Quantum Adventure

— Gamifying Quantum Concepts for High School Learners

This project translates five core quantum concepts—qubit, quantum state, superposition, entanglement, and measurement—into a board game format. By combining familiar mechanics with educational design, the game aims to enable high school students to intuitively grasp abstract phenomena through play, strategy, and interaction.

#EdTech #Interactive Design #SeriousGame **Duration: 3 months** **Role: Game Designer & UX Researcher**

Q-JAM SUMMER CAMP

TIME: 2025.5-2025.8

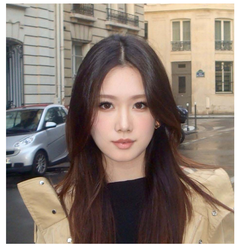
A quantum-themed interdisciplinary summer camp: bridging science, design, and education.

I participated in the Q-JAM Camp as a content contributor, responsible for organizing quantum knowledge, summarizing core concepts (superposition, measurement, entanglement), and developing a structured mind map to support idea generation for quantum game design.

Category
Education Program

Role
Content Contributor
Mind Map Designer

Project Status
Completed and Documented



Yuying (Sofie) Wang

Undergraduate Student in BSc Psychology with Education at University College London (UCL)

Content Contributor at Q-JAM Summer Program

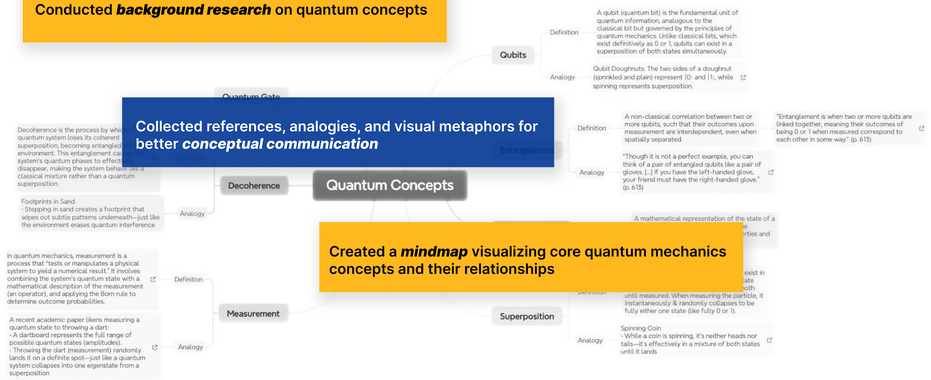
UCL

Preparation

Conducted ***background research*** on quantum concepts

Collected references, analogies, and visual metaphors for better ***conceptual communication***

Created a ***mindmap*** visualizing core quantum mechanics concepts and their relationships



Milestones

Phase 1: Define Focus
Identified key quantum concepts to teach. Teams met weekly by module; biweekly full check-ins ensured alignment.

Phase 2: Research & Mapping
Conducted desktop research and built mind maps to organize content and learner flow.

Phase 3: Design Activities
Drafted interactive modules (games, storytelling, media) mapped to learning goals.

Phase 4: Finalize Plan
Confirmed activity structure, materials, and team roles for the on-site camp.

Personal Reflection

How to make quantum concepts tangible through play?

Analysis

Challenge

Design

"Analyzed quantum concepts and created structured mind maps during Q-JAM

Identified the challenge: key ideas like superposition and entanglement remain abstract for learners"

"Decided to design a gamified learning tool to help high-schooler intuitively grasp quantum mechanics

RESEARCH

Understanding the Learner: What Quantum Concepts Are Teachable to Teens?

While quantum physics is often seen as advanced science, many foundational concepts—like superposition, entanglement, and measurement—can be introduced to high school students without math. These ideas are not only intellectually exciting, but also challenge students to think in new ways about uncertainty, information, and reality.

Why Games? The Pedagogical Value of Playful Learning

Quantum physics is abstract and invisible. Through game rules and mechanics, players experience core ideas like uncertainty and measurement. Learning becomes active, intuitive, and memorable—rather than passive or purely symbolic.

