SUSAN N. FRIEL AND WILLIAM T. O'CONNOR

Sticks to the Roof of your Mouth?

IS IT SMOOTH, OR DOES IT HAVE SMALL BITS of peanuts in it? Does it taste sweet and nutty, or does it have a slightly burned taste? Is it overly sticky or dry? These are just some of the characteristics that are considered when peanut butters are rated on quality (Consumers Union 1990). This topic appears to interest many people; Consumer Reports has published two studies about peanut-butter quality since 1990 (Consumer's Union 1990, 1995). How does a consumer use these data to determine what may be a "best buy"? One eighth-grade class explored this question with data-analysis activities (Lappan et al. 1998).

This investigation focuses on comparing data sets by using data about thirty-seven brands of peanut butter and their quality ratings **(fig. 1).** These data also include the sodium content and the price for each three-tablespoon serving for each brand. The brands are classified by four attributes: natural or regular, creamy or chunky, salted or unsalted, and name or store brand. Natural peanut butters do not have hydrogenated vegetable oil added; in regular peanut butters, this additive keeps the oil and peanut butter from separating and enhances the creaminess of the peanut butter. Store-brand peanut butters are sold under store names; often these peanut butters are less expensive than name-brand peanut butters.

Students began with a discussion about what characteristics make good peanut butter. They had various things to say:

- They shouldn't have too much salt.
- Peanut butter needs to taste like lots of fresh-roasted peanuts.
- The color of the peanut butter should be brownish or tannish, and the aroma should be "peanutty."
- The peanut butter shouldn't taste too sweet or rancid or stale or bland.

SUSAN FRIEL *is an associate professor and curriculum developer at the University of North Carolina—Chapel Hill, Chapel Hill, NC 27599-3500. She works with elementary and middle grades preservice and practicing teachers in mathematics education.* WILLIAM O'CONNOR *teaches mathematics and science in an interdisciplinary eighth-grade classroom at the Duke School for Children, an independent school in Durham, North Carolina.*

	Brand	Quality	Sod (mg)	Cost (¢)	R/N	Cr/Ch	S/U	N/S
1.	Smucker's Natural	71	15	27	natural	creamy	unsalted	name
2.	Deaf Smith Arrowhead Mills	69	0	32	natural	creamy	unsalted	name
3.	Adams 100% Natural	60	0	26	natural	creamy	unsalted	name
4.	Adams	60	168	26	natural	creamy	salted	name
5.	Laura Scudder's All Natural	57	165	26	natural	creamy	salted	name
6.	Country Pure Brand (Safeway)	52	225	21	natural	creamy	salted	store
7.	HollyWood Natural	34	15	32	natural	creamy	unsalted	name
8.	Smucker's Natural	89	15	27	natural	chunky	unsalted	name
9.	Adams 100% Natural	69	0	26	natural	chunky	unsalted	name
10.	Deaf Smith Arrowhead Mills	69	0	32	natural	chunky	unsalted	name
11.	Country Pure Brand (Safeway)	67	105	21	natural	chunky	salted	store
12.	Laura Scudder's All Natural	63	165	24	natural	chunky	salted	name
13.	Smucker's Natural	57	188	26	natural	chunky	salted	name
14.	Health Valley 100% Natural	40	3	34	natural	chunky	unsalted	name
15.	Jif	76	220	22	regular	creamy	salted	name
16.	Skippy	60	225	19	regular	creamy	salted	name
17.	Kroger	54	240	14	regular	creamy	salted	store
18.	NuMade (Safeway)	43	187	20	regular	creamy	salted	store
19.	Peter Pan	40	225	21	regular	creamy	salted	name
20.	Peter Pan	35	3	22	regular	creamy	unsalted	name
21.	A & P	34	225	12	regular	creamy	salted	store
22.	Food Club	33	225	17	regular	creamy	salted	store
23.	Pathmark	31	255	9	regular	creamy	salted	store
24.	Lady Lee (Lucky Stores)	23	225	16	regular	creamy	salted	store
25.	Albertsons	23	225	17	regular	creamy	salted	store
26.	Shur Fine (Shurfine Central)	11	225	16	regular	creamy	salted	store
27.	Jif	83	162	23	regular	chunky	salted	name
28.	Skippy	83	211	21	regular	chunky	salted	name
29.	Food Club	54	195	17	regular	chunky	salted	store
30.	Kroger	49	255	14	regular	chunky	salted	store
31.	A & P	46	225	11	regular	chunky	salted	store
32.	Peter Pan	45	180	22	regular	chunky	salted	name
33.	NuMade (Safeway)	40	208	21	regular	chunky	salted	store
34.	Lady Lee (Lucky Stores)	34	225	16	regular	chunky	salted	store
35.	Albertsons	31	225	17	regular	chunky	salted	store
36.	Pathmark	29	210	9	regular	chunky	salted	store
37.	Shur Fine (Shurfine Central)	26	195	16	regular	chunky	salted	store

