CodeR4MATH: Become Power Modelers via Intuitive Coding with R

Presentation · April 2019

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CodeR4MATH

Become Power Modelers via Intuitive Coding with R

https://concord.org/coder4math/nctm-2019

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Overview

- Introduction & Background
- R Quick Tour
- Modeling Activity: Driving for Gas
- Pilot study results
- Explore More Activities
- Questions & Feedback

Computing with R for Mathematical Modeling (CodeR4MATH)

Integrating ***computational thinking*** into high school mathematics classroom through ***mathematical modeling*** and ***intuitive coding with R***

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Team

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Principal Investigator

Learning scientist at the Concord Consortium. Expert on foundational research in computational thinking and theory-based instructional design.

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Benjamin Galluzzo

Co-Principal Investigator

Associate Professor at the Clarkson University. Head Judge for the SIAM/Math Modeling Challenge. MAA Henry L. Alder award winner for distinguished teaching.

Eric Simoneau

Co-Principal Investigator

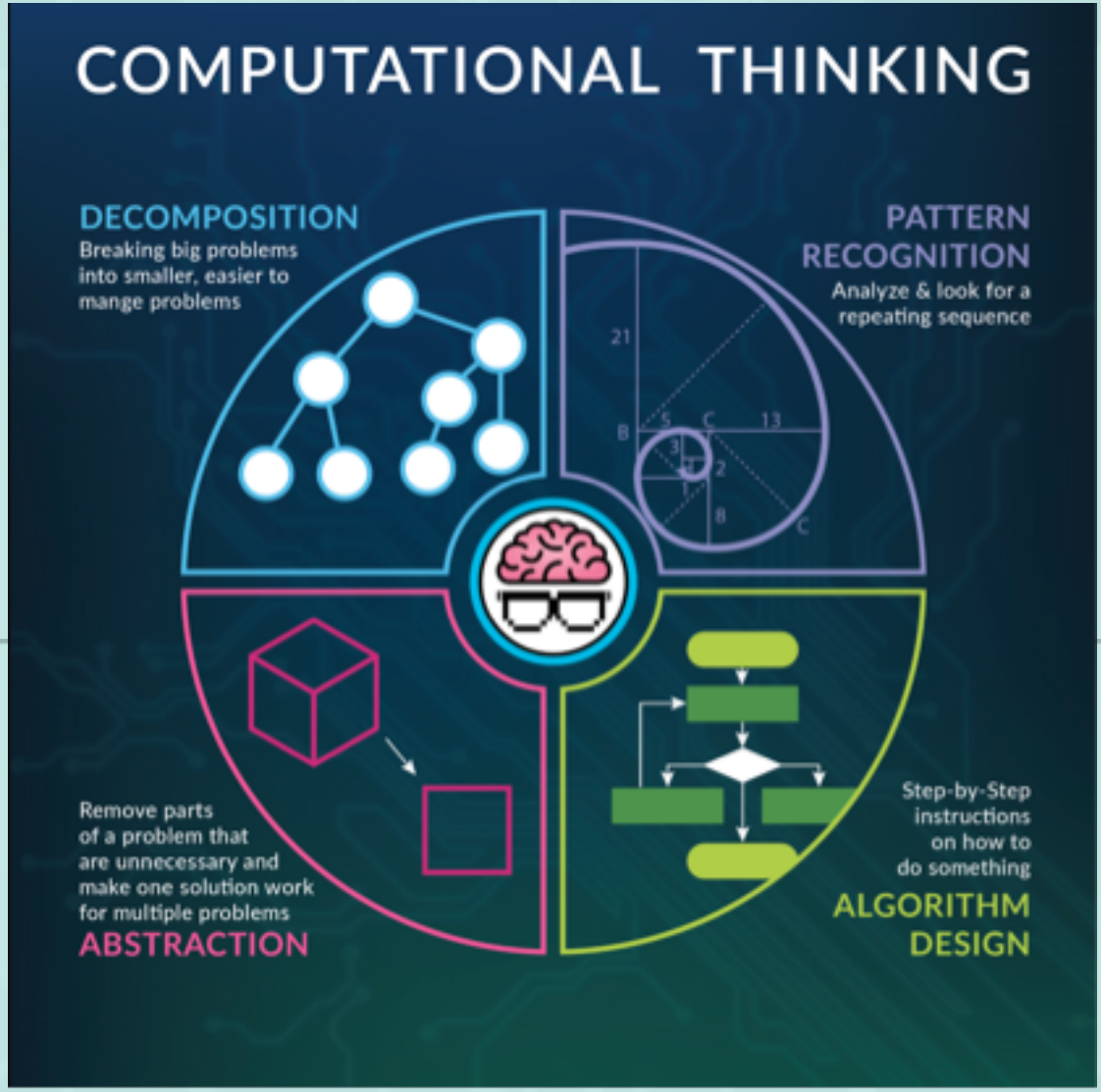
Award-winning math teacher at the Boston Latin School and creator of specialized web-based learning platform for CCSS-based math classroom

Kenia Wiedemann

Project Manager

Research associate at the Concord Consortium. Physicist and environmental scientist interested in science advocacy and education. Over ten years of R programming experience.