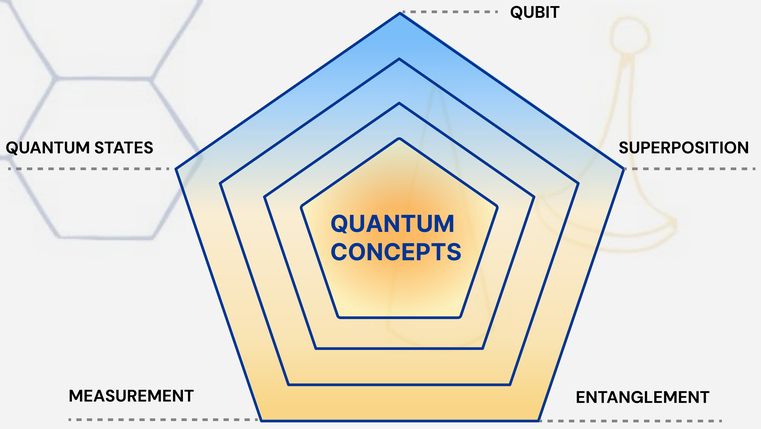
Constructivism — Learners build understanding through interaction—games provide a space to explore complex ideas like superposition or entanglement.

Experiential Learning — Games naturally follow a cycle of doing, reflecting, and adjusting, making abstract concepts feel real.

Situated Learning — Board games create a structured context where learners apply knowledge, not just receive it.

Theoretical Support

Five Core Quantum Concepts



QUBIT is the basic unit of quantum information, like a bit in a regular (classical) computer, but it can be in a state of 0, 1, or both at the same time.

QUANTUM STATE describes everything we know about a quantum system, like the exact way a qubit behaves. It can include being in multiple possible states at once.

SUPERPOSITION means a qubit can be in a mix of both 0 and 1 at the same time, instead of just one or the other.

ENTANGLEMENT is a connection between two or more qubits where the state of one instantly affects the state of the other, no matter how far apart they are.

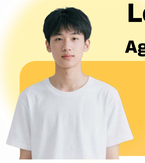
MEASUREMENT is when you check a qubit's state, and it "chooses" one definite value—either 0 or 1. Before measurement, the qubit can be in a mix of both, but measurement forces a single outcome.

INTERVIEW

To understand how teens perceive quantum physics, I conducted interviews with high school students to explore their acceptability with quantum concepts and their interest in learning them through games.

Key Questions

- Have you heard of quantum physics before?
- Can you describe what superposition, entanglement, or measurement means to you?
- Do these topics seem interesting or too difficult?
- Would you enjoy learning quantum ideas through games?
- What type of games do you usually play?



Leo Zhang

Age 17 **STEM Student**

Familiar with basic quantum ideas | Likes logic-based games

"Superposition sounds cool, I get the 'multiple state' idea."
"Games could make this stuff way less scary."

Interested
Confident

Emily Chen

Visual Art Student **Age 15**

Finds science class hard to follow | Likes board games

"Measurement collapse feels like rolling a die in a strategy game."
"If the game is fun, I'd give it a try."

Curious
Needs Accessibility

Jason Lee

Age 16 **Robotics Club Member**

Enjoys puzzle game (e.g. The Witness, Minecraft Redstone)

"Entanglement as a rule between players could be super fun."
"It sounds like a game mechanic already!"

Enthusiastic
Concept-Driven

Sara Kim

Science Club Member **Age 15**

Confused by physics jargon | Enjoys educational puzzles

"I don't know how it works, but I'd play if it explains stuff."
"Can we win or lose based on the quantum stuff?"

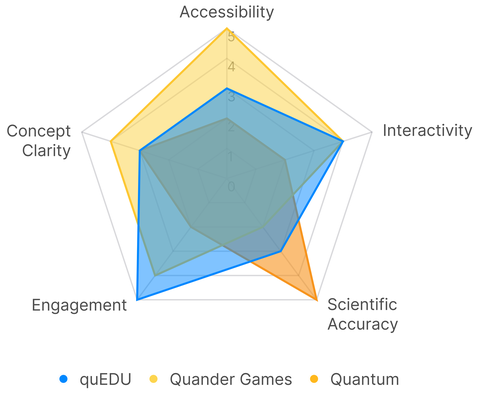
Open
Confused

COMPETITIVE ANALYSIS

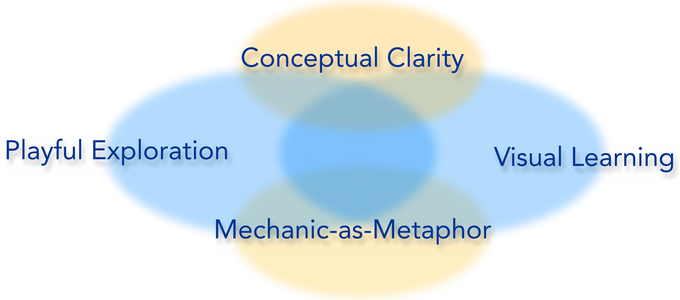
To identify design gaps and opportunities, existing quantum educational tools and games are analyzed.

