

KEYSMITH MANOR

A game that teaches Dijkstra's shortest-path algorithm without saying so.

Audience: puzzle-minded students, roughly grade 6 through introductory CS · **Time:** 20–40 minutes · **Setup:** any modern browser, no install, single player

THE PREMISE

Players inherit a manor of locked doors and a ring of keys. Each door has a price, paid once — after that it stays open forever, and walking through open doors is free. The goal is to reach the far stair, judged on the *route* found, not the wandering it took. Fog of war hides everything except rooms one door beyond explored halls, and a "Ledger" panel tracks the cheapest known cost from the Entrance to every room seen.

These rules are Dijkstra's algorithm in costume. Because open doors are free to re-cross, the only real decision each turn is *which unexplored room to commit keys to next* — precisely the algorithm's core loop. Students who develop a winning instinct have internalized the method before ever hearing its name.

LEARNING OBJECTIVES

- Judge options by **total cost from the start**, not by the cheapest next step (greedy thinking).
- Use and maintain a **table of best-known distances** that improves as new paths are found.
- Distinguish **settled** knowledge (proven cheapest) from **frontier** estimates (best so far).
- Articulate why settling the cheapest frontier node guarantees the first route confirmed is the shortest.

GAME TERMS → ALGORITHM TERMS

IN THE GAME	IN DIJKSTRA'S ALGORITHM
Rooms and doors	Nodes and weighted edges of a graph
Door price, paid once, open forever	Edge weight; cost measured from the source, never from where you stand
Settled halls (fully lit)	Visited set — shortest distance proven final
Candlelit frontier rooms	Frontier / priority queue — tentative distances
The Ledger's "keys from Entrance"	The distance table, relaxed as new edges are revealed
"Consult the Ledger" hint	Extract-min: settle the cheapest frontier node next
Secret passages (Floors II–III)	Long-range low-weight edges — why locality intuitions fail

HOW THE THREE FLOORS TEACH

Floor I — The Cellars. Small map; taking cheap doors mostly works. Students learn the interface and the paid-once rule. Lesson delivered on completion: the route matters more than any single door.

Floor II — The Grand Floor. Generated so that greedy door-picking is strictly worse than the true shortest route. Most students get burned here — the productive failure. Lesson: judge rooms by full cost from the Entrance.

Floor III — The Attic. Largest map, tightest key budget, two secret passages. Rewards deliberate Ledger use. The closing lesson names the discipline: *settle the cheapest frontier room, every time — that is Dijkstra's method.*

Every manor is regenerated on replay, so strategies transfer but memorized solutions don't. Scores are stars: three for finding the provably shortest route.

CLASSROOM SEQUENCE (ONE PERIOD)

1. **Play (15 min).** Students play Floors I–III unaided. Ask them to note any moment they wished they'd chosen differently.
2. **Discuss (10 min).** Use the questions below. Draw out the "cheap door, expensive route" trap from Floor II stories.
3. **The Workshop (10 min).** Open the Workshop from the header. Step Dijkstra one settle at a time while the Ledger updates; have students predict each next room before pressing Step. Then let them sabotage the map — edit door costs, move start and goal — and check their prediction still holds.
4. **Name it (5 min).** Only now introduce the terms: graph, edge weight, frontier, relaxation, Dijkstra. Students map each to something they already did.

DISCUSSION QUESTIONS

- When did the cheapest door lead you astray? What information would have warned you?
- Why is it fair that walking back through open doors is free? What does that let you compare?
- The Ledger sometimes tells you to explore a room *away* from the goal. When is that wise?
- Once a room is settled, can a cheaper route to it ever appear later? Why not? (Hinges on non-negative prices.)
- What would break if a door could *pay you* to walk through it — a negative price?

CHECKING FOR UNDERSTANDING

A student has understood the algorithm when they can: predict the Workshop's next settled room correctly three times in a row; explain why their Floor II route was or wasn't optimal using Ledger numbers; and earn three stars on a fresh Floor III manor without the hint button.

Extension: have students design a manor in the Workshop where the greedy player loses by as many keys as possible, then trade maps with a partner.