What's on Your Plate? Thinking Proportionally

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The dietary guidelines illustrated on the USDA's Choose My Plate diagram can also provide healthy portions of data analysis, health education, and cultural responsiveness.

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How better to promote a healthy lifestyle than to get an entire middle school involved in analyzing dietary information? The series of activities described here was part of an interdisciplinary schoolwide effort to discuss healthy food choices.

Mathematics teachers chose to focus on students' dietary habits and, over several days, engaged more than 400 sixth-, seventh-, and eighth-grade students in exploring the U.S. Department of Agriculture's (USDA) Choose My Plate program. In contrast to Selmer, Bolyard, and Rye's 2011 *MTMS* article, our lesson emphasized proportional reasoning, although components of analyzing data were incorporated. Since using graphs as a mathematical model is discussed in the Common Core State Standards for Mathematics (CCSSI 2010), graph interpretation was integrated as an essential part of the activity. Having students construct their own graphs allowed them to investigate how graphical representations contain information that answers questions and helps them make sound and reasonable decisions. We strongly feel that ending a lesson at the point when students complete the graph is a mistake, as it deprives them of several very important components—discussion, analysis, and interpretation of data. It is critical to move students to the point at which these important questions can be asked:

- What does the food plate graph "say" to you and to others?
- Who would like to know this information?
- How could it be interpreted in a different way?
- Would a different type of graph make you think differently about the data?

We used proportional thinking and data analysis to link mathematics instruction to the USDA's 2011 dietary guidelines, illustrated by Choose My Plate. These guidelines and diagram replaced the Food Pyramid, used since 1992 (USDA 2011). The Food Pyramid, which was updated in 2005, included six food categories, each with a recommended number of daily servings. It also included an image of a person walking up the pyramid's edge to represent exercise. Conversely, Choose My Plate includes only a diagram of a plate divided into four uneven different-colored sections labeled Fruits, Grains, Vegetables, and Protein. To the side of the plate is a blue circle representing Dairy. No percentages, fractions, number of servings, or numerical values of any kind are assigned to each food group, and exercise is not represented. Essentially, the Choose My Plate illustration provides a proportional image that represents the amount of food a person should consume from each food group.

The Common Core, Essential Understandings, and Choose My Plate Activities

This activity is aligned with the Common Core State Standards for Mathematics (CCSSI 2010) for sixth grade and seventh grade. The lesson aligns with the Ratios and Proportional Relationships domain, which states that students should "use ratio language to describe a ratio relationship between two quantities," "use ratio and rate reasoning to solve real-world and mathematical problems," and "analyze proportional relationships and use them to solve real-world and mathematical problems" (CCSSI 2010, pp. 42, 47).

This activity also addresses Mathematical Practice 2: Reason abstractly and quantitatively, which states that "mathematically proficient students make sense of quantities and their relationships" (p. 6); and Mathematical Practice 4, Model with mathematics, which notes that "mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace" (p. 7).

Moreover, this activity supports the development of two essential understandings from *Developing Essential Understanding of Ratios, Proportions, and Proportional Reasoning for Teaching Mathematics: Grades 6–8* (Lobato and Ellis 2010). Specifically, it aligns with Essential Understanding 4: "Ratios are often used to make 'part-part comparisons' " and Essential Understanding 8: "A rate is a set of infinitely many equivalent ratios" (Lobato and Ellis 2010, pp. 26, 42)

OVERVIEW OF THE LESSON

The activity described incorporates a model adapted from the GAISE report (Franklin et al. 2005), which states that students should (1) formulate questions, (2) collect data, (3) analyze data, and (4) interpret results (p. 11). Many of the students who were familiar with the Food Pyramid were intrigued by the new Choose My Plate diagram and were interested in comparing their own consumption of different food groups with the suggested guidelines. We posed the following teacher-generated question to launch the activity:

> How does your weekly consumption of food compare with the new USDA guidelines on Choose My Plate?

As you will see from our discussion below, we were mindful to give students opportunities for choice and ownership throughout this activity.