	quEDU	Quander Games	Quantum
Interface			
Features	Typically teacher-led, limited student interaction	Visual, symbolic, drag-and-drop interface; no math required	A fast-paced strategy game where dice represent ships with variable powers depending on their value
Pros	Offers real experimental results, not just simulation	Highly visual and metaphor-driven; reduces abstractness	Strong graphic design, good physical components, well-balanced rules
Cons	High cost and complexity, limited accessibility	Very metaphorical—limited direct connection to scientific terms or formalism	May be overwhelming for students under 13 or unfamiliar with modern board games

Conclusion



Design Opportunity



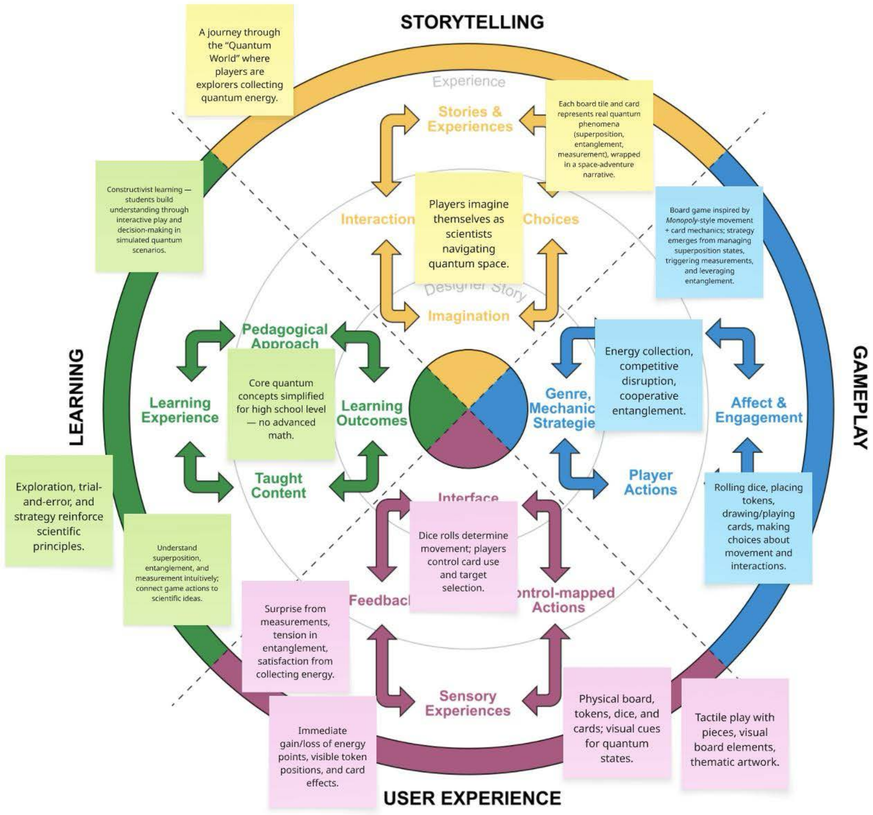
Integrating familiar board game structures with core quantum ideas opens up a playful, hands-on way to explore abstract quantum concepts through visible, interactive game mechanics.

IDEATION

To make complex quantum concepts approachable, the game adopts a grid-based progression system inspired by ***Monopoly***.

Why Monopoly?

- Turn-based mechanics that allow time to reflect on quantum concepts
- A familiar structure that reduces the learning curve for players
- Strategic decision-making that mirrors the uncertainty and probability in quantum physics



Brainstorming By Serious Game Design Methodology

CONCEPT

An Educational Board Game Designed To Help High School Students Explore Quantum Concepts

Brainstorming Conclusion

Game Type

A strategy-based serious game that merges classic board game mechanics with quantum physics concepts for playful STEM learning.

Game Aims

Help high school students *intuitively grasp five core quantum concepts* through interactive play, fostering curiosity and confidence in science.

Scenarios

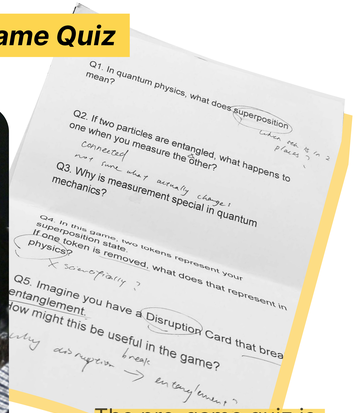
Set in a *fictional "Quantum World"* where players *explore, collect energy, and interact with quantum phenomena* represented by board spaces and cards.

Target User

High school students aged 15–18 with an interest in science, games, and problem-solving, but no prior physics background.