"...the thought processes involved in **formulating problems and their solutions** so that the solutions are represented in a form that can be effectively carried out by an **information-processing agent**" (Cuny, Snyder, and Wing, 2010)

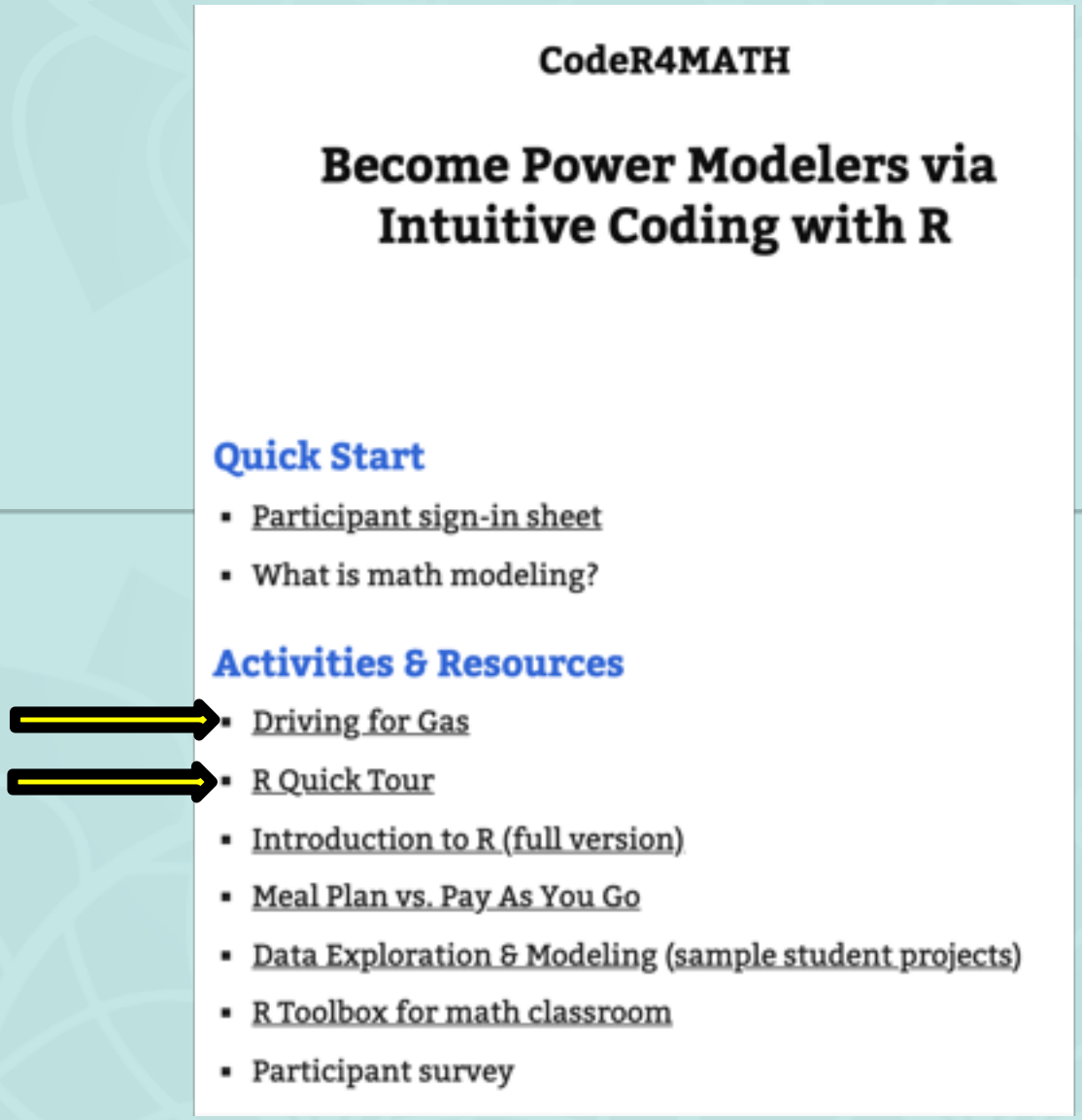


What is R?

- #1 tool among data scientists
- #6 among all languages
- Free, open-source
- Novice-friendly
- 10,000+ R Packages
- Data manipulation, statistical analysis, computing, graphing, and simulation
- Data scientists, business analysts, academic researchers……

R Quick Tour

https://concord.org/coder4math/nctm-2019



CodeR4MATH

Become Power Modelers via Intuitive Coding with R

Quick Start

- Participant sign-in sheet
- What is math modeling?