COLLECTING THE DATA

Using a prepared chart (see **fig. 1**), students recorded data representing their food intake for one school week (five days). Students tallied their number of servings in each of the food categories represented on Choose My Plate. Since we did not ask them to weigh their food, the students determined what constituted a "serving" and used their own discretion to determine how many servings of a specific food they ate at any given meal. For example, if a student got a second helping of mashed potatoes, he or she would count it as two servings. As a reminder, Choose My Plate does not contain serving suggestions.

Interesting conversations occurred when the recording charts were initially distributed and as teachers led a class discussion of students' questions about food categorization. For example, when discussing where to place Pop-Tarts®, all students agreed that Grains was the best category from which to choose, but it was probably not entirely accurate. This led students to question how they should record candy, since no junk food category existed. They were resigned to the fact that such items would remain unaccounted for when investigating "healthy eating." They also realized that the likely suggested, but unstated, proportion of that food group would be zero. Subsequently, they unanimously agreed that the new dietary guidelines were inaccurate based on the conclusion that a pie chart, which the food plate resembled, is supposed to represent a whole.

We were impressed by their level of reasoning and sense making. One student wryly noted, "I think maybe the government needs some math people to work for them." Overall, this discussion allowed us the opportunity to guide the students toward two important realizations. First, the circle graph they would be creating would not necessarily represent the whole (or everything) that they consume because some items (e.g., candy) and beverages are not accounted for on Choose My Plate. Second, one cannot be certain of everything that a classmate has consumed because all items are not represented on the graph.

ANALYZING THE DATA

After recording food intake for one week, students began organizing, comparing, and analyzing their data using **activity sheet 1**, which focused on proportional reasoning. We found this sheet essential to structuring the components of the activity in that it allowed students to work at their own pace and respond to various questions using numbers, words, and charts.

Starting with number 3, students

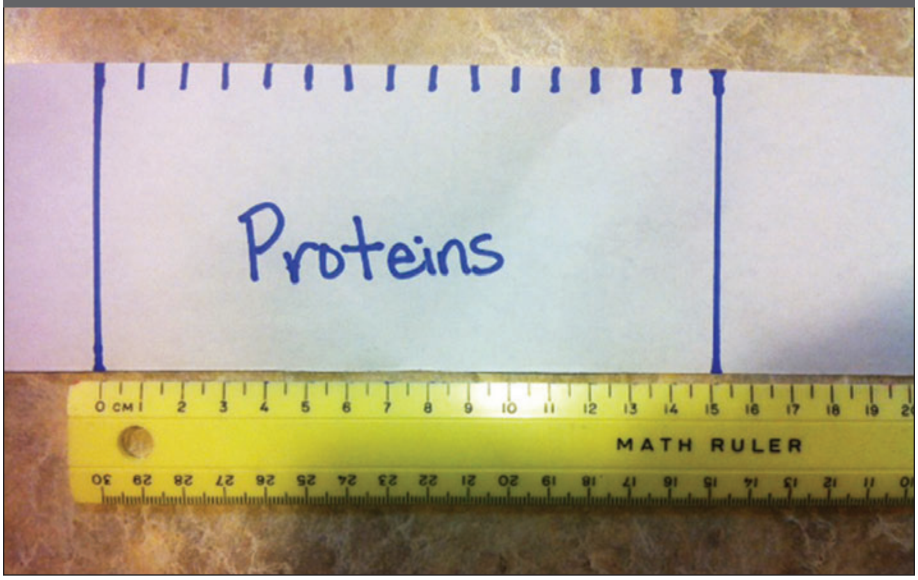
Fig. 1 Students used a food journal to tally and record data, representing their food intake for five days.

