

The Decision Meeting: Six Hand-Warmer Prototypes, Three Customers

Investigation question: Given test data from six hand-warmer prototypes, which prototype should go to each of three customers with different criteria and constraints, and when none fits, which characteristics from different prototypes can be combined into a better design?

Data-driven decision

Groups of 4

1 session

Setup 5 · Activity 42 · Cleanup 3 min

MS-ETS1-3 · assesses

MS-ETS1-2 · practice

MS-PS1-6 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Meeting chair:** Reads each customer brief aloud, keeps the team working through the matrix one customer at a time, and makes sure every pass or fail has a number beside it.
- ☐ **Data analyst:** Plots the three temperature curves, computes the rates, costs per hour and any interpolated values, and checks every number the team writes against the report.
- ☐ **Customer advocate:** Speaks for the customers: checks each proposed match against every criterion and every constraint in the brief, and refuses a match that breaks even one constraint.
- ☐ **Design recorder:** Writes the decision matrix, the feature-comparison table and the new design proposal, and makes sure every predicted number in the proposal is bracketed by data from two existing prototypes.

Safety

- No chemicals, no heat sources and no building in this lab; it is a data and decision task. Do not try to build iron-powder pouches at home or in class: iron powder is a fine dust that should not be breathed, and the reaction with salt and air is for the dataset only.
- If the class uses scissors to cut index cards, standard scissors rules apply.

Procedure

1. Read the test report and the three customer briefs on your recording sheet. The meeting chair reads each brief aloud while the customer advocate underlines every criterion (a goal with a number) and every constraint (a limit with a number).
2. The data analyst plots the temperature-time curves for P1, P2 and P3 on one graph in three colors, draws a horizontal line at 40 °C and one at 35 °C, and marks where each curve crosses them. Check the crossing times against the 'minutes to 40 °C' and 'hours above' columns of the report.
3. Fill in the feature-comparison table: for each listed pair of prototypes that differ by one feature, write the feature that changed and what happened to the peak, the minutes to 40 °C and the hours above 35 °C. These are your cause-and-effect findings.

4. Build the decision matrix one customer at a time. For every prototype write PASS or FAIL for that customer and, beside it, the first criterion or constraint it fails with the number (for example 'FAIL: peak 53 °C, limit 50'). A prototype passes only if it meets every criterion and every constraint.
5. Match a prototype to each customer who has one. If more than one passes, choose the cheapest or the lightest and say which rule you used. If none passes, write 'no prototype passes' and list, for each near-miss prototype, the one thing that kept it out.
6. For the customer with no passing prototype, design a new one. Use the feature-comparison table to pick the characteristic that gives a fast start and the characteristic that gives a long working time, choose an iron mass, and predict the peak, minutes to 40 °C, hours above 40 °C, mass and cost. Every prediction must sit between the values of two existing prototypes, and you must say which two.
7. Post your three matches and your new design on the class decision wall with sticky notes. Compare with other teams: where teams disagree, the numbers settle it.
8. Complete the analysis questions individually, then compare answers within the team.

Record your observations

Lab 3 recording sheet: The decision meeting

You are the engineering review board at a company that makes single-use iron-powder hand warmers. The lab team tested six prototypes and sent the report below. Three customers have sent briefs. Your job: match a prototype to each customer using the data, and where nothing fits, design something that will. The numbers in this report are a teaching dataset invented for this lab; they follow the patterns of real hand warmers but are not measurements of real products.

How the prototypes work and how they were tested — Each pouch holds iron powder; some also hold 2 g of salt, which speeds up the reaction of iron with oxygen. When the wrapper is opened, air reaches the iron through the pouch fabric and the reaction releases energy to the pouch and whatever is touching it. Thin cotton lets air in quickly; thick felt lets it in slowly. Every prototype was tested once in a 22 °C room in still air with a probe inside the pouch. Costs use the company's price list: iron \$0.025 per gram, thin cotton pouch \$0.10, thick felt pouch \$0.45, salt \$0.10.

