different. When we counted the square area it is different than the foot area but the perimeter is the same. Our yarn stretched a little too.*

The other groups reported their results by presenting broader generalizations.

From Marcie, Amy, David M., and David C.: *Our table disagrees with the person because when the perimeter stays the same it doesn't mean the area stays the same.*

From Nelson, Karine, Akiko, and Kathy: *If you have two shapes that are different, but have the same perimeter the area inside both shapes doesn't have to be the same.*

From Jonathan S., Seth, Melissa, and Jessica: *We do not agree with this method because it gives a too high number. But it is like The Perimeter Stays the Same in the way that if we took a foot perimeter and changed it* *into a thin rectangle, it will have a lower area than if we changed the perimeter into a thick rectangle or square. In The Perimeter Stays the Same the shapes with the least amount of area were thin. So if we put the foot perimeter into a thin shape the area will be less than what it would be with a thick shape.*

Groups read their reports aloud for a class discussion. Though all the students seemed to learn from the problem, it became clear to me that some of the students did not yet have sufficient understanding or experience to understand the broader generalization reached by others. It is essential that I get information about specific students in this way so I can plan appropriate instructional activities for them.

FINDING THE AVERAGE-SIZE FOOT

It is valuable to relate experiences from different strands of the mathematics curriculum. These children had had some previous experience with averages, and here was an opportunity to use a statistical idea to analyze a measurement activity. Also, this would set the stage for another group-of-four activity using their feet.

I drew the class's attention to the chart on which they had each recorded their foot areas. "Let's take a look at your foot area measurements," I said. What stood out first on the chart was that David C. had changed his foot measurement twice after initially recording, from 136 to 146 to 150 9/20.

"What's the story, David?" I asked. "Has your foot been growing these last several days?"

David is a bright boy, knowledgeable about mathematics and comfortable with abstractions. He is generally invested in being precise, and this was a clear indication of that need.

"When I checked my work the first time, I realized I had added wrong and changed it to 146. Then I did it again and figured the extra pieces more accurately," David explained.

I was perplexed about how to deal with his answer. Coming to an approximation that included 9/20 of a square centimeter seemed pretty ridiculous to me. But I knew David's tenacity about being exact.

"If you figured it again, do you think you would get exactly 150 9/20 again?" I asked David.

"Yeah, I think so, but maybe not," he answered.

I addressed the entire class, "When I first introduced this activity, I remember telling you that you couldn't really get an exact answer. Can someone explain why I said this?"

I waited, giving the students time to think, and then had several of the students offer their thoughts. They explained, using different words, that you can't really be exact with all those bits of squares that had funny shapes. It is important for students to understand that we sometimes rely on approximations because the constraints of measurement make accuracy impossible.

I finally brought my focus back to David. "So, David," I said, "what would you be satisfied with as a reasonable estimate for the area of your foot if I asked that it be made to the nearest square centimeter or half of a square centimeter?"

"I'd say 150½," he said and came up and changed it once more. Even giving an answer to the nearest half square centimeter seems inappropriate, but since so many of the other students had come to halves in their answers, I thought it was a degree of accuracy consistent with what the other students had used.

I changed the attention now. "Who has the smallest foot area in the class?" I asked.

"I do," Melissa said, giggling. "My foot is only 91 square centimeters."

David M. wears a size twelve shoe. The kids call him Bigfoot, but respectfully so, as I've heard that a stomp from him on the playground is no fun. David said, "Look, mine is 190 square centimeters. That's almost 100 more than Melissa's."

"Is David's foot area more or less than twice Melissa's?" I asked the class. I heard both answers and asked for explanations. It is from incidental opportunities such as this one that children's math concepts can be consistently supported.

David and Melissa came up to the front of the room and put their feet side by side. It was a startling contrast.

"Here's a problem I want you to think about in your groups," I told the class. "Using the information that Melissa's foot area is 91 square centimeters and David's is 190 square centimeters and what you know about your own feet, what do you think will be the average foot area in the class?"

