GHOST COIN · Facilitator Guide

A quantum penny-flip game · Grades 6–8

Players	2 players (A and B), or the class against the computer
Time	about 30 minutes
Big idea	Quantum "maybes" can cancel out, so a smart quantum move can always win.

Your job as the facilitator

You are the game guide. You do not need to be a quantum expert. Your job is to keep the game moving, read the rules out loud, and ask good questions. It is fine to say "Let's find out together."

What the game is about

A coin sits in a box with two sides: HEADS and TAILS. Chips show where the coin might be. A **green chip (+)** and a **red chip (−)** in the same box cancel out, like +1 and −1 make 0. Player A wins if the coin ends on HEADS. Player B wins if it ends on TAILS.

The surprise: with the Ghost card, Player A can win every single time. The game shows how quantum computers use canceling to get the right answer.

What you need

- A computer with GhostCoin_Offline.html (no internet needed), or a projector
- For a paper version: a sheet with two boxes (HEADS and TAILS), about 6 green and 6 red chips, and cards marked Leave, Flip, Sign and Ghost
- A real coin (for when the coin is in both boxes)

The four cards

Card	What happens to the chips
Leave	Nothing.
Flip	Swap what is in the HEADS box and the TAILS box.
Sign	Every chip in TAILS changes color (green ↔ red).
Ghost	Each HEADS chip becomes a same-color chip on HEADS **and** one on TAILS. Each TAILS chip becomes a same-color chip on HEADS and an **opposite**-color chip on TAILS.

Clean-up rule
A green and a red chip in the same box are a **zero pair**: remove both.
Two chips of the same color in one box: keep just one.

Run the game, step by step

> **Say:** “The coin starts as one green chip on HEADS. Player A wants HEADS. Player B wants TAILS. Each turn is secret.”

1. Choose a level. Start with **Level 1** (only Leave and Flip).
2. Player A picks a card in secret. Then Player B. Then Player A again. Cards stay face-down.

3. Reveal the cards and do the moves in order. Clean up after each move.
4. **Open the box.** If chips are in only one box, that side wins. If chips are in both boxes, toss the real coin.
5. Play several rounds at each level. Keep score.
6. Move up: **Level 2** gives Player A the Ghost card. **Level 3** gives Player B the Sign card. **Level 4**: everyone gets every card.

> **Projector tip**
> On the computer, players can type a letter (L, F, S, G) instead of clicking, so nobody sees the choice.

Watch for these mistakes

- Forgetting to clean up zero pairs after a move.
- Using the Ghost rule wrong on TAILS chips. A TAILS chip makes an **opposite**-color chip on TAILS.
- Thinking Sign does nothing because the coin still looks 50/50. It changes what happens next!

Questions to ask

- Is Level 1 fair? How often does each player win?
- Why does Player A win every time in Level 2?
- The Sign card changes nothing you can see. Why does it matter?
- A ghost coin with matching colors and one with different colors both look 50/50. Are they really the same?

Answer key: why A always wins in Level 2

1. A plays Ghost. Now there is a green chip on HEADS and a green chip on TAILS.
2. B can only Leave or Flip. Flip swaps two matching chips, so nothing changes.
3. A plays Ghost again. HEADS gets two green chips (keep one). TAILS gets a green and a red chip, a zero pair, so they cancel.
4. Only HEADS is left. A wins every time.

In Level 3, if B plays Sign, the HEADS chips cancel instead, and the coin lands on TAILS. A hidden sign decides the game.

The quantum words

In the game	In a quantum computer
A chip	An amplitude (a "maybe" with a + or − sign)
Ghost card	Hadamard gate (H): makes a superposition
Flip card	X gate (quantum NOT)
Sign card	Z gate (phase flip)
Zero pair cancels	Destructive interference
Open the box	Measurement

Wrap up (say this)

> **Say:** “Quantum computers do not just try every answer. They make the wrong answers cancel out, like our zero pairs, so the right answer is left.”