Food Journal
Tally Each Food Category for Each Day

Monday	Tuesday	Wednesday	Thursday	Friday
Vegetables _____ Fruits _____ Grains _____ Proteins _____ Dairy _____ Notes/questions:	Vegetables _____ Fruits _____ Grains _____ Proteins _____ Dairy _____ Notes/questions:	Vegetables _____ Fruits _____ Grains _____ Proteins _____ Dairy _____ Notes/questions:	Vegetables _____ Fruits _____ Grains _____ Proteins _____ Dairy _____ Notes/questions:	Vegetables _____ Fruits _____ Grains _____ Proteins _____ Dairy _____ Notes/questions:

used an approach developed by Lovitt and Clarke (1988), in which they marked a cash-register tape with their data using a scale of one inch (or one centimeter) to one serving. Some teachers required students to include all food groups on one strip, some asked students to make a separate strip for dairy, and others allowed students to choose how they wanted to represent the data. Students measured and marked their cash-register tapes to correspond to the number of servings they consumed in each food category. For example, if a student's recording sheet indicated that she ate fifteen servings of protein, she counted off fifteen centimeters on her strip and made a vertical line from the top of the tape to the bottom (see **fig. 2**). While constructing the tape representations, students instantly began comparing their proportions of food consumption in particular groups with those of their peers, noting those who ate more, less, or about the same amounts and in which categories.

Fig. 2 Fifteen cm represented fifteen servings of protein, as illustrated on cash-register tape.



For some students, the total lengths of some tapes elicited a discussion of outliers in a relevant and timely way, which, in turn, led to important analyses. Students were asked, "Does the longest tape represent the person who ate the most food?" Making an explicit effort to be sensitive to middle school students' awareness of body issues and weight, we guided the conversation so that students concluded that the number of food servings consumed in a week does not necessarily correspond with caloric intake. Since vegetables and fruits tended to have fewer calories, a healthy eater might have a longer tape but actually consume fewer calories. In addition, students noted that portion sizes were not recorded. They finally realized that comparing only the lengths, rather than including the proportions of each category of the tape, did not tell them a great deal about who was healthier.

By continually reminding students to focus on both the math and the health aspect of the data analysis,

Cash-register tape becomes a tangible tool for this activity.

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we found that students were able to connect both. For example, one eighth-grade student used ratio language and said, "My graph tells me that for every one veggie I eat, I need five more." Another eighth-grade student asked, "If they had sugars and junk foods [as a category] on the nation's food plate, what percentages would people in America have?"

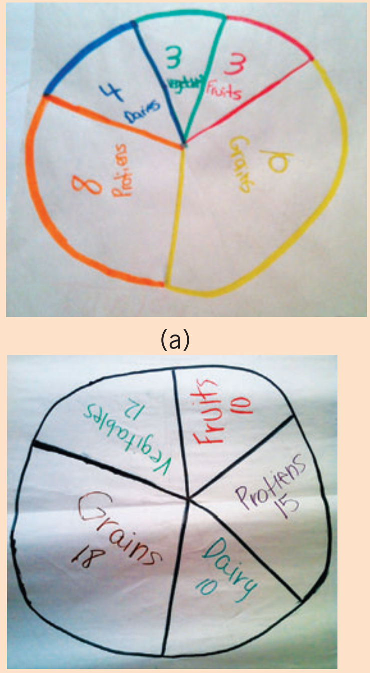
Also, we noticed a key misunderstanding. Several students took their total number from each food group and wrote it as their percentage for that food group. For example, if they had eight servings of the vegetable food group, they wrote 8 percent on their circle graph. We wrongly assumed that prompting students to separately examine the percentages when working on **activity sheet 1** would help prevent this error. Next time, it will be important to preteach this concept.

GENERATING CIRCLE GRAPHS

Students worked in pairs to construct circle graphs using their cash register tape. They connected the beginning of the strip to the end, matching (and taping) the front edge of the first food category with the last edge of the final food category, to form a circle, which was then positioned on a piece of chart paper. The students drew a circle on the chart paper and placed a marker inside the cash-register tape. They then put tick marks where they saw lines on the strip denoting changes in food groups (see **fig. 3**). Using a straightedge, students connected the tick marks on the circumference of the circle to the center of the circle. Thus, the students were able to easily construct equivalent corresponding pie pieces representing the sections on their cash-register tape. Students labeled each pie piece with the corresponding food category, and computed a percentage for each, based on the total number of servings for the whole week.

At this point, students continued to notice relationships between sections on the circle graph. Not only are the sizes of the sections representative of a student's individual proportion of consumption of different food groups (rather than what is on Choose My Plate) but, in the case of some students, dairy was also included. Five sections were on their graph, whereas Choose My Plate had only four, with dairy off to the side. **Activity sheet 2** provided questions so that students could make comparisons.