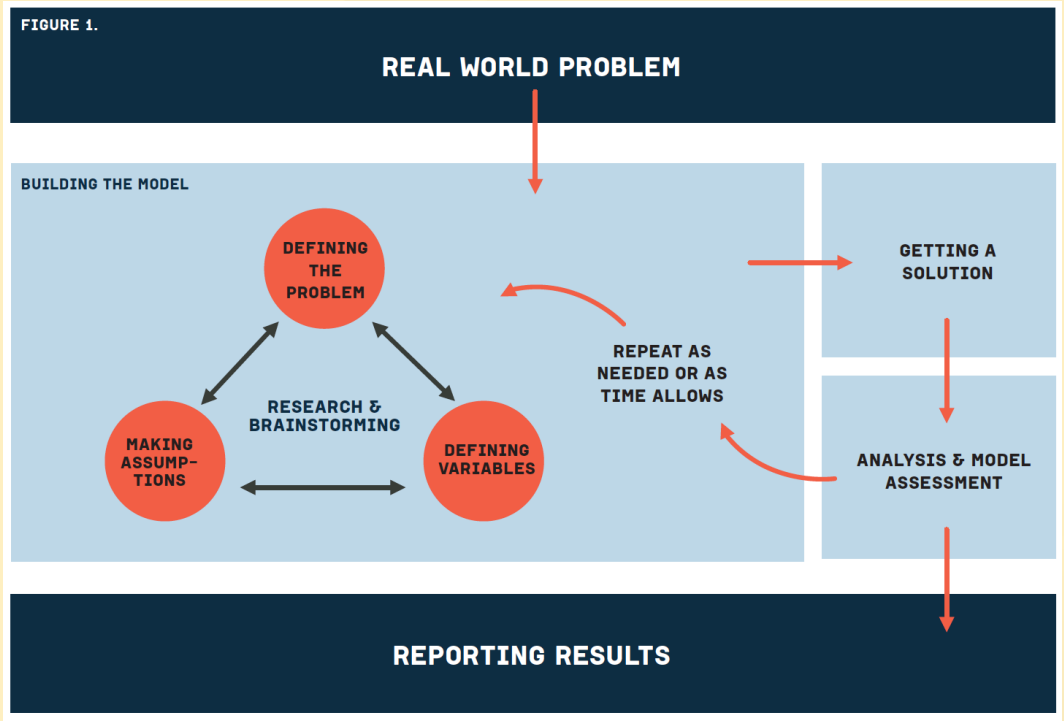
Activities & Resources

- Driving for Gas
- R Quick Tour
- Introduction to R (full version)
- Meal Plan vs. Pay As You Go
- Data Exploration & Modeling (sample student projects)
- R Toolbox for math classroom
- Participant survey

Driving for Gas

What is Math Modeling?

Modeling is an iterative process that uses math to represent, analyze, make predictions, or otherwise provide insight into real-world problems.



And, many more…

What Makes Modeling Different?

300 ÷ 25 =

295 ÷ 25 =

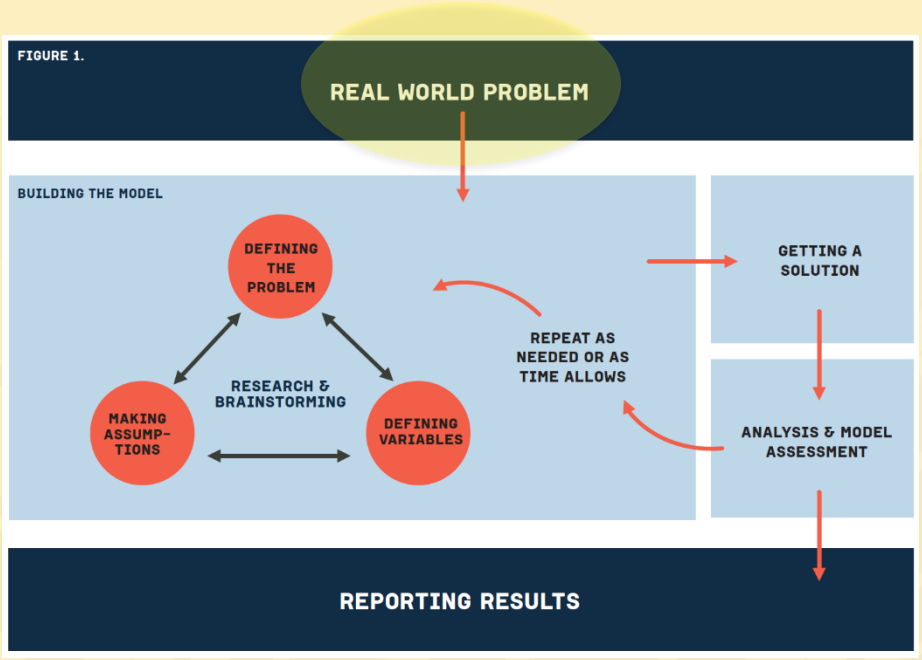
Our school has 300 students. A bus holds 25 students. How many buses are needed to take the students on a field trip?

Our school has 295 students. A bus holds 25 students. How many buses are needed to take the students on a field trip?

Our school has 295 students. What is the best way to transport the students for the field trip?

Driving for Gas

Gas prices change on a nearly daily basis, and not every gas station offers the same price for a gallon of gas. The gas station selling the cheapest gas may be across town from where you are driving. Is it worth the drive across town for less expensive gas?

