“Can I take these activities home to share? No one will believe it!”

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Introduction

While teaching proportional reasoning to my grade eight and nine mathematics students, I have enjoyed using real-world problems. Not only did the students learn about proportional reasoning as an important underlying mathematical structure, but they also began a journey where they saw proportional reasoning's connection to other subject areas. In this paper, students learned about the food safety standards of the United States; comparing these standards with Canadian standards was suggested as an extension activity. Students' initial (mis)understandings are documented in a preliminary activity before further activities are shared with the reader. Activities that were intrinsically motivating and – as the title implies – most students found that the problems were "gross!"

Background to Activities

The Third International Mathematics and Science Study (TIMSS) results of American high school seniors were described by Bruce Alberts (1998), President of the National Academy of Sciences, as "profoundly disappointing" (p.1)? Alberts added that on the TIMSS results 68% of U.S. students solved the following proportional reasoning problem correctly, compared with the international average of 71%.

> If there are 300 calories in 100 grams of a certain food, how many calories are there in a 30-gram portion of that food? (p.4)

Alberts stated that "It's no wonder that our nation's employers are so dissatisfied" (p.2) and that we need to respond to this crisis if we expect to "remain the leading nation in the world in the 21st century" (p.4).

The U. S. Food and Drug Administration/Center for Food Safety and Applied Nutrition (FDA 2005) established maximum levels of natural or unavoidable defects in foods for human use that present no health hazard. These are called 'Food Defect Action Levels.' "The FDA set these action levels because it is economically impractical to grow, harvest, or process raw products that are totally free of non-hazardous, naturally occurring, unavoidable defects" (p.1).

The FDA (2006) states that filth in food "includes contaminants such as rat, mouse, and other animal hairs and excreta, whole insects, insect parts and excreta, parasitic worms, pollution from the excrement of humans and animals, as well as other extraneous materials which, because of their repulsiveness, would not knowingly be eaten or used" (p.1). If one is feeling a little squeamish, you can feel a little better knowing that live infestation of a food product is frowned upon. ☺ The preliminary activity that follows prepares the students for the subsequent two activities.

Preliminary Activity - Purchasing a 'Pure' Chocolate Bar

You have just bought a 'pure' chocolate bar. The FDA (2005) considers chocolate unacceptable if any 100-gram sample contains 90 or more insect fragments or 3 or more

rodent hairs. That is, if the chocolate bar contains 89 or fewer insect fragments or 2 or fewer rodent hairs the chocolate bar is okay!

The students were asked to fill in the following table for this activity [the answers in brackets are not supplied]. I leave the first row blank to allow for class discussion of unit rate and the last row blank for the students to investigate a 'pure' chocolate bar of their choice.

'Pure' Chocolate Bar (gm)	Unacceptable if number of insect fragments is greater than or equal to	Unacceptable if number of rodent hairs is greater than or equal to	The largest number of insect fragments acceptable	The largest number of rodent hairs acceptable
1	[1]	[1]	[0]	[0]
45	[41]	[2]	[40]	[1]
50	45	[2]	[44]	[1]
100	90	3	89	2
200	[180]	6	[179]	[5]
300	[270]	[9]	[269]	[8]
310	[279]	[10]	[278]	[9]
1000	[900]	[30]	[899]	[29]
Student Bar				

These examples of three students' work indicate how a student might theorize how to solve the problems.

Student One: "I just × by 2 going down. I just ÷ by 2 by going up."

The student described their single-step vertical solution strategy to fill in the first column while not considering the existence of pattern breakers 45 and 310. It appears that the student used a comparable vertical solution strategy with a combination of multiplying and dividing by 2 and 3 for the remaining columns.

'Pure' Chocolate Bar (gm)	Unacceptable if number of insect fragments is greater than or equal to	Unacceptable if number of rodent hairs is greater than or equal to	The largest number of insect fragments acceptable	The largest number of rodent hairs acceptable
1	11.25	0.3	3.28	0.06
45	22.5	0.6	9.86	0.2
50	45	2	29.6	0.6
100	90	3	89	2
200	180	6	267	6
300	360	9	801	18
310	720	27	2403	54
1000	1440	81	7209	162
Student Bar				

Student Two: "I just added & subtracted 45, 3, 1 and 1."

This student's answers are found in the brackets below. In the first two columns, it appears that the student vertical solution strategy was to add and subtract 45 and three respectively. This student also did not consider the pattern breakers 45 and 310. How 0.45, 0.3, and 0.9 were obtained in the first two columns remains a mystery. When asked, the student did not know either! In the last two columns 0.44, 0.8, and 0.2 were calculation errors and 0.0 appears because the student was aware that you cannot have a negative value when calculating the number of fragments and hairs allowed.

Another objective of this activity was to have students recognize a horizontal solution strategy: The last two columns can be filled in by subtracting one from the previous respective column rather than by applying their strategy from the first two columns again on the last two columns. There are calculation mistakes, but this horizontal strategy is what the student meant in their quote above regarding the 1's.

'Pure' Chocolate Bar (gm)	Unacceptable if number of insect fragments is greater than or equal to	Unacceptable if number of rodent hairs is greater than or equal to	The largest number of insect fragments acceptable	The largest number of rodent hairs acceptable
1	0.45	0.9	0.44	0.8
45	0	0.3	0.0	0.2
50	45	0	44	0.0
100	90	3	89	2
200	135	6	134	5
300	180	9	179	8
310	225	12	224	11
1000	270	15	269	14
Student Bar				

Student Three: "The whay [*sic*] I figured it out was divied [*sic*] the number by 100 then the number you get multiply by the pure chocolate number."