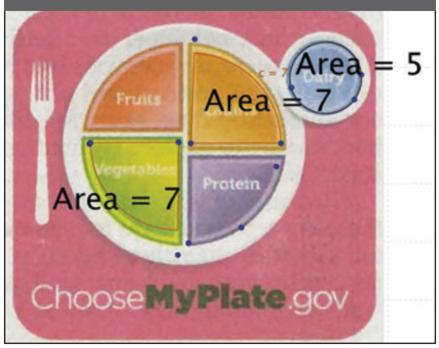
Fig. 3 Cash-register-tape pie charts were generated from students' linear representations of their data.



(a)

(b)

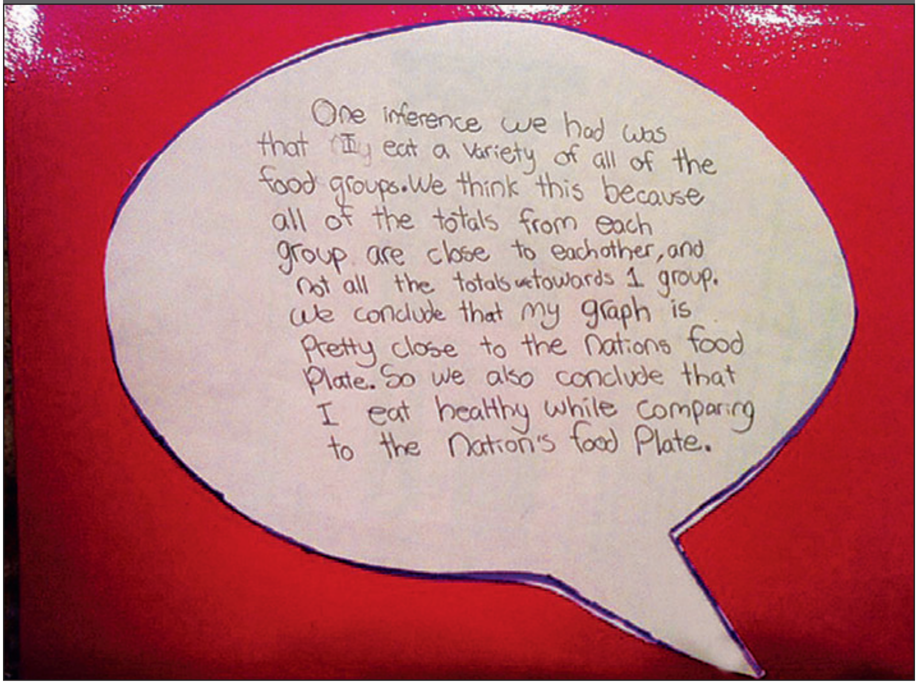
Fig. 4 A student superimposed GeoGebra shapes over the sectors of the Choose My Plate image to determine the relative areas of each sector.



INTERPRETING THE DATA

Because of the absence of numeric guidelines assigned to Choose My Plate and the uneven areas without a common central angle, eighth-grade students attempted to gain a more precise estimate by using GeoGebra (www.GeoGebra.org) to measure the area of each section. They inserted into the program a scanned image of

Fig. 5 If the pie chart could talk: How a student described what it would "say."



Choose My Plate, and then placed several circle sectors onto the image that were approximately the same size as the food category sections. They used the area function to calculate the area of each food group (see **fig. 4**).

The students noticed that Choose My Plate does not have a common vertex where the sectors come together at the center of the circle, which is different from the representation they knew. This caused them to shift how they analyzed this model that lacked a common central angle. They then divided the area of each section by the total area to obtain an estimated percentage for each food category. By using GeoGebra, students realized that Choose My Plate is not a true circle and, consequently, it was difficult to calculate the area. Meanwhile, sixth-grade and seventh-grade students interpreted the data by informally comparing individual percentages to the given estimates of the percentages represented on Choose My Plate.