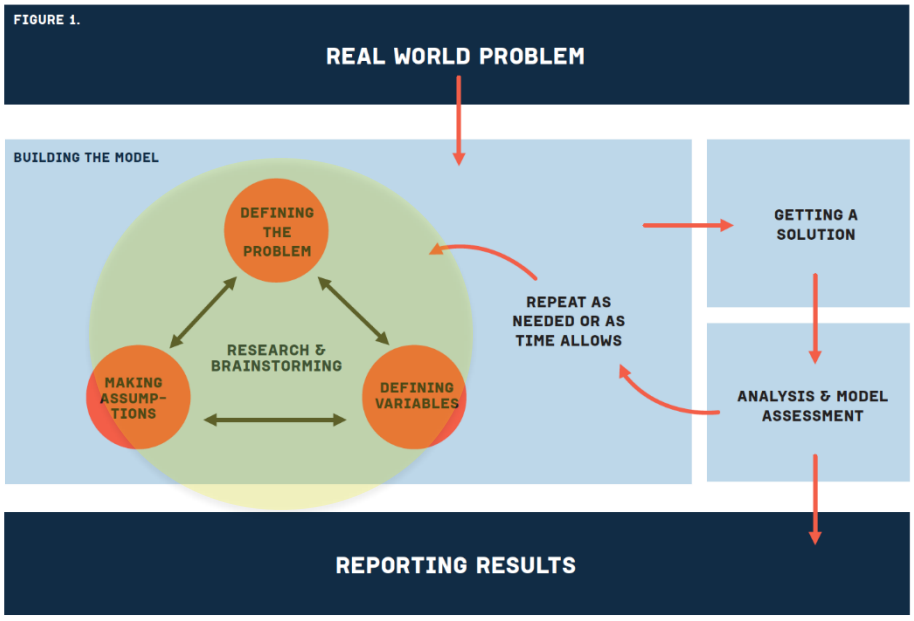


Driving for Gas

Research & Brainstorming

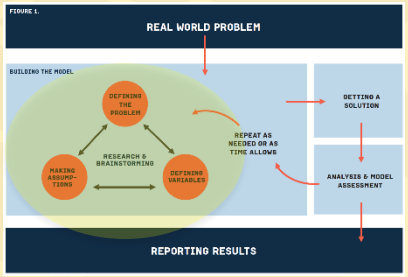
Gas prices change on a nearly daily basis, and not every gas station offers the same price for a gallon of gas. The gas station selling the cheapest gas may be across town from where you are driving. Is it worth the drive across town for less expensive gas?

What do we need to know in order to build a model to investigate this problem?



Driving for Gas

Research & Brainstorming



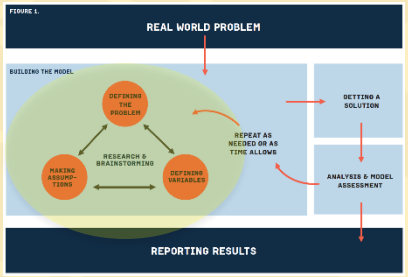
Gas prices change on a nearly daily basis, and not every gas station offers the same price for a gallon of gas. The gas station selling the cheapest gas may be across town from where you are driving. Is it worth the drive across town for less expensive gas?

Considerations:

- Cost of gas at gas stations ($/gallon)
- MPG of our vehicle
- Location of other gas stations
- Number of other gas stations
- Distance to our destination
- Amount of gas in our car
- How much gas do I need?
- Available time
- More…

Driving for Gas

assumptions & variables



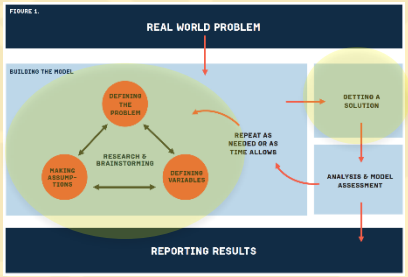
Gas prices change on a nearly daily basis, and not every gas station offers the same price for a gallon of gas. The gas station selling the cheapest gas may be across town from where you are driving. Is it worth the drive across town for less expensive gas?

Considerations:

- Cost of gas at gas stations ($/gallon) → $3/gal (on route) vs. $2.75/gal (detour)
- MPG of our vehicle → 25 mpg
- Location of other gas stations → 5 mile detour
- Number of other gas stations → One additional gas station
- Distance to our destination
- Amount of gas in our car → enough (save for later)
- How much gas do I need? → 15 gal
- Available time →
- More…

Driving for Gas

Build a model



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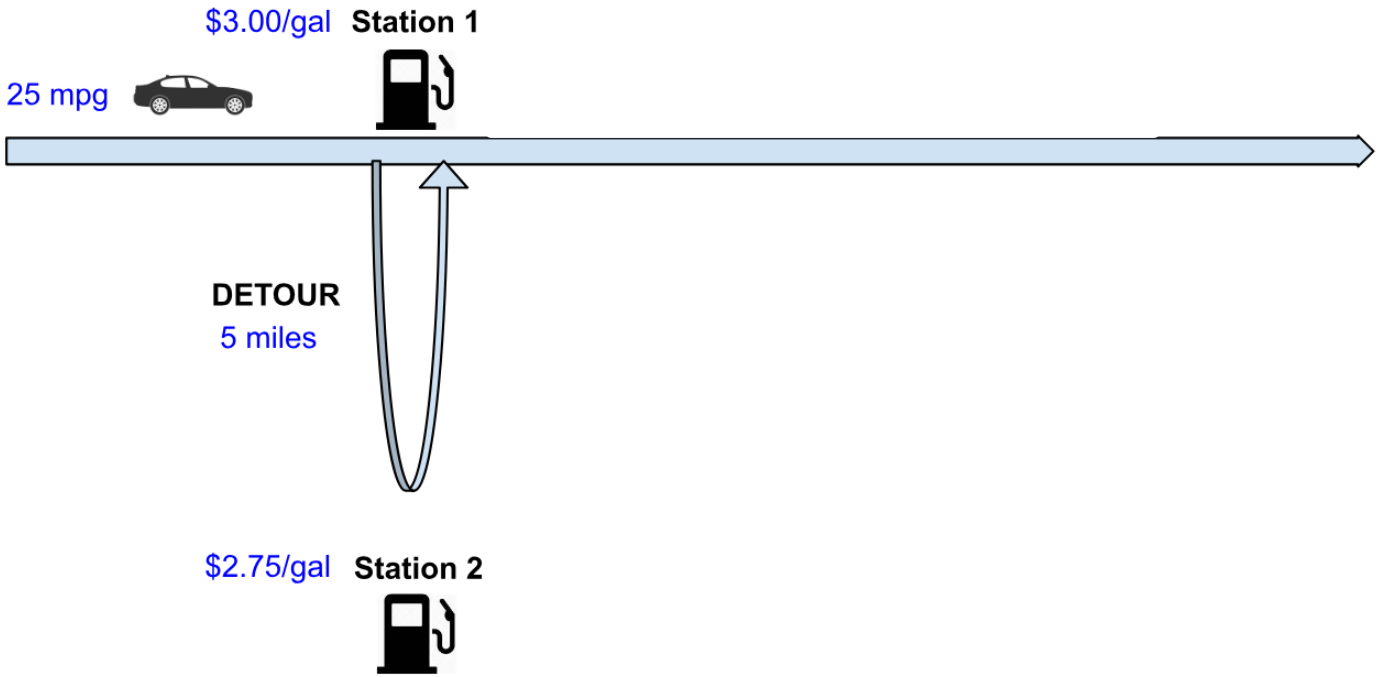
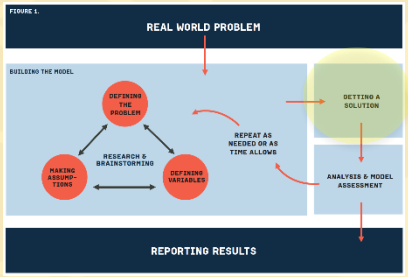


