Cream Capacity Increase-Teacher Notes

A Practice Understanding Task

Purpose: In this activity, students are designing an additional heat exchanger to add to an existing heat exchanger for NCSU Dairy Plant to enable an increase in production of dairy products. Then, students are asked to finish an excel template that is used to answer various "what if" questions that could occur on the job.

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Engineering (Chemical & Mechanical Engineering and Electronics)
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NC Math 4 Standards:
AF.1.1 Execute algebraic procedures to compose two functions.
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.

Unit Alignment:
NC Math 4 - Unit 2: Functions
MAT 121 - Unit 1: Functions

Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
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

- Unit Conversations (complicated ones with rates)
- Some knowledge of liquid weight using specific gravities
- Volume formulas of cylinders and cones
- Inputting Excel formulas

Time Required

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

Materials Needed

- Calculator
- Excel

The Teaching Cycle:

Launch: The Launch Teacher Desmos Activity is very important to the success of the explore parts of the lesson. The Desmos introduces the student to concepts like unit conversations with rates, heat capacity of various liquids, specific gravity of various liquids, engineering charts that contain heat capacity and specific gravity, as well as calculating some volumes. The launch video includes some explanation into these concepts and gives a broad overview of the problem to be solved.

Explore: Task 1, 2, & 3 all involve the function $\mathbf{Q} = \dot{\mathbf{m}} \times \mathbf{Cp} \times \Delta\mathbf{T}$, where **Q** = steam heat flow in BTU's/hr, **m** = cream flow rate in pounds/hour, **Cp** = Heat capacity for cream in BTU / (pound * ^{o}F), and $\Delta\mathbf{T}$ = change in temp. Pay close attention to the units on each quantity will help students progress through this formula. Also, to find the Steam heat flow needed in the additional heat exchanger, you find the total heat flow needed to go from 36^0 to 165^0 and then subtract the heat flow that already exists taking 36^0 up to 90^0.
Task 4 uses $\mathbf{W} = \mathbf{Q} / \mathbf{h_v}$, where **W** = steam flow rate in pounds / hour and $\mathbf{h_v}$ = Latent Heat for steam at 35 psi , and **Q** = steam generated heat flow in BTU's/hr and this is your composition of functions idea. To find h_v, interpolate the two given latent heat values for steam.
In Task 5, be sure to use the equal percentage column option in the given table. This one component of the additional heat exchanger costs between $10,000 and $50,000, so it is imperative to not make a mistake!
Task 6 and 7 is fairly straight forward, but do make sure specific gravity for cream is used to find the weight (not just the volume). Also, the rate going in the tank minus the rate going out of the tank only begins after 2 minutes of filling.
Task 8 is working with the excel spreadsheet. You can either use the excel version with or without the formulas already in the highlighted cells. If you use the excel sheet without formulas, the students are just formulating the math that they have already computed by hand in tasks 1-5. Once the formulas have been completed (making sure their spreadsheet results the same answers as they have already computed earlier), then make the appropriate changes in each what if scenario. Goal Seek (an excel option under the Data Tab on the tool bar) is nice to use when you are determining an input needed to produce a formula output value.
When answering student questions, remember to let them struggle a bit and do not lead them directly to the answer. Maybe remind them to include the units on each input and keep in mind what unit is desired on the output. Maybe tell the group to re-read the initial given information that includes formulas and several starting values of quantities. Maybe remind them that the specific topic was taught in the Desmos, and hint to them to review it again. Giving hints and not answers will help the students become better problem solvers and learn to use critical thinking skills that is a valuable but missing soft skill in many employees in todays workforce.

Discuss:

Students will share their results and compare what they arrived at compared to other groups. Groups can explain their process they used at arriving at their result. You could have groups trade their answers and have groups compare their results with the results of the paper they are reviewing. Again, time is a factor in how you handle the discussion part of the activity. Do at least have each group explain to some degree how they arrived at some part of their results.

OnLine Class Option: Below find the blackboard post for this activity assignment for an online class. The discussion part of this schematic could be assigned as the Discussion part of an in class face to face class.

Group Project 4 - Cream Capacity

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Project Steps

Step 1: **GOAL COMPLETION BY Wednesday 3/29.**

- Complete the Desmos Launch individually. https://student.desmos.com/join/snkymc
- Watch the Launch Video that is embedded in the Desmos and take notes.
- Read through the activity and use your groups to chat to begin to understand the goals of the project.
- You will have the same groups for this activity as you had for your last Industry Project.

Step 2: **MUST BE COMPLETE BY WEDNESDAY 4/5 @ 2:00 PM.**

- Explore the task as a group.
- This does not mean, divide up the tasks into individual pieces but as a group, discuss the problem and agree on the best solution to the problem.
- As part of the explore phase, your group will be expected to solve the problem and bring one copy of your answers as a group to class on April 5 with all group member names that worked on the solutions.
- I strongly encourage you to set up at several teams meetings to work through this as a group.

Step 3: **MUST BE COMPLETE BY WEDNESDAY 4/5 @ 2:00 PM.**

- There is a discuss portion of this task at the end.
- The discuss portion is important to this project because it allows you to see how other students approached their problems and whether or not you all had the same thought process.

- Your group will produce an electronic **explanation of your approach** and solutions to questions in ***Task 8*** only.
- You can choose from the following list for the discuss portion of the project:
  - An MS Teams meeting recording (record it for posting on blackboard)

Exit Ticket:

Given the following conditions below and using the Technical Relationships $\mathbf{Q} = \dot{\mathbf{m}} \times \mathbf{Cp} \times \Delta\mathbf{T}$, where $\mathbf{Q}$ = steam heat flow in BTU's/hr, $\mathbf{m}$ = cream flow rate in pounds/hour, $\mathbf{Cp}$ = Heat capacity for cream in BTU / (pound * ºF), and $\Delta\mathbf{T}$ = change in temp and $\mathbf{W} = \mathbf{Q} / \mathbf{h}_v$, where $\mathbf{W}$ = steam flow rate in pounds / hour and $\mathbf{h}_v$ = Latent Heat for steam at 35 psi , and $\mathbf{Q}$ = steam generated heat flow in BTU's/hr , FIND the steam flow rate needed for the additional new design for the given final temperature.

Cream flow rate = 80 gpm
Starting temp = 40 F
Current final temp = 100 F
New design final temp = 185 F
Specific Gravity for cream is 1.023
Water weighs 8.34 pounds per gallon
Heat Capacity for cream is 0.89
Latent Heat for steam at 30 psi is 945.2 BTU / pound
Latent Heat for steam at 40 psi is 933.6 BTU / pound

Ans: 3298 pounds / hour

Two example assessments for testing:

If specific gravity for gasoline is 0.72, and 1 cubic foot can hold 7.4805 gallons, and water weight is 8.34 pounds per gallon, how much does a FULL cylindrical gasoline tank weight that is 15 feet long and 10 feet diameter.
ANS: pi*5^2*15 * 7.4805 * 8.34 = 73,498.39 pounds

How long will it take this tank to fill if a gasoline tanker can pump 525 gallons per minute?
ANS: pi*5^2*15 * 7.4805 / 525 = 16.8 minutes