Fig. 1 Data from Peanut Butter Study (Lappan et al. 1998)

- The consistency should be smooth and creamy, not gritty. Also, it needs to be the "correct" thickness for spreading.

Some students indicated that personal preference or experience may influence taste. For example, if a student eats only low-fat or low-salt peanut butter at home, then that accustomed flavor will affect what he or she thinks makes a good peanut butter.

Testing the Peanut Butter

STUDENTS CARRIED OUT THEIR OWN PEANUT butter taste test with two different peanut butters that were secretly chosen by their teacher. This blind taste test used two creamy, regular, salted peanut butters: a name-brand peanut butter, Jif, selected from the list of thirty-seven brands, and a store-brand peanut butter, Food Lion, from a local

supermarket chain. For the blind taste test, the teacher removed all identifying labels from both containers; one brand was marked "K" and the other, "M." The teacher explained that these letters had little meaning for people, unlike such letters as A or B, which may suggest levels of quality. The students developed the following procedure for taste testing:

- They used one kind of cracker, like saltless saltines, and spread the peanut butters in the same way on all the crackers. Each student in the class should have one cracker for each brand. Some students in the class may not eat peanut butter; they can help record other students' reactions during the taste test.
- Students tasted both the peanut butters one right after the other so that they could make some comparison of "goodness" and "badness" immediately, but they rinsed their mouths with water between tastings. Small cups were provided, and students were encouraged to swallow the water.
- Since the students wondered whether it mattered which peanut butter was tasted first, the teacher randomly assigned half the class to taste Brand K first and half to taste Brand M first.

Graphing the Data

STUDENTS RATED EACH PEANUT BUTTER ON A scale of 1 (worst) to 10 (best) with 5 being average or mediocre. **Figure 2** contains line plots showing the ratings and the different orders of tasting. The green X indicates that the person tasted brand M first; the red X indicates that brand K was tasted first.

In examining these data, some students observed that they saw clusters of data. For Brand K, the data clustered in the interval of 6 to 8 points; for Brand M, the cluster was again 6 to 8, but the shape of the cluster suggested a greater preference for this brand. The medians for Brands K and M are 6 and 7, respectively. Students did note that not a great deal of difference was detected between the two brands, a finding that surprised them once they knew what the brands were. They also commented that it did not seem to matter which peanut butter was tasted first; the evaluations were scattered throughout for both brands.

Students spent time examining the data set of thirty-seven brands of peanut butter **(fig. 1),** identifying ways in which the data are organized and suggesting interesting questions that might be posed and answered or that cannot be answered from these data; for example:

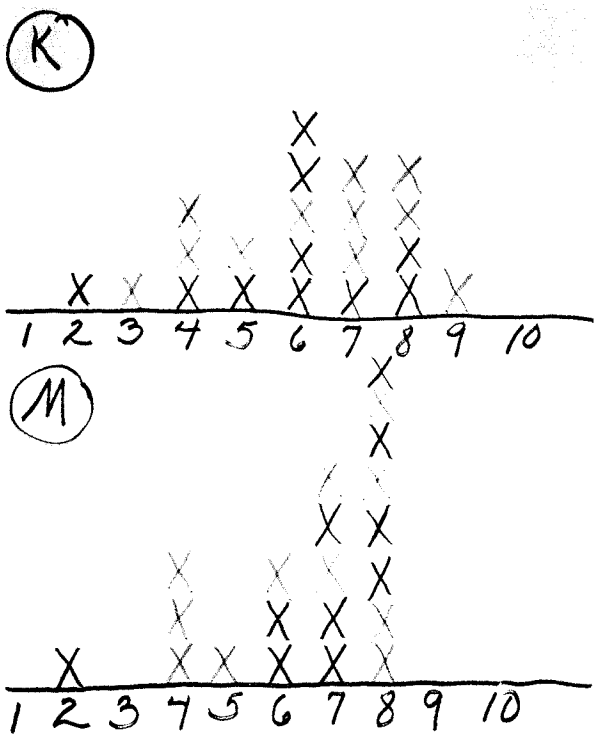

Fig. 2 Students record their data on line plots.

- "Why do they have Smuckers Natural twice? Oh, I see. One's creamy and the other's chunky."
- "Look, there's my favorite. And it does have a high quality rating!"
- "What does sodium content mean?"
- "How come they didn't put these data in some kind of order? Oh, they did. Natural and regular. So it's organized."
- "Is there a wide range of ratings among different kinds of peanut butters?"

Natural		Regular
	0	
	1	1
	2	3 3 6 9
4	3	1 1 3 4 4 5
0	4	0 0 3 5 6 9
7 7 2	5	4 4
9 9 9 7 3 0 0	6	0
1	7	6
9	8	3 3
	9	
Mean: 61.21		Mean: 42.74
Median: 61.5		Median: 40
Range: 34–89		Range: 11–83

Fig. 3 Back-to-back stem plot

- "I wonder what would happen if we looked at fat content or sugar content?"

Given these data, students can make several comparisons as they think about what might be important in identifying a good peanut butter. For example, students can compare the quality ratings of regular brands with the quality ratings of natural brands. One way to proceed with the investigation is to open up the problem to students and have them apply familiar data-analysis techniques to compare the quality ratings for natural brands and regular brands. In such discussions, students often mention finding the mean for each data set.

Sometimes, students suggest making stem-and-leaf plots, or stem plots, to compare the two data sets. The back-to-back stem plot in **figure 3** compares the quality ratings for natural and regular brands. This kind of graph is helpful because the individual data values can still be identified and the shape of the data emerges. Clusters of data can be noted and compared between the data sets; in this example, we can see a cluster with quality ratings from 50 to 70 for natural peanut butters and a cluster with quality ratings from 30 to 50 for regular peanut butters. In addition, often a few students will remember that the median and the range can also be determined.

In this eighth-grade class, after talking about determining the means, the students focused on the median and on the low and high values for each data set. As they talked, their teacher created the diagram in **figure 4** to show their thinking. He first drew the scaled number line and marked the location of the two medians when students first determined those statistics. Then, as they began to talk about the high and low values in the data, he drew lines to indicate the spread, or range, in these data. The diagram provided a good introduction to students' work with box-and-whisker plots, or box plots, that followed. Although students agreed that this number line gave them some information, they did not know where all the "bunches" of data might be, which is more evident when using stem plots. They did know that half the data were below the median and half the data were above the median.

A useful representation for comparing multiple sets of data is the box plot **(fig. 5).** Indeed, one purpose for using this problem was to introduce box plots. Following their preliminary discussions, students went on to learn how to make box plots. Although it is possible to do this activity without using calculators or computers, this class used the graphing calculator extensively, so students often did little work by hand. If they needed a "paper copy" of a set of box plots, they first made the box plots with the calculator and then, using the trace function to identify the five number summaries, made copies of the graphs on paper.

Students need to find ways to talk about the comparisons among data sets when they use box plots. As they compared natural and regular peanut butters **(fig. 6a),** two reasoning strategies emerged. Some students argued that "the whole graph [natural peanut-butter quality ratings] is higher than

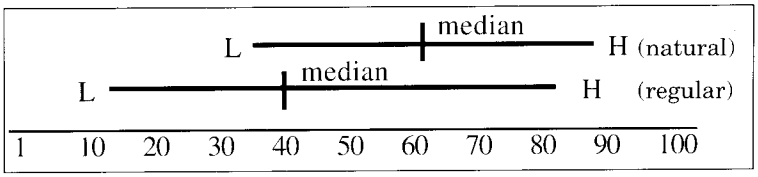

Fig. 4 Diagram to show students' thinking