Computing with R for **Mathematical Modeling**

Infuse Computational Thinking into Math Classrooms through Math Modeling with R

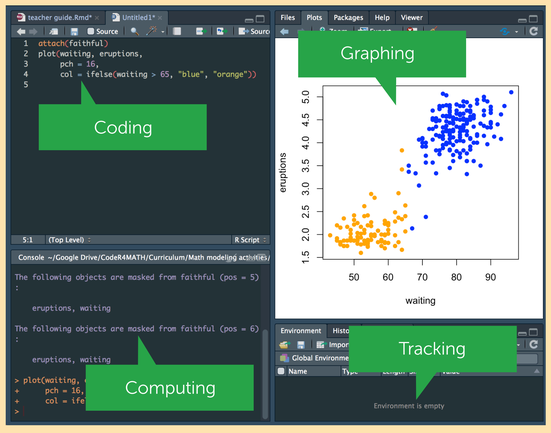
PROJECT OBJECTIVE

Integrating computational thinking into high school math classes permits students to learn and apply computing concepts and skills in a more established and accessible math context. The CodeR4MATH project leverages the inherent connections between computational thinking and mathematical modeling practices and a multitude of representational tools to create a synergistic solution for supporting students to simultaneously develop competencies in both domains.

R AS A MATH MODELING ENVIRONMENT

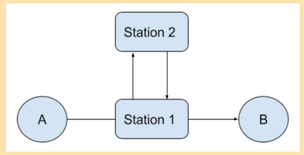
R is a programming language and environment for computing and graphics. R and related tools (i.e., RStudio and R packages) provide abundant supports for learning and teaching math modeling:

1. Express ideas with intuitive code and inline comments.
2. Track variables and parameters in a Global Environment tab.
3. Visualize models with diagrams and graphs.
4. Use powerful computing facilities.



Driving for Gas

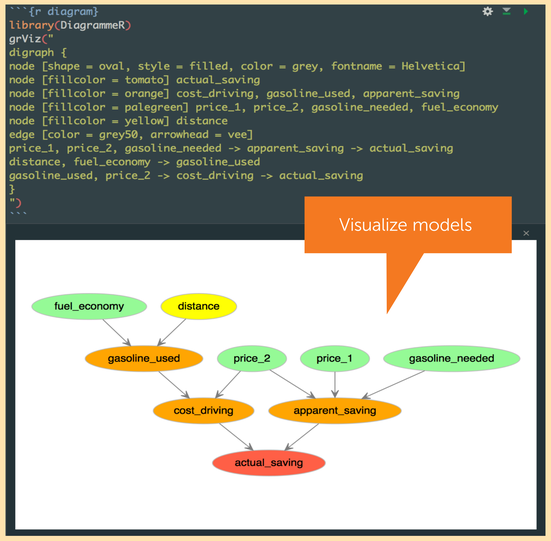
A sample activity



Gas prices change often, and not every gas station offers the same price per gallon. The gas station selling the cheapest gas may be across town from where you are driving. Is it worth the drive across town? Create a mathematical model that can be used to help understand under what conditions it is worth the drive (GAIMME, 2016, p. 14).

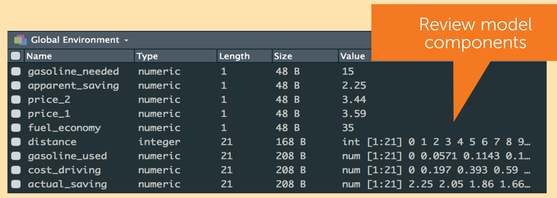

```r
# ##### MAKING ASSUMPTIONS #####
fuel_economy = 35 # the fuel economy of the car is 35 miles per gallon
gasoline_needed = 15 # the amount of gasoline to be purchased is 15 gallons
price_1 = 3.59 # the price of gasoline at Station 1 is $3.59/gallon
price_2 = 3.44 # the price of gasoline at Station 2 is $3.44/gallon

# ##### DEFINING VARIABLES #####
distance = numeric() # the distance (in
affects the actual saving because driving to and
distance = 0:20 # set a sequence of possible values
two stations: 0, 1, 2.....20 miles

# ##### BUILDING THE MODEL #####
# the apparent saving by purchasing gasoline at Station 2 instead of Station 1 ($)
apparent_saving = (price_1 - price_2) * gasoline_needed
# the gasoline used driving to and from Station 2 (gallon)
gasoline_used = (distance * 2) / fuel_economy
# the cost of driving to and from gas station 2 ($)
cost_driving = price_2 * gasoline_used
# the actual saving accounting for the cost of driving to and from Station 2 ($)
actual_saving = apparent_saving - cost_driving
```

Express ideas with R code and inline comments.




```r
library(DiagrammeR)
grViz("
digraph {
node [shape = oval, style = filled, color = grey, fontname = Helvetica]
node [fillcolor = tomato] actual_saving
node [fillcolor = orange] cost_driving, gasoline_used, apparent_saving
node [fillcolor = palegreen] price_1, price_2, gasoline_needed, fuel_economy
node [fillcolor = yellow] distance
edge [color = grey50, arrowhead = vee]
price_1, price_2, gasoline_needed -> apparent_saving -> actual_saving
distance, fuel_economy -> gasoline_used
gasoline_used, price_2 -> cost_driving -> actual_saving
}
")
```

Visualize math models using the DiagrammeR package.



Name	Type	Length	Size	Value
gasoline_needed	numeric	1	48 B	15
apparent_saving	numeric	1	48 B	2.25
price_2	numeric	1	48 B	3.44
price_1	numeric	1	48 B	3.59
fuel_economy	numeric	1	48 B	35
distance	integer	21	168 B	int [1:21] 0 1 2 3 4 5 6 7 8 9…
gasoline_used	numeric	21	208 B	num [1:21] 0 0.0571 0.1143 0.1…
cost_driving	numeric	21	208 B	num [1:21] 0 0.197 0.393 0.59 …
actual_saving	numeric	21	208 B	num [1:21] 2.25 2.05 1.86 1.66…

Track variables in the Global Environment tab.


```r
{r analysis}
##### ANALYSIS AND MODEL ASSESSMENT #####
# visualize the relationship between distance and actual saving
plot(
  x = distance,
  xlab = "Distance of Station 2 (miles)",
  y = actual_saving,
  ylab = "Actual Saving ($)",
  pch = 16,
  col = ifelse(actual_saving >= 0, "blue", "red")
)

legend("topright", legend = c("Save", "Waste"), col =
```

Analyze and assess models through interactive graphs.

CT concepts: variables, sequences, conditionals, iterations, data structures

CT practices: problem decomposition, data analysis and representation, abstraction, automation

Reference

GAIMME: Guidelines for Assessment and Instruction in Mathematical Modeling Education, Sol Garfunkel and Michelle Montgomery, editors, COMAP and SIAM, Philadelphia, 2016. View the entire report, available freely online, at http://www.siam.org/reports/gaimme.php.

concord.org/CodeR4MATH
@ConcordDotOrg

Jie Chao (PI) jchao@concord.org

Eric Simoneau (Co-PI) mrsimoneau@gmail.com

Ben Galluzzo (Co-PI) bgalluzz@clarkson.edu

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