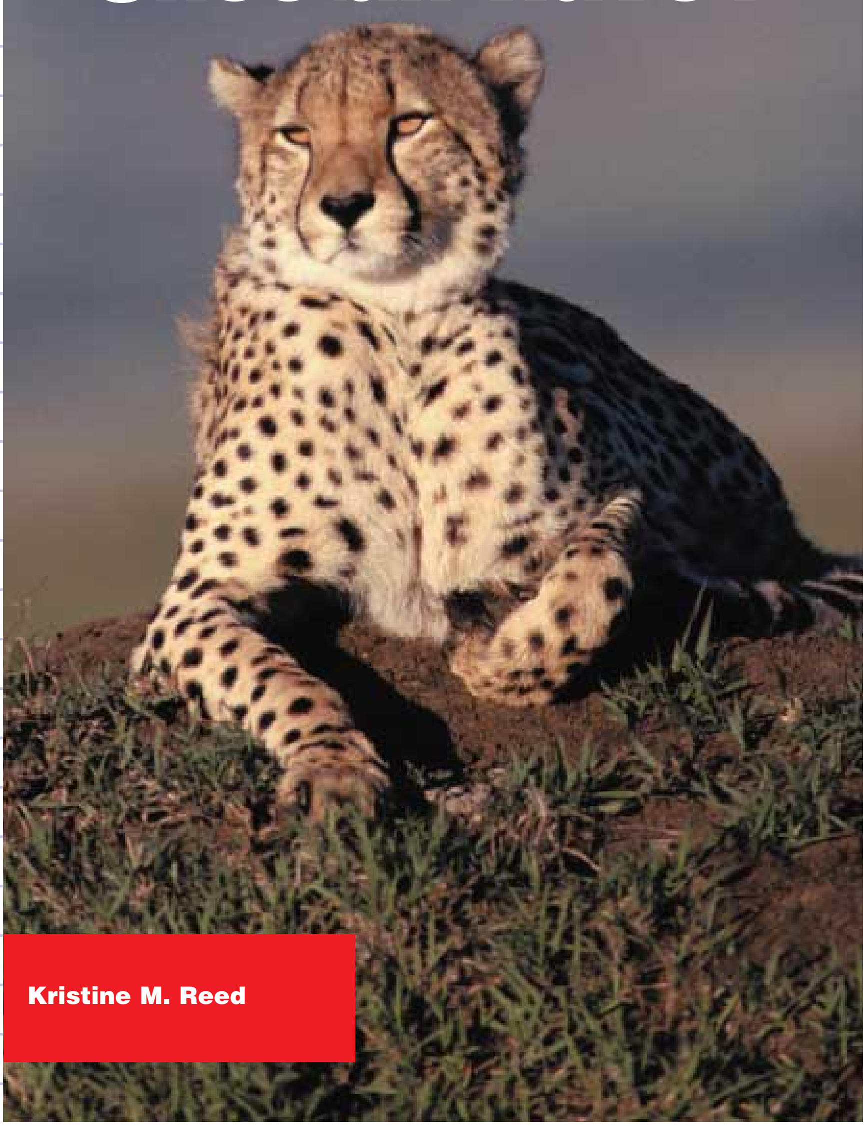
How Many Spots Does a Cheetah Have?



Kristine M. Reed

Kris Reed, kris254@aol.com, teaches first grade at T. W. Miller School in Wilton, CT 06897. She serves as a K–3 instructional leader in mathematics and science for the school district. Her areas of interest include children's mathematical communication and teachers' professional development.

Mathematicians pose problems; they predict outcomes, collect data, offer conjectures, and share strategies. Mathematicians "do math"; they use tools—for example, calculators, rulers, and Unifix cubes. Mathematicians communicate; they "talk math" and "write math." Mathematicians clarify and revise their ideas, and then they pose new problems. This article describes how twenty first graders undertook the work of mathematicians in their investigation of the problem "How many spots does a cheetah have?" The exploration of counting and estimation strategies that grew from this cheetah investigation gives evidence that mathematicians come in all ages, young and old.

Spotting the Problem

"In the summer, I went to a zoo in Washington, hmm . . . I think, D.C.," Hayden announced to her fellow first graders assembled on the rug. "And know what I saw? A cheetah, a real one."

Matt, another child in the class, exclaimed, "Hey, there's math happening there. . . . We could count the spots on a cheetah. How many spots does a cheetah have?"

The six-week cheetah investigation that began from Matt's spot question ultimately linked the NCTM's Standards of problem solving, reasoning, communication, number sense, and estimation (NCTM 1989) in a meaningful and engaging manner that I never could have foreseen as I prepared for the school year. The cheetah study emerged from a mathematical question—a problem—posed by a first grader in our classroom. The children had arrived at the problem themselves and so had true ownership of it. As a result, their commitment to the cheetah problem was evident from the very first day.

The children began their investigation with a discussion in which they noted that "a real cheetah would never let someone walk up and count its spots." They had an awareness of the limitations and obstacles that their investigation presented, and they recognized the need to turn to other resources and strategies. The group suggested that they watch videotaped segments of the cheetah in its natural habitat; viewing these clips would come closest to actual observations of a live cheetah.