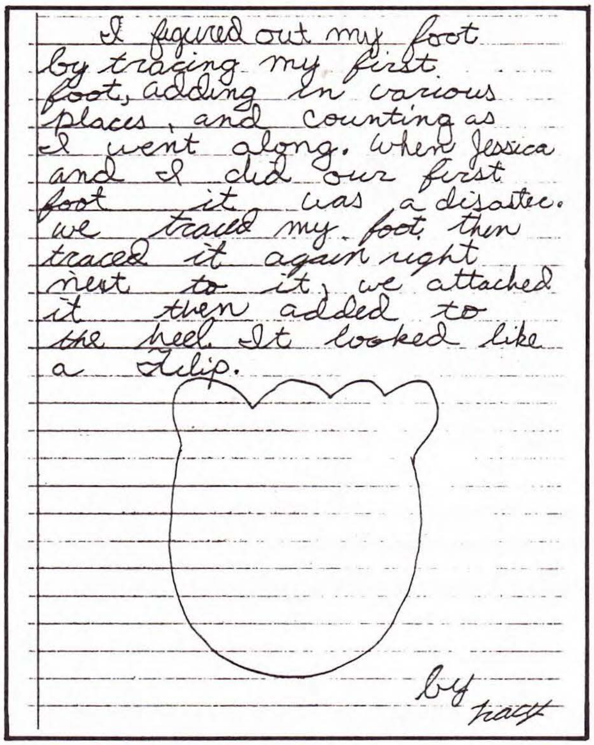
Most groups averaged the two numbers by adding them and dividing by two. Two groups went further, averaging their own feet and then changing the average of David and Melissa's areas to more closely align with their average.

We discussed those answers, and then talked about how we could find the class average. This gave me a chance to explain the difference between mean, median, and mode. To find the median, they lined up in the order of the size of their foot areas and found who was in the middle of the line. There was no mode.

To figure the mean, we talked about the usefulness of calculators, and the students used them to find that the mean was just about 160 square centimeters. They did this in their groups of four and compared answers before reporting. Most found it helpful to work in pairs, with one reading the numbers and the other punching them in, which helped to avoid mistakes.

THE GIANT'S-FOOT PROBLEM

The average foot area was needed for this last activity – to draw a giant's foot, given the information that the area of the giant's foot is just about twice the area of their average foot. Once again they were given an accompanying writing assignment – to describe how they accomplished the task.



I figured out my foot by tracing my first foot, adding in various places, and counting as I went along. When Jessica and I did our first foot it was a disaster. we traced my foot then traced it again right next to it, we attached it then added to the heel. It looked like a Tulip.

by Tracy

Tracy describes the initial attempt she and Jessica made to draw the giant's foot.

Also, students were given the option to work alone, with a partner, or with a group. Twenty-two of the twenty-four students were in class that day. Five chose to work alone, ten worked in partners, and there were a group of three and a group of four. About half of the students needed time the next day to finish their work.

The methods the students chose varied. Several used one of their feet as a starting place. Tracy and Jessica began by using Tracy's foot. Because it was just a bit smaller than the class average, they figured that the giant's foot was a little bigger than two of their feet. Tracy wrote: *I figured out my foot by tracing my first foot, adding in various places, and counting as I went along. When Jessica and I did our first foot it was a disaster. We traced my foot then traced it again right next to it, we attached it then added to the heel. It looked like a Tulip.*

They went back to work the next day, deciding to work independently, but then submit one final foot. The final foot was Tracy's idea. She began with her foot again, but proceeded differently this time. Jessica recorded: *The next day we got into an arguement. I tried my own plan but it didn't work. I know how Tracy did hers. First, she copied her foot. Then, she*

Akiko Yusa

First I made a rectangle of 260 boxes.
The way I got this rectangl is by mutipling 26x10. I made the rectangle a little bigger in case the toes will be wider or taller. I made a shape of a foot. When I Counted the boxes it was to big 274. So I cut 14 boxes around the heel, then I got 260.
But I didn't really like the shape that much.

Akiko begins her solution by drawing a rectangle with the area of the giant's foot.

added on to it until she got to 260. I think it looks like a giant human foot. She did a very good job!

David M. was a member of the group of four. David is the boy who wears size twelve shoes. They used his shoe for a starting place. Jonathan S. recorded in his usual step-by-step style:

(1) First we took David Master's shoe and outlined it on two peices of graph paper. We did this because David's shoe was the closest to 260 and it would be a good support for the origanal outline.
(2) We all counted the area of his foot drawing. It had an area of 230.
(3) Because it was 30 square cm short we added on to the heel of the drawing.
(4) We copied the foot on another two pieces of graph paper. We counted the area and we got 260 square cm on the dot.
(5) We copied it agian and then we cut it out and taped it on another piece of paper.
(6) Now we rest.