Driving for Gas

(start) to get a solution



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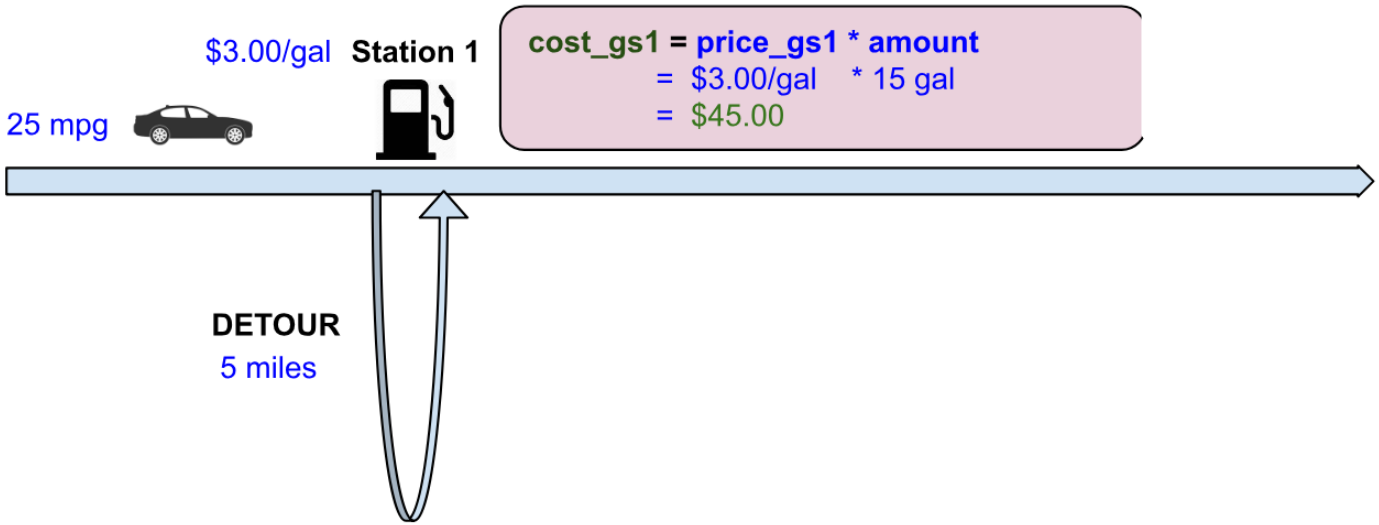
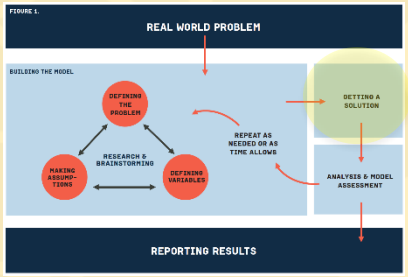


Driving for Gas

(start) to get a solution



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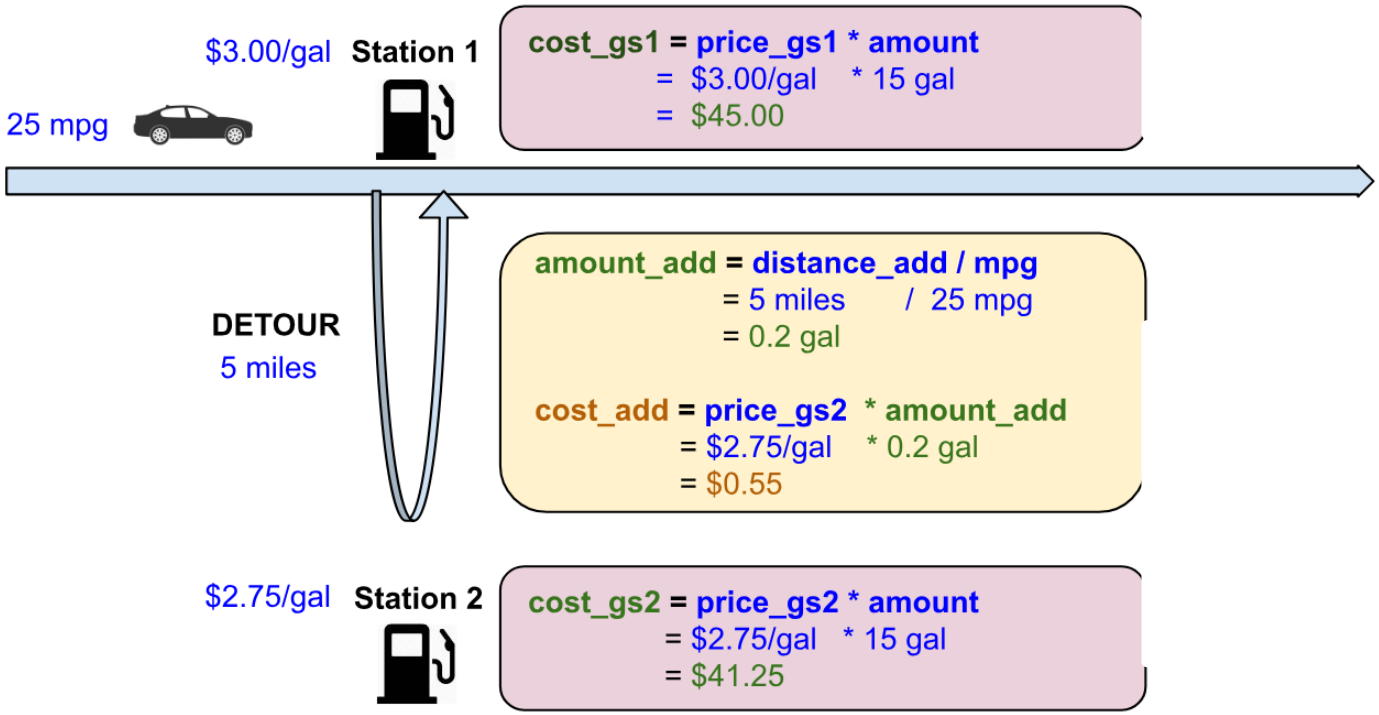
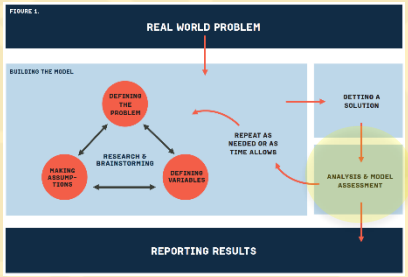


