

The Sixty-Thousand-Fork Problem: Choosing a Material for the Cafeteria

Learning target: I can define testable criteria and constraints for a real materials problem, compare four competing options against them using evidence about each material's origin, cost and ending, choose one, justify it, and revise my plan when new information arrives.

Transfer and design

About 50 min

Pairs

MS-ETS1-1 · practice

MS-ETS1-2 · practice

MS-PS1-3 · practice

engineering design

data analysis

writing

Name _____

Date _____

Period _____

Directions

Read the memo and the facts about your school. In Part A, write the criteria and constraints precisely enough that someone could test whether a plan meets them. In Part B, do the math for each option and fill in the comparison matrix. In Part C, choose, justify, and then revise your plan when the new information arrives. There is more than one defensible choice; what earns credit is a decision that follows from your criteria, your constraints and the evidence, and that names the trade-off you accepted.

You will need: This worksheet, Pencil, Calculator, Ruler for the sketch

Memo from the district (teaching scenario) — Lincoln Middle School serves about 330 lunches a day for 180 school days, roughly 60,000 meals a year, and hands out a single-use polystyrene fork with every one. The board wants each school to propose a fork plan for next year. The plan must: keep the lunch line moving (students should not wait for forks); cost the school no more than \$2,500 per year for forks, washing and replacements combined; and send less fork waste to the landfill than this year. Staff can give at most 30 extra minutes per day to the plan. Submit your criteria, your comparison and your choice.

Facts about Lincoln's waste streams. Trash bins go to the county landfill. The recycling bin accepts bottles and cans only; no cutlery of any kind. The green bin takes food scraps and items marked compostable and is hauled to an industrial composting facility, which at present accepts PLA cutlery. The cafeteria has a dishwasher that already runs every day for trays.

Four fork options (teaching dataset)

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

Option	Natural resource	Cost	Forks that break per 100 uses	Where it goes after use at Lincoln	Mass of one fork (g)
A: Polystyrene, single-use	petroleum	2 cents per fork	1	trash bin: landfill	3
B: PLA, single-use	corn starch	4 cents per fork	4	green bin: industrial composter (accepted at present)	4
C: Birch wood, single-use	birch trees (regrow in decades)	5 cents per fork	3	green bin: industrial composter	3
D: Stainless steel, reusable	iron ore and chromium ore	60 cents to buy; 1 cent per wash	0	washed and reused; about 15 of every 100 forks are lost or thrown away each year	20

Simulated figures chosen to be realistic. Break rates come from an imagined two-week trial of each fork on cafeteria food.

Extra facts for Option D. Covering three lunch periods with washing in between takes about 700 forks in rotation. Collecting, loading and sorting the forks adds about 25 minutes of staff time per day. Lost forks that land in the trash go to the landfill.

Part A: Define the problem precisely

A vague requirement cannot be tested. 'Good for the environment' is vague; 'sends less than 50 kg of fork waste to the landfill per year' can be measured. Criteria say what a successful plan must do. Constraints are limits the plan must stay inside.

1. Write three criteria for the fork plan, each specific enough to test. At least one must be about what happens to the forks after use (their ending) and one about how the forks work during lunch. For each, write how you would measure it.

2. Write the constraints from the memo and the school facts (there are at least three). Then explain why 'costs no more than \$2,500' is a constraint rather than a criterion, and why a plan that costs \$1,000 is not automatically better than one that costs \$2,400.

Part B: Compare the options

3. Complete the matrix. Yearly cost for a single-use option is 60,000 forks times the cost per fork. For steel, add the cost of 700 forks, 60,000 washes, and replacing the forks lost in a year. Landfill waste is the number of forks that reach the landfill times the mass of one fork, in kilograms. Show every calculation below the table.

Yearly cost (\$)	Within the \$2,500 limit?	Fork waste to landfill per year (kg)	Resource renewable?	Meets your lunch-line criterion?
A: Polystyrene				
B: PLA				
C: Birch				
D: Steel (first year)				

4. Which option has the lowest cost in its second year, and why does its cost drop? Which option is ruled out by a constraint no matter how good it is otherwise?

Part C: Decide, justify, revise

5. Choose one option (or a combination). Justify it in a paragraph that names the criteria it meets, the constraints it stays within, the natural resource it draws on and where its waste ends up. Then name the trade-off you accepted: what does your choice cost that another option would not?

6. New information: in March, the composting facility announces that starting next year it will no longer accept any plastic cutlery, including PLA, because too much polystyrene has been arriving mixed in with it. Which options does this affect, and how? Rewrite any criterion or constraint that must change, and say whether your choice in q5 survives. If it does not, name your new choice.

7. Sketch your plan as a flow: the natural resource, the fork, the lunch line, and where each fork goes after use (label every bin and its destination). Then add a box describing a two-week pilot test: what you would count each day, and what result would tell you the plan has failed a criterion.

Criteria frames and the cost formula

Criterion frames: 'No more than ___ forks break per 100 uses.' 'Fork waste to the landfill is less than ___ kg per year.' 'A student gets a fork within ___ seconds of reaching the counter.' Cost formulas: single-use yearly cost = $60,000 \times \text{cost per fork (in dollars, so 2 cents is \$0.02)}$. Steel first year = $700 \times \$0.60 + 60,000 \times \$0.01 + (15 \text{ percent of } 700) \times \$0.60$. Landfill waste = forks reaching the landfill $\times$ grams per fork $\div 1,000$.

Reduce before you replace

Every option on the sheet assumes 60,000 fork uses. A survey (invent realistic numbers and label them) finds that about one meal in five is pizza, a sandwich or fruit that needs no fork, yet every tray gets one. Redo the matrix with forks handed out only on request, estimate the new yearly cost and landfill mass for your chosen option, and write a paragraph on which saves more, changing the material or changing the habit. Then name one criterion that a 'forks on request' plan might fail and how you would test it.