Constraints with Food Bank Operations – J. Warfel

Purpose
This activity teaches students to model systems as an industrial engineer might by important quantities in the system and stating (algebraically and verbally) the relationships between those quantities that are crucial for the system to work properly.

Overview
In this activity, students learn about the way that refrigerated and frozen foods are stored at a food bank through a lecture. They then model the food storage system using algebra, and they learn about *constraints*, algebraic statements that must be true in order for a system to function properly. In the homework, they learn about other systems which can be modeled algebraically. The final exercise is to describe a system they have observed in the world, describe it algebraically, then formulate constraints for it.

Student Outcomes
Students will be able to describe the quantities in a system algebraically.
Students will be able to formulate constraints (algebraic statements that describe how quantities in a system must be related in order for the system to work properly).

Associated standards:
Common Core A-SSE-1 (Interpret expressions that represent a quantity in terms of its context); A-CED-2 (Create equations in two or more variables to represent relationships between quantities); and A-CED-3 (Represent constraints by equations or inequalities); also addresses Common Core standards for High School – Modeling.
Illinois Learning Standards for Mathematics: Goals 8.A.4b, 8.B.4a, 8.D.4
Texas Math TEKS: Algebra I 1.D, 3.A; Math Models 1.B

Time
If used as an extension to a lesson about modeling real-world systems with algebra (such as *Translating between verbal and algebraic expressions for the Retail Donation Program (RDP)*), this lesson should take only one 50-minute class period. Otherwise, it may take 1.5 or 2 class periods. You may also want to use a class period to discuss the homework, when students could present the systems they modeled and the constraints they derived for those systems.

Level
This lesson is appropriate for Algebra I or any higher math course. It is especially relevant to a course in mathematical modeling, applied math, or engineering.

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Materials and Tools

Constraints Handout (during lecture)
Constraints Homework
Any materials that you want the students to use to present the systems they have modeled (poster paper and markers, PowerPoint, etc.)

Preparation

No special preparation is required.

Prerequisites

The activity *Translating between verbal and algebraic expressions for the Retail Donation Program (RDP)* is thematically and conceptually relevant to this lesson, but it is not required as long as the students have sufficient experience with variables and algebraic statements (including inequalities).

Background

In this activity, we study how we can make algebraic statements about systems in the world that must be true in order for the system to function correctly. These statements are called "constraints." Understanding the constraints of a system is an important step in being able to participate in or control the system effectively.

We begin by studying a food storage system at a food bank. In this system, the constraints must be followed for foods to be held at safe temperatures. Then, in the homework, we consider a variety of other real-world systems that you may have interacted with.

Teaching Notes

The handout should be completed by the students in class. First, describe the system with the diagram, then have the students write the definition of each variable and label the diagram. If you feel your students may not be familiar with pallets, emphasize the meaning of this term. There is considerable parallelism in the system; you should only have to define the first four variables, they should be able to figure out the rest on their own.

The next section of the handout has four statements which may or may not be constraints. Work through at least the first two with the class, modeling the process of first converting the algebraic statement to words, then thinking about whether that statement must be true in order for the system to work correctly. It may be helpful to provide concrete examples with numbers, i.e., "If there are 60 pallets in the cooler at the beginning of the day and the cooler has a capacity of 40, does that make sense?" Ideally, the students will be able to complete the third and fourth problems on their own, but if not, go through these with the class as well.

The remainder of the handout should be completed independently or in groups.

In the homework, students study three other systems related to agriculture, service science, and transportation[1]. A significant difference from the handout is that students are expected to draw a picture of the system being modeled. This is an important step – this is usually one of the first things that professional mathematicians do when creating a model.

[1] This lesson was written for use in Illinois, so some of the systems in the homework may be unfamiliar to your students, and should be discussed before the homework is assigned. Alternatively, you can modify the potentially confusing question.

For the last question of the homework, students are assigned to choose a system in the world, model it with variables, and find constraints (as well as algebraic statements that are not constraints). The answers to this question could be presented during the class and used as the basis for a discussion about the wide variety of applications for mathematical modeling, and relevance of mathematics to the real world.

Assessment

The handout and homework can be graded, as well as the presentations of models (if applicable).

Additional Information

Description of the constraints of a system is usually only a first step in creating an optimization problem which, when solved, provides instructions for controlling the system to achieve some goal. A lesson about the formulation and solution of optimization problems in the context of nutrition (*Optimize Me!*) is available from Reach for the Stars: http://gk12.ciera.northwestern.edu/classroom/lessonplans.html

I would like to improve this lesson plan. If you use it, or it inspires to create a similar lesson, please contact me to let me know about your experience: joseph.warfel@u.northwestern.edu