Another common approach was to draw a rectangle about the right size and work from that. Kasara worked alone using this method. *I started off by myself and thought to myself how I was going to do this problem out. I thought if I made a box and then counted the toe space, it would be easyer than counting the hole foot. I thought how long and wide I wanted my foot. I made my foot 31 by 8 which would be 248. I added some on and then counted the rest of the hole square cm. I added 8 + 5 and 248 and got a total number of 261. And thats how I got my strange foot.*

Akiko also worked alone. *First I made a rectangle of 260 boxes. The way I got this rectangl is my multipling 26 × 10. I made the rectangle a little bigger in case the toes will be wider or taller. I made a shape of a foot. When I counted the boxes it was to big 274. So I cut 14 boxes around the heel, then I got 260. But I didn't really like the shape that much.*

Amanda and Amy began with the same approach, but they made an error at first that caused them a problem. They changed methods, and after three tries they were satisfied. They described their process:

Our job was to draw a foot in which the area was 260 square cm. We thought *it would be EASY. HA!*

*Our first try we figured out we should make a rectangle 130 × 20. We thought that would equal 260 cm. We taped six sheets of paper together. Mrs. Scheafer [*their teacher*] didn't know what we were doing. Neither did we.*

Our second try we did 30 × 8. We tried to make it look like a foot. We didn't try hard enough.

Our third try was more successful. We just enlarged Amanda's foot 4 sqs out. It actually looked like a foot.

We counted the sqs and they equaled exactly 260 cm.

Other students began by drawing a foot and adjusting it. Lisl, Marcie, and Karine reported their method: *We taped two pieces of paper together to make the rectangle of 300 square cm fit. Then we drew a foot inside. After that we colored all the wholes green and the fractions yellow. Then we counted whole squares and added the fractions. We found out the answer was 250 altogether so we added to the toes and got 257, so we added to the heel and finally got 260.*

Summarizing the activity with the class the second day provided the chance for students to hear each other's methods and compare solutions. The children were curious about each other's drawings and enjoyed sharing their work in this activity. Each posted their giant's foot and came to the front of the room for a presentation. Knowing they will be presenting helps them realize that it is important to be clear and complete in their descriptions.

After each presentation, I asked the other students if they had questions to ask to clarify any part of the description and if they had any comments. Several times the comments began, "We did ours like that, but instead we . . ." In those cases I interrupted the students and asked that they not explain their work yet, but keep their comments to reactions to what had been presented.

After the presentations, I asked a question. "Did anyone think of making a giant's foot that was twice as long and twice as wide as one of yours? Would that be a good idea?" I gave them a moment to discuss it among themselves before I asked for a response. I called on Peter.

"That wouldn't work," he said, "because the foot would be way too big."

Amy chimed in. "First I thought so. But then I realized that if you made it twice as long and twice as wide, you'd be able to fit in four of your feet, not two. It would be four times as big."

Tracy raised her hand. "My tulip foot was the right size, and it was only twice as wide. If I made it twice as long, I'd need to use two more feet."

Having a discussion such as this after the students' concrete experience is a way to help them begin to think about what happens to the area of a shape when you double both its dimensions.

I had one more question for the class. "Suppose we averaged the giant's foot in with your feet. Would that change the class average?" The students all nodded yes. I continued, "Discuss in your groups what you think the new average would be. Think about the mode, median, and mean and how each might change."

I knew this would be a difficult question for many in the class, possibly for two-thirds of the students. Even so, I thought there was value in posing it. In situations such as this one, the more capable students have the chance to explain their thinking to others – a thinking opportunity in which they often clarify their own understanding as they explain.

Also, the other students have the chance to hear an approach to a solution and to observe someone thinking in perhaps a different way from what they had experienced before. Even for students who do not understand totally, the experience can contribute to their math learning. I remind these students, that rather than looking at it as something they don't know, they can see it as something they haven't learned yet. It's this attitude toward learning that I want to be pervasive in the math classroom.