



TeachEngineering

STEM Curriculum for K-12

Using Data to Manage Your Vending Machine



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Part I: Using a Vending Machine to Raise Money

Lots of teams, groups and clubs need to raise money to attend regional competitions: Band, choir, rocketry, sports, you name it! They need funds to pay for all sorts of things, like:

- Registration
- Food
- Transportation
- Hotels
- Uniforms/t-shirts

You are part of the FIRST robotics team at your school and your team needs to raise \$10,000 to attend this year's regional competition. To help you meet your goal, your coach has purchased a vending machine for the team. Your school principal has agreed to let the team operate the vending machine on school grounds and keep all of the money it makes to go towards fundraising. You will have 6 months to operate the vending machine.

About Your Vending Machine



This is your vending machine!



These panels slide out, and are made up of slots



There are ten total slots that each hold 30 beverages

Each slot correlates with a button on the front of the machine



Your Criteria and Constraints

Your team has complete control over the vending machine, including what to stock it with and how much to charge. There are some criteria and constraints to work around:

Criteria: The vending machine needs to sell popular drinks to help your team earn as much money as possible in 6 months. The vending machine is restocked twice a month.

Constraints:

- Only standard-size 12-oz. cans, 20 oz. plastic bottles, and single-serve milk cartons will fit in the machine. (Note: In real life, most vending machines can only sell one type of container).
- Due to federal nutritional guidelines, sodas must be sugar-free. Non-carbonated juice and milk are also allowed.
- There are 10 slots to stock. Each one can hold 15 8 oz. milk cartons, 12 12 oz. cans, or 6 20 oz. bottles.

Discuss: What other criteria/constraints do you see?

What is Optimizing and How is It Used?

Optimizing means to make the best or most effective use of a situation, opportunity, or resource.

Many different types of engineers use optimizing every day!

Agricultural Engineers	Aerospace Engineers	Packaging Engineers
Optimizing feed so animals have the right amount of food to eat	Optimizing payloads so planes and rockets can fly	Optimizing packaging so that it's easy to transport while minimizing waste
Optimizing irrigation systems so crops stay hydrated without wasting water	Optimizing designs to fly safely without wasting fuel or labor hours	Optimizing packages to perform well for purposes like storage, shipping, and protection

Examples of Optimizing in Engineering

Toyota

Identified bottlenecks to reduce waste by collecting data throughout manufacturing process – not just at the end.

Data helped them to better plan for busy/slow times, helping them save money – “Just in Time” system is now used by many companies.

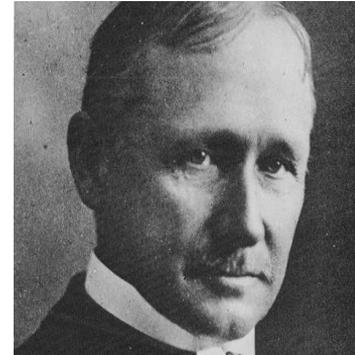
“Toyota Production System” regarded as a great example of industrial optimization.

Frederick Taylor, 1856-1915

Famous for studying the results of his established processes – didn’t stop working on making them more efficient.

Observed workers in a steel mill to optimize shovels, increasing average worker output from 16 to 59 tons per day

Methods frowned upon today – treated workers like machines rather than people.



Using Optimization in Your Vending Machine

- Engineers consider different factors when optimizing: they collect data, then use that data to make things more efficient – helping their companies save and earn more money. This helps to keep prices low for consumers like us!
- In this case, you need to optimize the vending machine space to maximize profit.

What factors could you consider when optimizing your vending machine?

What costs more? What could you sell for more? Where will you store extra drinks?

How can you collect data on what drinks are selling best?

What are Trade-Offs?

Wikipedia defines trade-offs:

A **trade-off** (or **tradeoff**) is a situational decision that involves diminishing or losing one quality, quantity, or property of a set or design in return for gains in other aspects. In simple terms, a tradeoff is where one thing increases, and another must decrease.

You'll need to make trade-offs when deciding how to stock your vending machine. For instance:

- One drink may be more popular but have a shorter shelf life.
- Another drink may also be popular, but due to its size you can't fit many in the machine.

You'll need to weigh these competing considerations in order to make your machine profitable.

Activity #1

Work with your teacher to create a survey to deliver to students outside of your class. Surveying real students will give you hard data on which drinks (that fit within the given constraints) will likely sell the best at your school. You need to identify the **ten most popular drinks**.

Your survey should:

- Give students a wide range of choices – more than 10
- Be simple for students to complete
- Be delivered however your teacher decides is best for your school

*Remember, you need to **earn the most money given the space available** in your vending machine, so only include the drinks most likely to sell well.*

Example Survey

Our class is doing a survey on the most popular drinks to stock a new vending machine with. Please circle any of the following drinks you'd like to purchase:

- Diet Coke
- Diet Sprite
- Diet root beer
- Diet orange soda
- Lemonade
- Fruit punch
- Milk
- Iced tea
- Diet Mountain Dew
- La Croix

You can deliver your survey...

-**On paper** (that respondents will submit to you)

-**Via a checklist** (you can ask the question aloud and record respondent answers)

-Via online methods like **Google forms**

Tally up the results to identify the 10 most popular drinks!

Part II: Maximizing Performance by Using Data

Problem #1: You've stocked your vending machine and it has been selling drinks to students for a whole month. You put the most popular drink in slot #1, the second most popular in slot #2, and so on.

The team has been restocking drinks as needed and keeping an eye on performance. However, your coach informs the team that the drinks in the #3 and #5 slots aren't selling well.

Brainstorm: Why aren't these drinks selling as well as the others?

Part II: Maximizing Performance by Using Data

Answer: Not all of the students who filled out the survey have the money to use the vending machine regularly. That means that while those drinks are popular, they're not popular among your real customer group.

How could you redesign the survey in the future to avoid this problem?

Part II: Maximizing Performance by Using Data

Problem #2: The school principal is concerned that some of the drink choices aren't the healthiest or most sustainable.

Take a look at the Popular Drink Information Chart on nutrition and sustainability.

As you rework which drinks to include in your vending machine, factor in the trade-offs you'll need to make to achieve profitability while also reducing waste and giving students healthy options.

Activity #2: Final Assessment

Write a Letter to Your Principal

Write a 1-page letter to your principal that answers the following questions:

- Explain how you would do the survey differently in the future to achieve more useful results
- Explain how you would improve slow sales in slots #3 and #5
- Decide on, and defend, the trade-offs you made to balance sustainability and health considerations while maximizing profits.

Your paper should be double spaced, 12 pt. Times New Roman font.

References

1. The Mag. “Frederick Winslow Taylor, the Patron Saint of the Shovel.” Mental Floss, April 27, 2015. <https://www.mentalfloss.com/article/63341/frederick-winslow-taylor-patron-saint-shovel>.
2. Corporation., T. M. (0AD). *Toyota Production System: Vision & Philosophy: Company*. Toyota Motor Corporation Official Global Website. <https://global.toyota/en/company/vision-and-philosophy/production-system/>.