Students were quick to point out the difficulties that resulted from Choose My Plate's lack of numeric notation. One student remarked, "I don't get how we know if our amounts are larger or smaller because the nation's food plate doesn't include a total." Another reflected, "I don't understand why they didn't put percentages on the graph." Sixth-grade and seventh-grade students used their estimation skills as they estimated that Choose My Plate recommended that a little bit more than 50 percent of one's food consumption should consist of vegetables and grains. By focusing on estimating skills with sixth-grade and seventh-grade students and more precise measurement using GeoGebra with eighth-grade students, we were able to differentiate this activity to fit students' needs and the appropriate mathematics standards.

To gather information about students' thinking, as suggested in CCSSM Practice 1: Make sense of problems and persevere in solving them, students were given "speech bubbles" like those in novels or comics. They were instructed to write in the bubble what the graph is "saying," as shown in **figure 5**. Students were asked to avoid comparisons that simply named the largest and smallest sections in their graphs. They were given a menu of choices centering primarily on comparing their own graphs with those of other students or to Choose My Plate.

STUDENT REFLECTIONS

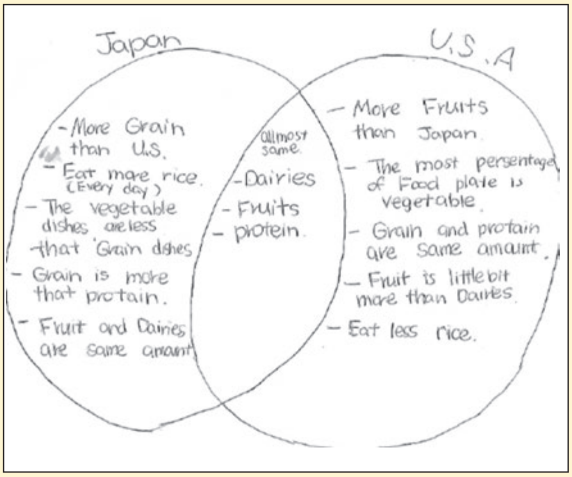
This lesson gave students an opportunity to engage in meaningful proportional reasoning in a real-life context. One eight grader remarked during class discussions how the proportional nature of the data collection made it easier to make healthy changes. She based this comment on the idea that, assuming a person eats about the same number of servings every week, he or she can easily determine about what percent of the weekly diet one serving comprises. She reasoned:

> If one serving is 2 percent, and my vegetables are 20 percent too low, then I need to eat about 10 more vegetables every week.

Other students revealed their new learning through culminating reflective writing pieces. Seventh graders' responses included these statements:

- "Surveys can be made into a chart. I noticed this when we were making our circle graphs representing the food groups we ate. I thought, 'Was this how other people make charts? By collecting their data first then making a graph?' The answer turned out to be yes."
- "Making ratios is much easier than I thought. It's just a comparison between two groups using numbers comparing how many of one group are in another group. For example, 1:2 means that for every one there is in one group there are two in the second."
- "The ratio isn't the actual number [value], it's how the numbers relate to each other."

Activity Extension: International Comparisons



Some students who required an extension compared the Choose My Plate activity to the various representations of dietary guideline graphics from Japan, China, Great Britain, Canada, Slovenia, Spain, Greece, Germany, France, Hungary, and Switzerland. These international options were obtained online by clicking on the slideshow at http://www.good.is/post/pyramids-plates-and-pagodas-dietary-guidelines-from-around-the-world/ (Good Lifestyle 2011). This extension introduced cultural connections as students examined other countries' apparent emphasis or lack of emphasis on proportional representations and the different food groups they used, such as "olive oil," and, in some cases, discussions of sugary foods.

A seventh-grade student from Japan immediately took interest in comparing the Choose My Plate guidelines to Japan's food guidelines. To compare and contrast, she organized the similarities and differences by creating a Venn diagram, which is shown above.

One eighth grader proposed an interesting future exploration while examining Greece's food pyramid. He said that he had heard his mom talk about a healthy Mediterranean diet. Since Greece's food pyramid appears to contain an element of proportionality, he said it would be interesting to use GeoGebra to estimate Greece's recommended category percentages and then compare them with the Choose My Plate percentages.