These first graders also spent the first days of the investigation gathering such resources as photographs of cheetahs, nonfiction books about big cats, wildlife magazines, and even Internet Web sites to collect information. The children gathered their resources not only at school but at home, as well; their cheetah work was not an isolated school activity but rather became a part of their "living the life of a mathematician." The reports of "spot data" came pouring into the classroom each day:

"The spots are different sizes."

"No spots on the belly."

"There's tear lines on the face. That's different than spots."

"The tail spots are so close together, they make stripes."

I, too, was a member of this community of mathematicians, but my role was far from that of the traditional teacher role of an all-knowing "expert" who holds the answer. I facilitated classroom investigations and developed learning experiences in response to the questions raised and the information reported by the children. Most of all, though, I was a learner. I was a mathematician myself who also researched the cheetahs and became intrigued by the spot patterns of these big cats.

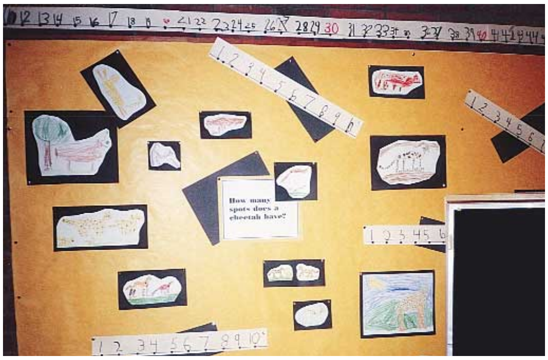
Lots of Spots and Counting

From the beginning, the notion of "how many" fascinated these first graders, and they were convinced that they could arrive at a "count" of the cheetah's spots. They held tightly to the power of counting; they felt empowered by their developing sense of mathematical competence and numerical fluency. They therefore would not quickly surrender counting as their primary problem-solving strategy. They needed opportunities to "have a go" with the counting in which they believed so strongly, for they needed to come to question it themselves.

In the early weeks of the investigation, many of the children huddled over photographs of cheetahs, counting, counting, counting. Often a sigh would be heard as one of them would lose count and ask a partner, "Where was I?" or "Did I already count that one?" Then they would begin again. Eventually, Matt, the student who raised the cheetah problem initially, suggested a revision of this counting strategy. He proposed the idea that if the group had copies of a cheetah photograph that they could mark and write on, then they could "keep track" of the spots that they counted and thus solve the problem.

The other children in the group embraced this idea, and together they began their search for a photograph that would "work best" for their counting. They were surprisingly selective in this photograph search; they had come to realize—in an interesting consideration of spatial sense and reasoning—that "a picture doesn't show the whole cheetah." It was an astute observation made by these mathematicians regarding the relationship between a two-dimensional representation and its three-dimensional form. Such an observation was possible only because of the time that had been given for these children to engage in their exploration. Time given in the classroom to view the videotaped segments, mold clay sculptures of the cheetah's body, and examine photographs allowed the children to build bridges from the concrete form of the cheetah to the pictorial representations. Flexible study-group blocks in the classroom schedule each afternoon afforded the time for such an extended, in-depth investigation while the daily morning mathematics blocks continued to address the scope and sequence of the district-adopted curriculum.

At last, the group reached a consensus and agreed on a photograph that showed one full side of the cheetah, as well as portions of its back, neck, and face. With that, the children arrived enthusiastically at the day that they believed would mark the solving of their cheetah problem. Pairs headed off confidently with copies of the photograph, pencils, a clipboard, and blank paper on which to record their work. When the counting began, the variety of strategies that emerged and the commitment to the work at hand were impressive. Some children marked each spot with an X while a partner kept track of the counting orally. Others used tally marks to record a spot each time a partner marked it on the photograph. Some pairs reached for a calculator to



keep track of their counting. One pair color-coded the spots; each time ten spots were counted, they chose a marker of a different color with which to cross out the spots. Still another pair poked a hole through the paper on each spot counted.

Oops . . . a Need for Revision

A sense of disequilibrium was evident, however, when we came together to share the results of these efforts. Several in the group began to question their counting strategy entirely; many pairs reported that even with the photograph, they could not keep track of all the cheetah spots. They had begun to see the limitations of their counting strategy and were opening their minds to alternative strategies. Some offered alternative strategies on the basis of the work they had just undertaken; their revised strategies—their own mathematical "theories"—rang of estimation.

One child suggested that "if we knew how many spots were on one side of the cheetah, we could make a good guess about the other side." Another suggested counting parts of the cheetah one at a time—a leg, the head, and so on—and then putting all these counts together. Several students suggested that calculators could be valuable in this work. All these new strategies and conjectures were recorded in the whole-group Mathematician's Notebook kept in the classroom, and these first graders then set out to make another "run" at the cheetah problem with these latest ideas in mind.

