GHOST HUNT · Facilitator Guide

A quantum search game · Grades 6–8

Players	2 players or 2 teams
Time	about 45 minutes
Big idea	A quantum computer can find a hidden thing faster than a normal computer.

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 ghost hides in one room of a hotel with 8 rooms. A normal computer has to open the rooms one at a time. A quantum computer sends a "search wave" into every room at once. It cannot look at the wave, but it can change it. Each round of **flip** and **reflect** piles more of the wave into the ghost's room. Then you **look**, and the wave lands in one room.

This is a real quantum computer program called **Grover's search** (1996). Students do the same math the quantum computer does.

What you need

- The Ghost Hunt printables (Wave Tracker sheet, one per pair)
- 7 coins for each pair (for the "look")
- Pencils and scrap paper
- Optional: a computer with GhostHunt_Offline.html (no internet needed)

Get ready (5 minutes before)

1. Print one Wave Tracker sheet for each pair.
2. Try one round yourself using the example below, so you know the steps.
3. If you use the computer, open the file and press Full screen.

Words to know

Word	What it means here
Room numbers	The 8 rooms are named in binary: 000, 001, 010, 011, 100, 101, 110, 111.
Wave	A number in each room. Every room starts at 4.
Flip	The ghost room's number changes sign: 4 becomes −4.
Reflect	Every room's new number = 2 × average − old number.
Look	Measure. Flip 7 coins to see if you catch the ghost.

Run the game, step by step

> **Say:** “A ghost is hiding in one of 8 rooms. We cannot open all the rooms. But we can send a wave into every room and make it pile up where the ghost is.”

1. **Show one round together.** Every room starts at 4. Flip the ghost room to −4.
2. **Find the average.** Add all 8 rooms and divide by 8: $(7 \times 4 - 4) \div 8 = 3$.
3. **Reflect.** New number = 2 × average − old number. Ghost room: $2 \times 3 - (-4) = 10$. Every empty room: $2 \times 3 - 4 = 2$.
4. **Check.** Square every room and add: $10^2 + 7 \times 2^2 = 100 + 28 = 128$. It should always be 128. If not, look for a mistake.
5. **Look.** Flip 7 coins in a row. Heads = 1, tails = 0. Read them as a binary number (place values 64, 32, 16, 8, 4, 2, 1). If the number is **less than** (number of ghosts) × (ghost number)², you caught a ghost. One ghost at 10 means less than 100.
6. **Play the Ghost Duel.** The hider secretly writes 1, 2 or 3 ghosts. The hunter secretly writes 0, 1, 2 or 3 rounds. Reveal: the hider says how many ghosts (not where). Fill in the Wave Tracker together, then the hunter looks.
7. **Score and swap.** A catch is 1 point. Swap hider and hunter. Play 6 nights. Most points wins.

Shortcut
All the empty rooms always have the same number. So you only need to track two numbers: G (each ghost room) and E (each empty room).

Watch for these mistakes

- Forgetting that minus a negative is a plus: $2 \times 3 - (-4) = 6 + 4 = 10$.
- Using the old average after the flip. Always flip first, then average.
- Thinking more rounds is always better. It is not! Too many rounds push the wave back out of the ghost room.

Questions to ask

- After 0 rounds, what is your chance of catching the ghost? (Just a guess: 1 out of 8.)
- Which number of rounds is best for 1 ghost? What happens with one round too many?
- You don't know how many ghosts there are. Which choice is the safest?
- Why do the squares always add up to 128?

Answer key: chance to catch a ghost (8 rooms)

Ghosts	0 rounds	1 round	2 rounds	3 rounds
1	12.5%	78.1%	94.5% (best)	33.0%
2	25.0%	100% (best)	25.0%	25.0%
3	37.5%	84.4%	2.3%	99.0% (best)

Big pattern: when the hotel gets 4 times bigger, quantum search needs only about 2 times as many rounds. A million rooms need about 804 rounds. A normal search needs about 500,000 looks.

Wrap up (say this)

Say: “The quantum computer never looked inside the rooms until the very end. It just flipped and reflected, and the wave piled up on the answer. That is how quantum search works.”