This student's answers using a unit-rate [for example 0.9] vertical solution strategy are in the table below. Like the first student, this student was unaware of the horizontal strategy for filling in the last two columns in the table and like all the others did not recognize the whole number constraint on the answers.

'Pure' Chocolate Bar (gm)	Unacceptable if number of insect fragments is greater than or equal to	Unacceptable if number of rodent hairs is greater than or equal to	The largest number of insect fragments acceptable	The largest number of rodent hairs acceptable
1	0.9	0.03	0.89	0.02
45	40.5	1.35	40.05	0.9
50	45	1.5	44.5	1
100	90	3	89	2
200	180	6	178	4
300	270	9	267	6
310	279	9.3	275.9	6.2
1000	900	30	890	20

Student Bar				

This is not an exhaustive list of strategies that students might use to solve this problem. However, it is important to acknowledge the strategies students use to solve such problems to see if they are capable of applying proportional reasoning strategies. Levin (2002) states "We must not only teach these strategies to our students but also reinforce the underlying meaning of the proportional reasoning in the situation" (p.144). In order to accomplish this, I have the students fill in the table for this preliminary activity with me. It is important that they justify that this is a proportional reasoning situation by openly stating, for example, that "the number of grams of 'pure' chocolate in the bar is being compared to the smallest number of insect fragments not allowed for that amount." We then discuss the strategies they used, the constraints on the problem, and the reasoning that will be involved to fill in the table.

Activity 1 - Making a Pizza

You have decided to make a pizza. The FDA (2005) considers pizza sauce unacceptable if any 100-gram sample contains 15 or more fly eggs or 1 or more maggots. With this in mind, fill in the remainder of the table below:

Pizza sauce (gm)	Unacceptable if number of fly eggs fragments is greater than or equal to	Unacceptable if number of maggots fragments is greater than or equal to	The largest number of fly eggs acceptable	The largest number of maggots acceptable
1				
20				
55				
100	15	1		
200				
300				
430				
1000				

After I am convinced that the students understand how to do the preliminary activity, I trust the students to fill in the above table on their own. It is still important that students explain why it is a proportional reasoning situation by describing what they are comparing and how they arrived at their answers.

Activity 2 - Purchasing Golden Raisins

You have just bought some golden raisins. The FDA (2005) considers golden raisins unacceptable if there are 10 or more whole or equivalent insects or 35 Drosophila eggs per 8-ounce cup of golden raisins. By a whole or equivalent insect the FDA (2005) means "a whole insect, separate head, or body portions with head attached" (p.6) implying again a whole number constraint.

It is still important that students explain why it is a proportional reasoning situation by describing what they are comparing and how they arrived at their answers. It is important to note that the number of samples is usually randomly selected from a lot and then examined to see if the food defect action levels are satisfied. With this in mind, fill in the remainder of the table below and answer the questions following:

Golden raisins (oz)	Unacceptable if number of whole or equivalent insects is greater than or equal to	Unacceptable if number of whole or equivalent Drosophila* is greater than or equal to * Fruit fly	The largest number of whole or equivalent insects acceptable	The largest number of Drosophila* eggs acceptable * Fruit fly
1				
4				
5				
8				
16				
44				
50				
66				
100				

- Why does the FDA consider "whole" insects when considering raisins but not when they considered chocolate in the first example?
- Is it possible that there might be more filth than is allowed when you make a purchase? Explain your response.
- Should manufacturers just try to stay below the defect action level for their product?

Extension Activity

Students are asked to look at the information contained in the Health Protection Branch Guidelines for the General Cleanliness of Food an Overview Health Canada (1999) and compare and contrast these guidelines set out by Health Canada with U.S. regulations.

This activity has added significance since the implementation of the North American Free Trade Agreement which began on January 1, 1994 and removed many barriers to trade and investment between the United States and Canada. As of January 1st, 1998, “virtually all tariffs on Canada - U.S. trade in originating goods were eliminated. Some tariffs remain in place for certain products in Canada's supply-managed sectors (e.g. eggs, dairy and poultry products). In the U.S., tariffs remain in place for certain products such as sugar, dairy, peanut and cotton." (Foreign Affairs and International Trade Canada, 2007, p. 2).

Final Thoughts

The activities presented here are restricted in that they do not consider the pesticide residue in foods grown organically and conventionally. "It is FDA's position that pesticides are not the alternative to preventing food defects. The use of chemical substances to control insects, rodents and other natural contaminants has little, if any impact on natural and unavoidable defects in foods. The primary use of pesticides in the field is to protect food plants from being ravaged by destructive plant pests (leaf feeders, stem borers, etc.). A secondary use of pesticides is for cosmetic purposes--to prevent some food products from becoming so severely damaged by pests that it becomes unfit to eat" (FDA, 2005, p. 2).

It is important to ensure that students understand how to solve proportional reasoning problems before a formal algebraic approach is taught (Kaput and West 1994). Also of importance is that teachers are aware of such problems and become creative in applying them in the classroom to further reinforce the value of proportional reasoning. The situations described in these proportional reasoning activities are admittedly a little grotesque, but they are still a food issue that is of concern to everyone. Today an extension activity across different subject areas investigating Chinese food safety standards might be of interest.

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