As I had done from the beginning of the school year, I emphasized the expectation that mathematicians would use pictures, numbers, and words to record and communicate their strategies and findings. Carrie and Amy attempted estimation strategies in their problem-solving efforts and used a calculator to render the computation accessible. "There's 343 on one side and there might be 343 on the other side. And there's 22 on his back, and put them together makes 708 with a calculator. It helped us solve the problem. We poked holes in the cheetah to count the spots."

Kit and Ian's work in **figure 1** illustrates a much more functional use of the recording tools; they used the paper to record the counts that they made for each body part. These two examples shed light on the range of student work that emerged from the cheetah problem given the different learning levels represented in the group.

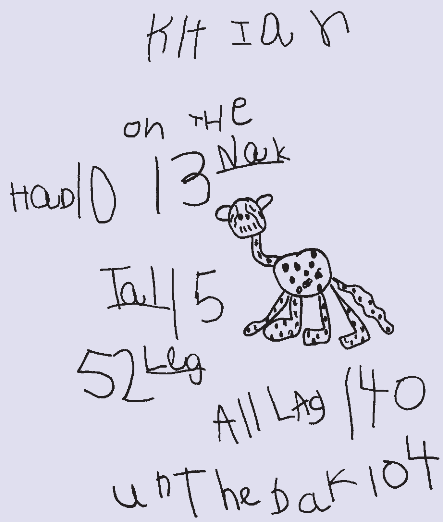
Not all the children in the group were fluent in counting such large quantities, and not all arrived at strategies of estimation in this investigation; the "big ideas" of mathematics develop gradually and need to be revisited and refined over time by each learner. But the cheetah problem did provide multiple entry points that allowed all learners in the group to participate at their current level of understanding. Each child became engaged in the work at his or her own ability level, be it by counting spots on a single leg or offering an estimation strategy to try, and as a result the group's "spot reports" (see **fig. 2**) reflected the range of learners in the classroom. Carefully pairing the children allowed them to support and challenge each other's mathematical thinking in this work and the safe, respectful climate of the classroom validated each child's contribution.

The "spot reports" of all the children were not only shared and displayed in the classroom but also "published" as an addendum to our weekly parent newsletter. This publication acknowledged the work of these first graders and extended the "community of mathematicians" into the home. It also served as an important piece of communica-

FIGURE 1

Kit and Ian's work

They found spots in these areas and quantities: head, 10; neck, 13; tail, 15; one leg, 52; four legs, 140; and back, 104



tion to parents, informing them of the power of the cheetah study.

Through the Eyes of the Teacher

As shown by the "spot reports," this cheetah problem did more than simply offer an opportunity to practice counting skills. It brought together a "community of mathematicians" that consisted of children and adults in both the classroom and home environments. It promoted collaboration among, and fostered mathematical power in, all members of the group. It developed problem-solving strategies and a growing sense of number operations. Perhaps most significant, it allowed many of these young students to construct for themselves, in a most meaningful and purposeful manner, strategies of estimation and a sense of the "why" of estimation. The skills served not as isolated ends in this work but rather as the tools needed to tackle the problem.

These first graders came to marvel at the mathematics embedded in their intriguing cheetah problem, just as a mathematician appreciates the beauty that is inherent in the patterns and relationships of the mathematical world. We never did arrive at a single, definitive solution to the cheetah problem. "Spot reports" continued to come in for days as different students in the classroom worked in self-chosen pairs or small groups to refine their application of the "count parts and put them together" or the "good guess" estimation strategies that had been put forth by others in the group. A few children even approached the notion of an "average" cheetah. They proposed the idea that more than one cheetah photograph should be checked because different cheetahs would have different numbers of spots. "We don't need to check all cheetah photos," one of these first graders clarified, "but a few more!"

The cheetah problem thus remained a "work in progress." For this group of first graders, keeping the inquiry and the questioning alive was more satisfying than any final solution. Such is the work, the attitude, and the spirit of mathematicians, young and old.

FIGURE 2 "Spot reports" from the class

How Many Spots Does a Cheetah Have?

Reports from Problem-Solvers in Room 1R

Erin and Nathan: 57 spots on one front leg, so 58 spots on the other (they decided the legs may not be exactly the same, but close)

Selden: "If we know all the spots on one side, then we know the spots on the other."

Matt and Drew: 120 spots for the legs

Elise and Hayden: 11 spots on the head, 17 spots on the foot, 20 spots on the neck

Kit and Ian: 52 spots on the front legs, 88 spots on the back legs, 140 spots on the legs in all

Ingrid and Andrew: 26 on a leg

Cathy and Sean: 26 spots on one leg, 26 spots on the other = 52 spots; also, 299 spots on one whole side + 299 for the other side = 598 in all

Hollister and Kelsey: "375 on this side. That gives us a clue that there are 375 on the other side."

Michael and Danielle: 27 spots on a leg

Kevin: 232 spots on one side, 232 on the other, 232 on the back, 696 spots in all

Amy and Carrie: "There's 343 on one side and there might be 343 on the other side. And there's 22 on the back, and put them together to make 708. The calculator helped us."

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