Test report: six prototypes (simulated teaching data)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Prototype	Iron (g)	Pouch	Salt	Peak temp (°C)	Minutes to peak	Minutes to reach 40 °C	Hours above 40 °C	Hours above 35 °C	Mass (g)	Cost (\$)
P1	20	thin cotton	yes	44	15	8	0.9	1.5	30	0.7
P2	40	thin cotton	yes	53	20	7	2.6	3.9	50	1.2
P3	40	thick felt	yes	42	90	45	4.4	7.1	60	1.55
P4	60	thick felt	yes	45	80	35	7.5	10.2	80	2.05
P5	40	thick felt	no	33	120	never	0	0	58	1.45
P6	40	thin cotton	no	41	40	30	0.7	2.9	48	1.1

Simulated data. Room temperature 22 °C. 'Hours above' counts the time the probe read above that temperature.

Temperature inside the pouch over time for P1, P2 and P3 (simulated teaching data)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Time (min)	P1 (°C)	P2 (°C)	P3 (°C)
0	22	22	22
5	34	36	25
10	43	46	28
15	44	51	31
20	44	53	33
30	43	52	37
45	42	50	40
60	40	48	41
90	36	45	42
120	31	43	42
180	24	39	42
240	22	35	41

Time (min)	P1 (°C)	P2 (°C)	P3 (°C)
300	22	31	40

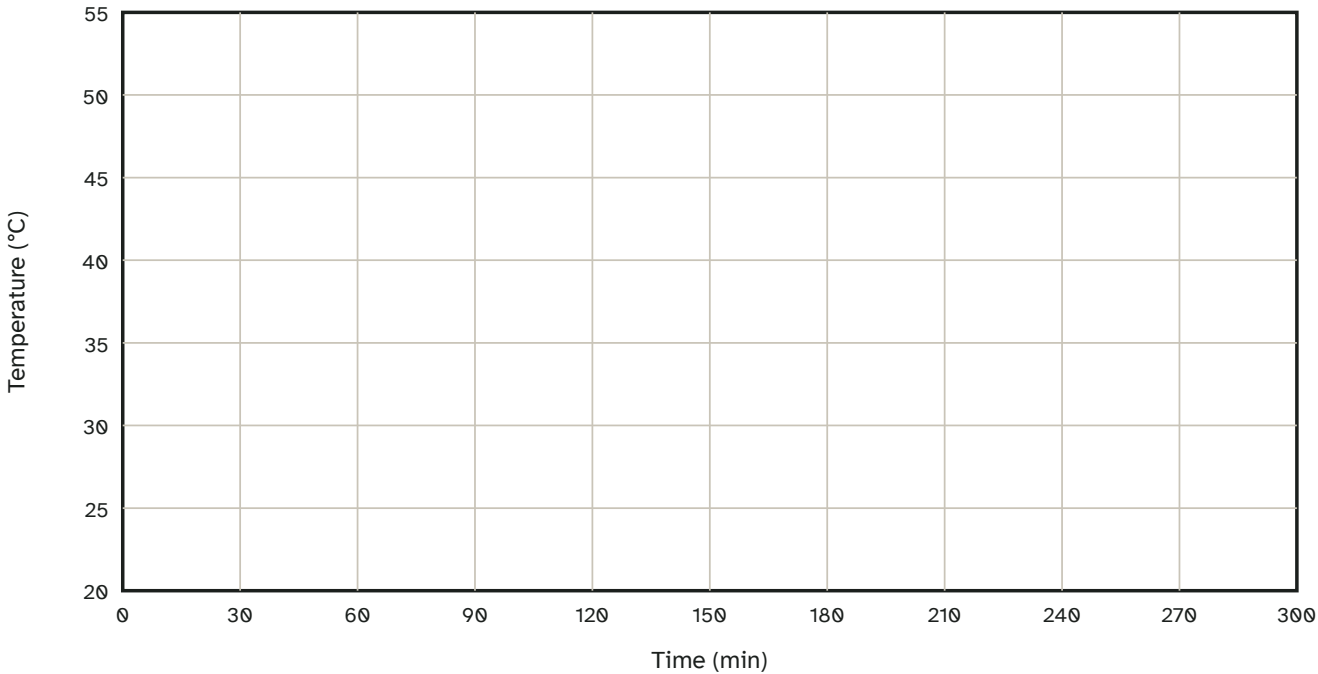
Simulated data. P3 stayed above 40 °C until about 310 minutes and above 35 °C until about 450 minutes (not shown).

