GHOST GRID · Facilitator Guide

Quantum tic-tac-toe (two versions) · Grades 6–8

Players	2 players (X and O)
Time	about 15 minutes per game
Big idea	A spooky mark can be in two places at once until it is measured.

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

This is tic-tac-toe with a quantum twist. A **spooky mark** is one move written in **two squares at once**, like a quantum object that is in two places until someone measures it. Later, the spooky mark **collapses**: one half becomes a real mark and the other half disappears. Only real marks count for three in a row.

There are two versions. Start with **Superposition Only**. Move to the **Full Goff game** when students are ready.

What you need

- A computer with Superposition_Only_TicTacToe_Offline.html or Goff_TicTacToe_Offline.html (no internet needed)
- For paper play: a tic-tac-toe grid, two colors of pencil, and one die
- The Grade 6 handouts in this folder (optional)

Words to know

Word	What it means here
Real mark	A normal X or O. It locks its square.
Spooky mark	A pair of small marks with the same move number in two squares (half A and half B).
Entangled	Two pairs that share a square. What happens to one decides the other.
Measure / collapse	Pick which half of a spooky pair becomes real. The other half disappears.

Version 1: Superposition Only (with a die)

> **Say:** “Each turn you can play it safe with one real mark, or go spooky and put your mark in two squares at once.”

1. X and O take turns. On your turn choose:
   - **Classical move:** one real mark in an empty square, or
   - **Superposition move:** a spooky pair in two different squares.
2. A square can hold at most two marks. A real mark locks its square.

3. Keep placing until every square has at least one mark.
4. **Measure.** Take turns. Each player measures only their own pairs. Pick a pair and roll the die: **odd keeps half A, even keeps half B**.
5. The kept half becomes a real mark. If another pair shared that square, it is forced into its other square (entanglement). Empty squares open up again.
6. When every pair is measured, check for three real marks in a row. If nobody wins and there are empty squares, keep placing and measure again.

Version 2: The Full Goff game (no die)

1. Every move is a spooky pair. X plays odd move numbers (1, 3, 5...). O plays even ones.
2. Pairs that share a square become entangled. Draw a line between them in your head.
3. When a new pair closes a **loop** (a circle of shared squares), the whole group must collapse.
4. The player who did **not** close the loop chooses where the newest pair goes. That choice forces every linked pair into one square.
5. Only real marks count. Three real marks in a row wins. If two rows happen at once, the row with the lower highest move number scores 1 point and the other ½ point.

Computer tip
The computer does the forced collapses for you, one step at a time. Click "Next step" so the class can follow each forced move.

Watch for these mistakes

- Counting spooky marks toward three in a row. They never count.
- Putting a mark in a square that already has a real mark. Real marks lock the square.
- Forgetting that a forced collapse can cause another one (a chain).

Questions to ask

- When is a spooky move better than a safe classical move?
- What happened to the other half of your spooky mark when you measured?
- How did measuring one pair change a different pair? (That is entanglement.)
- Is a spooky mark "really" in one square before we measure?

The quantum words

In the game	In quantum physics
Spooky mark in two squares	Superposition
Rolling the die / choosing a square	Measurement and collapse
Pairs sharing a square	Entanglement
Real mark	A definite, measured result

Note: Ghost Grid is a **metaphor**, a story that helps us think about quantum ideas. Real quantum objects follow math rules, not tic-tac-toe rules. Rules adapted from Allan Goff (2006).

Wrap up (say this)

Say: “Before we measured, your mark was in two places at once. Measuring made it pick one. That is one of the strangest and most important ideas in quantum physics.”