



Connecting Industry to Mathematics Instruction

NSF ATE Award # 1954291

Sustainability - Teacher Notes

A Practice Understanding Task

Purpose: In this activity, students will examine how environmental engineers use matrices and regression modeling to manage the cost of waste disposal at their manufacturing facility.

Students will also look at forecasts for future waste production to examine expenditures associated with disposal as well as impact on environmental certifications.

Career Field: Environmental Engineering, Grifols Therapeutics LLC

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NC Math 4 Standards:

NC.M4.AF.1 Apply properties of function composition to build new functions from existing functions.

NC.M4.AF.1.2 Execute a procedure to determine the value of a composite function at a given value when the functions are in algebraic, graphical, or tabular representations.

NC.M4.N.2 Apply properties and operations with matrices and vectors.

NC.M4.N.2.1 Execute procedures of addition, subtraction, multiplication, and scalar multiplication on matrices

NC.M4.AF.5 Understand how to model functions with regression.

NC.M4.AF.5.1 Construct regression models of linear, quadratic, exponential, logarithmic, & sinusoidal functions of bivariate data using technology to model data and solve problems.

Unit Alignment:

Indicate where this lesson would be used in the course

NC Math 4 - Unit (Matrices / Quad & Exp Regressions)

WTCC Math 121

WTCC Math 110

In partnership with



**WAKE COUNTY
PUBLIC SCHOOL SYSTEM**



Common Core State Standards for Mathematical Practice

Indicate which of the standards are highlighted in this lesson

- 1. Make sense of problems and persevere in solving them.**
- 2. Reason abstractly and quantitatively.**
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
- 5. Use appropriate tools strategically.**
- 6. Attend to precision.**
- 7. Look for and make use of structure.**
8. Look for and express regularity in repeated reasoning.

Prerequisite Skills

List any prerequisite skills that may need to be addressed in a warm-up

- Create and evaluate linear functions and direct variation relationships
- Matrix operations (can be excluded and activity done with Excel)
- Regression modeling with Quadratics and Exponentials

Time Required

The time required to complete this activity is approximately 100-120 minutes.

Part 1 and Part 2 can be completed independently of one another. A suggested strategy is to start Part 1 for the last half of a class day, then complete Part 2 in the next class day. This gives students the opportunity to reflect on their work, making the task more meaningful and long-lasting.

Materials Needed

- Students Activity Sheet
- Spreadsheet technology and/or technology capable of operating with matrices

Vocabulary

- Waste stream - source of waste from a company, for example office waste, byproducts for the manufacturing process, trash, etc.
- Waste-to-energy - materials are sent to an incinerator to generate electricity
- Waste to be treated and recycled - the disposal of medical waste is tightly regulated, and since products are being made from human blood plasma, any materials that have come in contact with the plasma must be treated/decontaminated as part of the recycling process.

The Teaching Cycle:

Launch: Ask students to consider what happens to the trash when it is picked up from their homes. Think about the amount of trash your household generates in a week. Take a guess at how much trash is generated by a manufacturing company in a week. Ask what they think happens to that company's trash when it is picked up.

Show the Launch video {title}.

Invite questions about ideas or terms encountered in the video/in the introductory paragraphs of the Student Activity sheet. Be clear that these are not the only waste products from the site - thinking back to the introductory question - they're just the ones we are focused on. 2021 data shows that 17.6% of the total waste generated by Grifols consists of plasma donation byproducts at this manufacturing plant.

{{Script a Desmos activity for entering information into a matrix and perform operations on that matrix - optional if teachers use Excel for this task}}

Explore1: Grifols is considering the costs associated with contracts for disposal of medical waste. Students will engage with questions to examine these potential contracts in search of a cost-effective solution. Students may need some guidance that changing companies for the collection of shredded bottles does not address the collection of medical waste waste-to-energy materials or recyclable materials.

- Students may ask about the dramatic change in overall costs should the company change to selling the plastic bottles as opposed to being charged for removal.
- Students may ask if Clayton Waste Transport would also take over both waste-to-energy and removal of waste to be recycled. They will, at the designated price, but both categories will then be sent to waste-to-energy incineration.
- Students may need clarification about the different contract options. Grifols may (1) keep their existing contract with ProSan Solutions; (2) send shredded bottles to MedCycle and medical waste to ProSan Solutions (with expected price increase) ; or (3) send shredded bottles to MedCycle and medical waste to Clayton Waste Transport. It may be worth discussing with students why ProSan Solutions current contract prices are not a reasonable solution if shredded bottles go to MedCycle.

Discuss1: Students share their reasoning and conclusions. Recommendations should be supported with calculations. Students should notice a dramatic change in overall costs when Grifols changes to the company paying for the shredded bottles. This is a good opportunity to examine why the change is so drastic. The shredded bottles comprise a huge portion of the waste under consideration, and the expenditure of \$0.04/pound is being exchanged for a \$0.22/pound income, so a large decrease in net costs is expected. Students may need some clarification of how products will be handled under the new plan.

- If Grifols changes to MedCycle for disposal of shredded plastic bottles, ProSan would continue with Waste-to-Energy and Medical Recycling, but BOTH categories would see an increase in cost of \$0.22 per pound. The takeaway for students is to determine whether the change will save money or cost money.
- Clayton Waste Transport will dispose of all medical waste, but it does not have the capacity to recycle - all medical waste goes to Waste-to-Energy. While this does not impact the question of cost, it brings up the concern for their Zero-Waste-to-Landfill certification, a matter of importance to the company.

Discussion questions are intended to be an extension of material and help facilitate “what if” mathematical modeling thinking. These questions can provide some differentiation for groups who work through Part 1 at a faster pace.

Students should conclude that changing to ProSan is the best financial decision at this time.

**** This activity was built in July 2021, when industry shortages influenced by Covid-19 pandemic greatly impacted business operations and decisions****

Explore2: Grifols is invested in maintaining their [Zero-Waste-to-Landfill Certification](#) from Underwriters Laboratories. Students will engage with Part 2 questions to examine the proportion of waste-to-energy products to the overall volume of waste generated based on company contracts discussed in Part 1 and forecast future proportions based on projected production.

- Students may need some guidance on deciphering the amounts of each type of waste. 8.5% of all waste is discarded using waste-to-energy incineration - in 2021, 5% is Medical Waste (625,000) and 3.5% of other facility waste streams is incinerated.
- Students should notice that with either ProSan Solutions or Clayton Waste Transport, medical waste materials sent for waste-to-energy incineration will eventually exceed the 10% allowance.

Discuss2: Students will share their reasoning and strategy for determining waste-to-energy proportion and forecasting, including determining the models that best describe the plasma donation waste growth.

While changing to ProSan will save money in the immediate future, eventually, Grifols could jeopardize their Zero-Waste-to-Landfill Certification. In this event, the company will have to find a new arrangement for disposing of medical waste. This leaves a number of unknown factors, which could theoretically cost more money than was saved by changing companies.

Exit Ticket: Grifols has recently switched to compostable plates and utensils in the company cafeteria. These items will degrade naturally, creating no new material for the local landfill. What other steps do you imagine could be taken to reduce the amount of waste generated by Grifols?

** This activity could be extended into a larger project and {Grifols} invited in to talk with students about their results. Have students explore a factor of choice and research how that factor would influence different questions asked in this activity and change their solutions (mathematical modeling - what if XX changes) **

Student Activity Sheet

{{Copy and paste}}