Driving for Gas

Get an (initial) solution!



Does our result make sense?

$3.00/gal **Station 1**

25 mpg

cost_gs1 = price_gs1 * amount
= $3.00/gal * 15 gal
= $45.00

difference =
cost_gs1 - cost_gs2_real

DETOUR
5 miles

amount_add = distance_add / mpg
= 5 miles / 25 mpg
= 0.2 gal

cost_add = price_gs2 * amount_add
= $2.75/gal * 0.2 gal
= $0.55

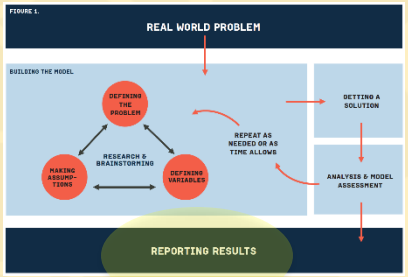
cost_gs2_real = cost_gs2 + cost_add
= $41.25 + $0.55
= $41.80

$2.75/gal **Station 2**

cost_gs2 = price_gs2 * amount
= $2.75/gal * 15 gal
= $41.25

Driving for Gas

Report (use!) our results



Given our assumptions, we have a solution!
Save $3.20 and **go to station 2!**

$3.00/gal **Station 1**

25 mpg

cost_gs1 = price_gs1 * amount
= $3.00/gal * 15 gal
= $45.00

DETOUR
5 miles

amount_add = distance_add / mpg
= 5 miles / 25 mpg
= 0.2 gal

cost_add = price_gs2 * amount_add
= $2.75/gal * 0.2 gal
= $0.55

$2.75/gal **Station 2**

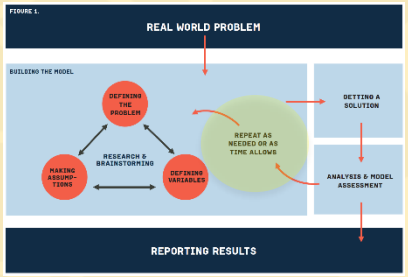
cost_gs2 = price_gs2 * amount
= $2.75/gal * 15 gal
= $41.25

cost_gs2_real = cost_gs2 + cost_add
= $41.25 + $0.55
= $41.80

difference =
cost_gs1 - cost_gs2_real

Driving for Gas

Can we do better?



What if our parameter values change?
What if we remove some assumptions?

$3.00/gal **Station 1**

25 mpg

cost_gs1 = price_gs1 * amount
= $3.00/gal * 15 gal
= $45.00

difference =
cost_gs1 - cost_gs2_real

DETOUR
5 miles

amount_add = distance_add / mpg
= 5 miles / 25 mpg
= 0.2 gal

cost_add = price_gs2 * amount_add
= $2.75/gal * 0.2 gal
= $0.55

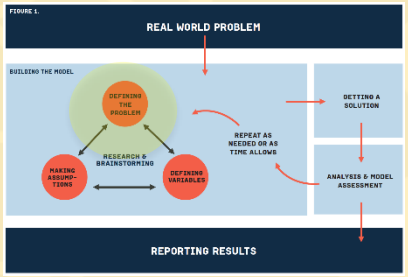
cost_gs2_real = cost_gs2 + cost_add
= $41.25 + $0.55
= $41.80

$2.75/gal **Station 2**

cost_gs2 = price_gs2 * amount
= $2.75/gal * 15 gal
= $41.25

Driving for Gas

Are improvements needed?



Can we do a better job?
Do we have more time to revisit assumptions?