The third statement related directly to the statement in *Essential Understanding* that "a rate is a set of infinitely many equivalent ratios" (Lobato and Ellis 2010, p. 42).

Student misconceptions were also revealed. For example, one student tried to use additive thinking instead of multiplicative (a misconception detailed in Van de Walle, Karp, and Bay-Williams in press) to compare ratios:

> I learned to add to the ratio or subtract from the ratio so I could guess how many the other nation has compared to mine.

The revelation of this misconception helped the teacher target additional support for this student. Another basis for future instruction was the collection of questions that students wrote at the conclusion of the activity:

- "Are ratios and dividing the same thing?"
- "Can ratios be simplified?"
- "Can ratios be a decimal?"
- "Is rounding to get ratios the same as estimating? What's the difference?"
- "What do ratios tell us?"

CONCLUDING REMARKS

This activity motivated and engaged students in thinking about proportional reasoning while meeting the needs of an interdisciplinary healthy lifestyle unit planned by the school. Students who took part in this activity were able to explore their own individual eating habits, which created a sense of curiosity and ownership. They gladly kept track of their food intake for a week, anticipating the comparison of their data with Choose My Plate, their peers, and even the dietary guidelines of other countries.

Many students were engrossed in learning about the food graphics of other countries (see the extension **sidebar**), which added other dimensions to this activity. An added benefit was students' newfound cultural awareness about the differences in dietary guidelines and eating habits of various countries. Throughout the activity, students continually reasoned about their own food group proportions, carried out problem solving based on data, learned new aspects of data analysis, and engaged in meaningful tasks.

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activity sheet 1

Name ______________________________

ORGANIZING DATA FROM THE FOOD JOURNAL

1. From your food journal, determine your five-day total for each category below:

Vegetables __________

Fruits __________

Grains __________

Proteins __________

Dairy __________

2. Record your grand total from question 1 and write it here. ________

3. Cut a piece of cash-register tape as many centimeters long as the total foods you have from question 2. For example, if you had a grand total of 42 foods, cut a piece of cash-register tape 42 cm long.

4. Divide your cash-register tape into sections on the basis of your answers from question 1. For example, if you had 12 servings of vegetables, the first section on your cash-register tape would be 12 cm long.

5. Once the five sections are made, form your cash-register tape into a loop and use transparent tape to attach the ends.

6. Place your tape loop on a sheet of chart paper and trace the inside of the circle.

7. Use your pencil to mark your five sections representing the five food categories on your chart paper.

8. Use a ruler or meterstick to plot a point in the center of the circle, and then finish the circle graph by drawing radii from the marked sections to the center of the circle. Use your pencil to label each section of your “Food Plate” on the circle graph using the five food categories.

9. Calculate the percentage of each of your five categories. List the percentages here.

Vegetables __________

Fruits __________

Grains __________

Proteins __________

Dairy __________

activity sheet 2

Name ______________________________

CHOOSE MY PLATE'S SIMILARITIES AND DIFFERENCES

Make some comparisons between *your* food plate and Choose My Plate.

1. Compare *your* food plate with Choose My Plate. What do you notice?

If Mr. Clayton has a fruit section that is twice as large as the fruit section in Choose My Plate, the ratio is 2:1, meaning that for every 2 fruits Mr. Clayton eats, Choose My Plate recommends eating 1 fruit.

2. Take a minute to compare ***your* food plate** with **Choose My Plate**. Try to estimate the following ratios:

Your food plate's vegetables: Choose My Plate's vegetables __________

Your food plate's dairy: Choose My Plate's vegetables __________

Your food plate's proteins: Choose My Plate's nonproteins __________

Your food plate's dairy: Choose My Plate's total __________

Choose My Plate's fruits: *Your* food plate's fruits __________

Your food plate's total: *Your* food plate's grains __________

3. Use the answers from question 9 on **activity sheet 1** to complete the following. (Hint: you may have to estimate.)

- For every 5 fruits on *your* food plate, Choose My Plate would have ________ fruits.
- For every 100 vegetables on *your* food plate, Choose My Plate would have ________ vegetables.
- For every 2 grains on Choose My Plate, *your* food plate would have _________ grains.