Customer briefs — Customer A, Maya, three-day backpacking trip: criteria: at least 6 hours above 35 °C from one pack. Constraints: mass 60 g or less; cost \$1.75 or less; peak never above 50 °C.

Customer B, Mr. Alvarez, 25-minute bus wait every winter morning: criteria: reaches 40 °C within 10 minutes; at least 45 minutes above 40 °C. Constraints: cost \$1.00 or less; peak never above 50 °C.

Customer C, Dani, wildlife photographer at dawn in the Sierra: criteria: reaches 40 °C within 15 minutes; at least 3 hours above 40 °C. Constraints: peak never above 48 °C (the pack sits inside a glove against skin); mass 70 g or less; cost \$2.00 or less.

Temperature inside the pouch over time: P1, P2 and P3 (draw lines at 40 °C and 35



Feature comparison: pairs that differ by one feature

Pair	The one feature that changed	Effect on peak (°C)	Effect on minutes to 40 °C	Effect on hours above 35 °C	What this feature controls
P1 → P2					
P2 → P3					
P3 → P4					
P3 → P5					
P2 → P6					

Decision matrix: PASS or FAIL, with the first failing item and its number

Prototype	Customer A (Maya)	Customer B (Mr. Alvarez)	Customer C (Dani)
P1			
P2			
P3			
P4			
P5			
P6			
Our match (or 'none passes')			

New design proposal for the customer with no passing prototype

Design feature or predicted value	Our choice or prediction	Borrowed from or bracketed by which prototypes	Why
Iron mass (g)			
Pouch material or construction			
Salt?			
Predicted peak (°C)			
Predicted minutes to 40 °C			
Predicted hours above 40 °C			
Predicted mass (g)			
Predicted cost (\$)			

1. Customer A gets prototype _____. Customer B gets prototype _____. Customer C gets prototype _____ (or 'none').
Number of prototypes that pass for at least one customer: _____.

2. For the customer with no passing prototype, which two of their requirements pull against each other in this dataset, and which design feature is responsible for the tension?

Analysis questions

3. Calculate the cost per hour above 40 °C for P1, P3 and P4 (cost divided by hours above 40 °C). Which is the best value? Explain why best value alone could not choose a pack for Maya.

4. Using the temperature-time dataset, calculate the average warming rate in °C per minute over the first 10 minutes for P2 and for P3. These two prototypes hold the same iron and the same salt. Explain what the pouch material changed about the reaction and about how fast energy was released to the pouch.

5. P2 has the highest peak of all six prototypes, yet it fails for every customer. Explain why, using numbers from the briefs. Then compare P2 and P3, which hold the same 40 g of iron: does the felt pouch change how much energy the iron can release in total, or how fast it is released? Use the hours-above data to support your answer.

6. P5 never reached 40 °C and its peak was only 33 °C, even though it holds as much iron as P3. What does comparing P3 with P5 tell you about the salt? Explain the result with energy language: why does a reaction that releases energy slowly fail to warm the pouch much, even though the total energy released may be similar?

7. Describe the new design your team proposed for Dani. Name the characteristic you borrowed for a fast start and the prototype it came from, the characteristic you borrowed for a long working time and its prototype, and justify each predicted number by naming the two prototypes it sits between.

8. A classmate says the meeting was a waste of time: 'Just give everyone the hottest one that is under budget.' Explain, with one example from the matrix, why a pass-or-fail check against every criterion and constraint gives a more trustworthy decision than picking by a single number.

9. Every prototype was tested once, in a 22 °C room with still air. Dani will use hers at dawn in the mountains, perhaps near 0 °C with wind. Predict how colder surroundings and moving air would each change a pouch's peak and working time, say which customer's match you are least sure of, and describe the one retest you would order before shipping.