Considerations:

- Cost of gas at gas stations ($/gallon)
- MPG of our vehicle
- Location of other gas stations
- Number of other gas stations
- Distance to our destination
- Amount of gas in our car
- How much gas do I need?
- Available time
- More…

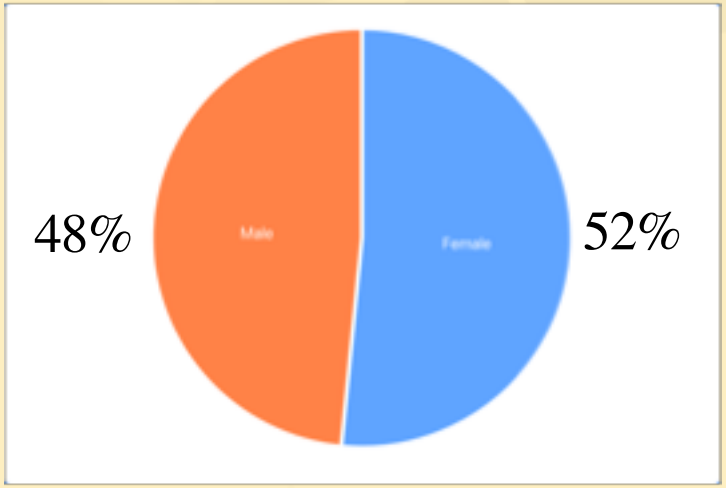
Math Modeling with R

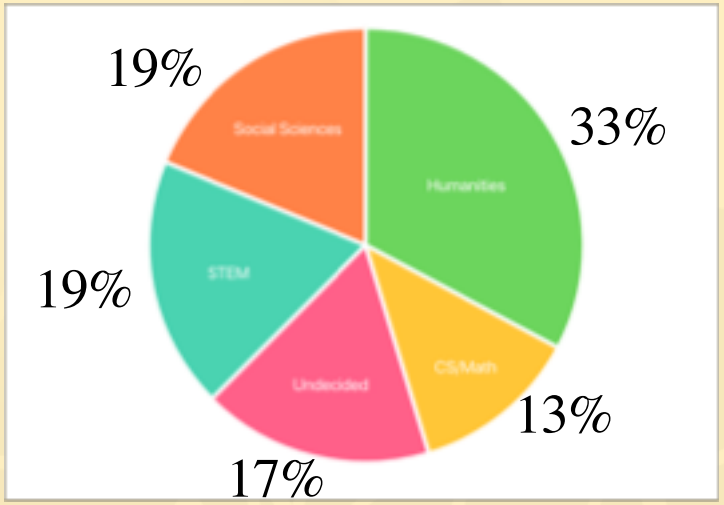
- Unit Overview
- R Coding Space
- Meal Plan vs. Pay As You Go
  - The Challenge
  - Exploring Data
  - Algorithm & Code
  - Estimate Parameter Values
  - Question and address assumptions
  - Investigation
- Intro to RStudio
- Driving for Gas (assessment)

Pilot Study Results

Pilot Study - 2019 Spring

- 2 teachers, 85 students
  - Discrete Math, Senior (3 sections)
  - Intro to CS, 9-12 (1 section)
- 7 hours unit
- Exit questionnaire
  - 64 respondents (75%)



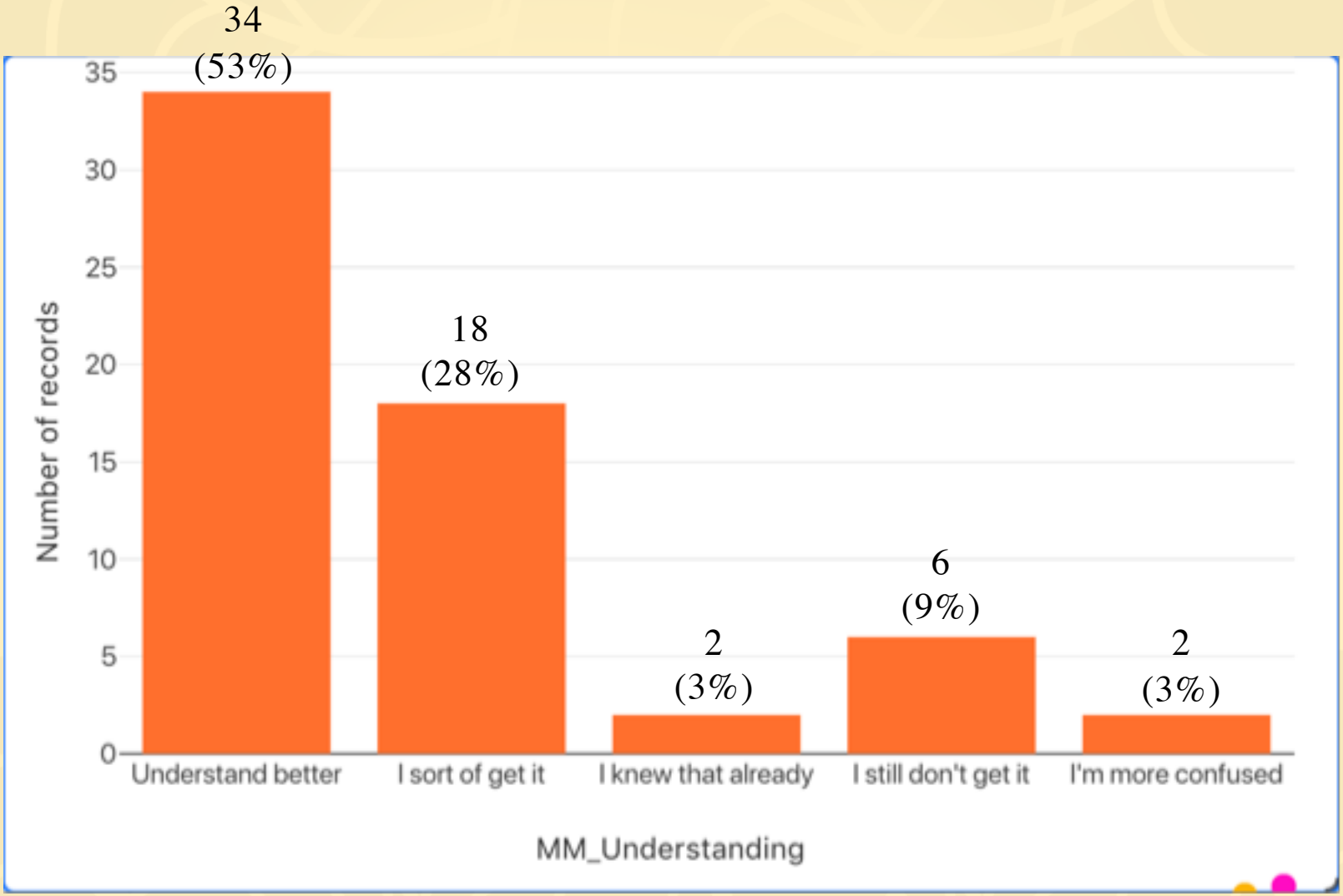


Teachers' Experience

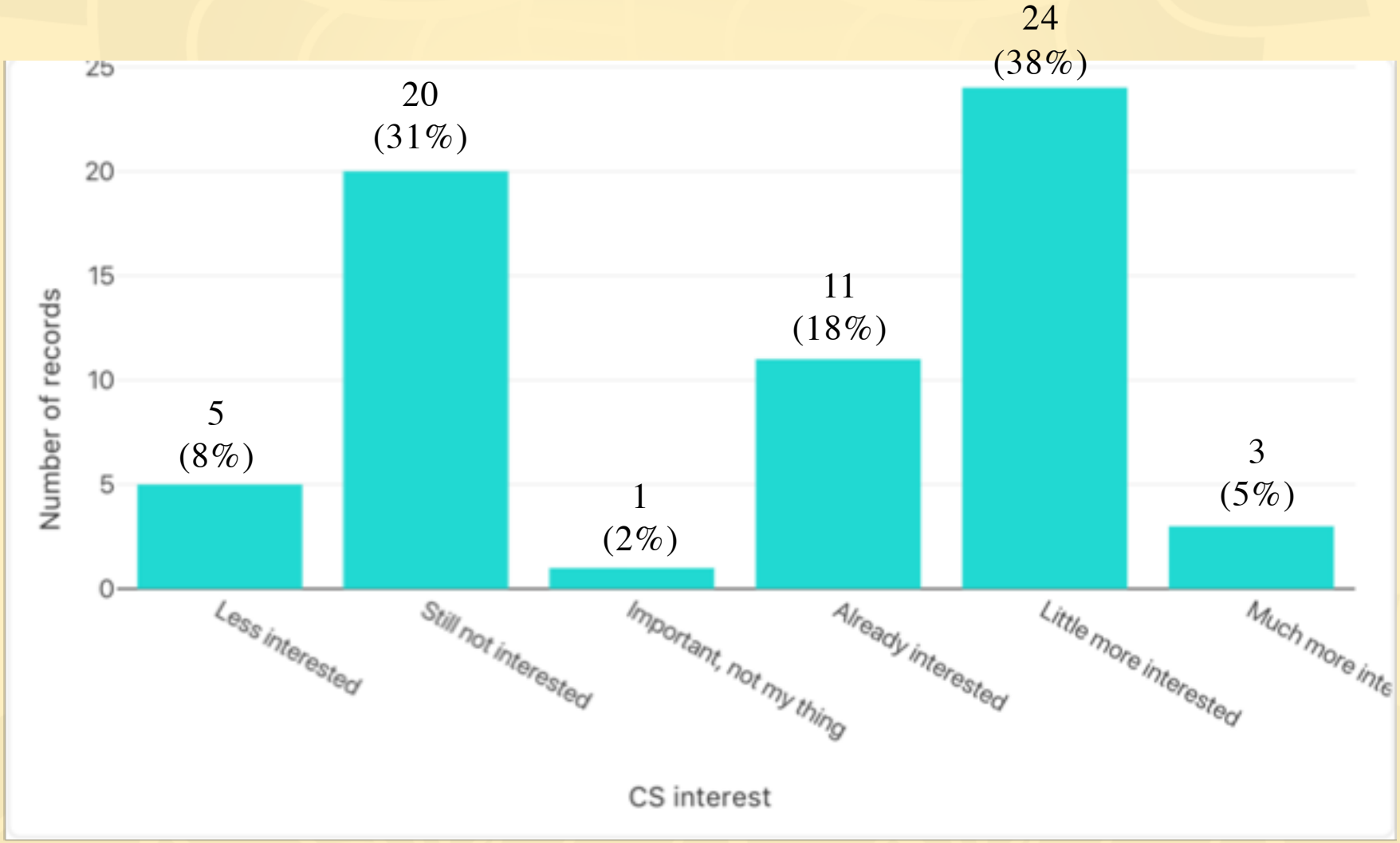
- "…think outside the classroom, there's things out there that you can add value, getting them to brainstorm, getting them to be more aware, that was my favorite part." (*C.B.*)

- "…getting them to think bigger than themselves…that the discussion piece for me was probably my favorite part." (*M.L.*)

How has this learning experience influenced your understanding of **mathematical modeling**?



How has this learning experience influenced your interest in taking **computer programming** courses in the future?



What did you like about the Math Modeling with R unit?