Prototype Test

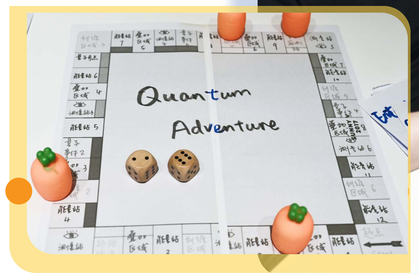
1 Pre-Game Quiz

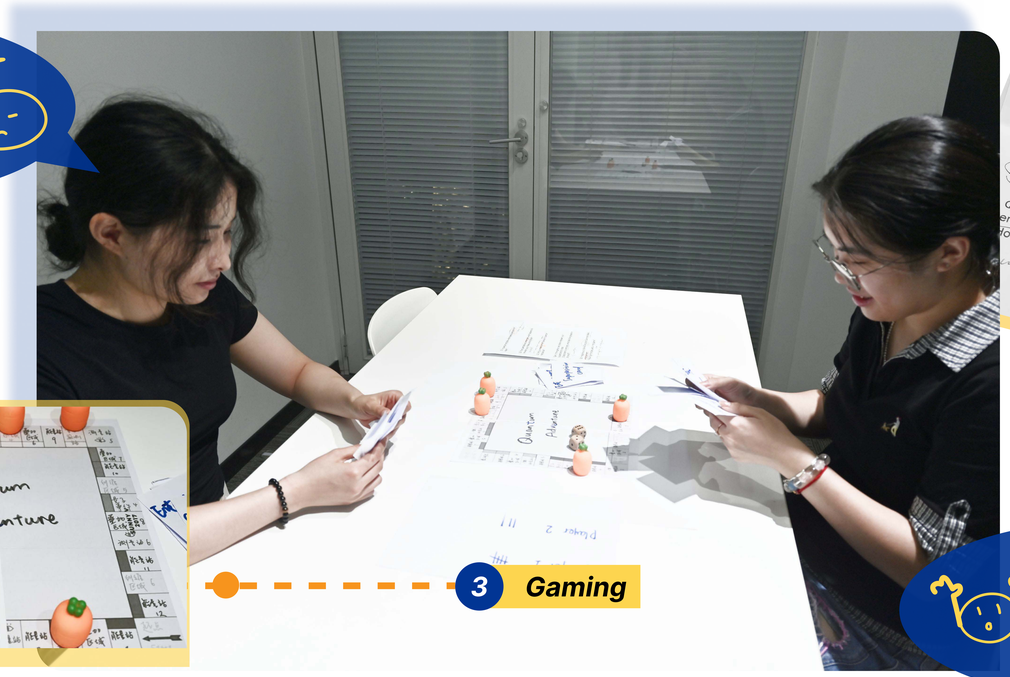


The pre-game quiz is used to compare with the learning outcomes after the game.

The cards contain too much text and are hard to read quickly.

2 Pre-Game Test





3 Gaming

I keep forgetting how much energy I already collected!

Feedback & Improvement

Card Layout: Text-heavy design reduced readability	Simplify with larger icons and concise keywords
Energy Tracking: Players often lost track of collected energy	Introduce energy tokens on a personal tracker board
Token Design: Tokens were perceived as plain and lacking appeal	Redesign with custom pieces reflecting quantum superposition

ITERATION

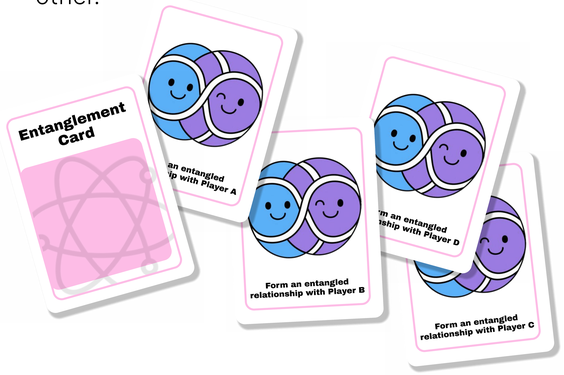
the game evolved from concept sketches to a playable system that links quantum ideas with strategy

Thinking Process

Mapped ***core quantum ideas*** onto ***concrete board actions***.

Focused on ***balancing scientific*** meaning with ***strategic gameplay value***.
Simplified card text into icons + keywords while keeping ***conceptual clarity***.
Refined board layout to maintain rhythm and variety across 40 spaces.
Unified visual language across tokens, cards, and tiles for accessibility.

Used ***playtesting as feedback*** loops, observing both confusion and excitement.
Iteration shaped a system where ***learning goals*** and ***fun mechanics*** reinforce each other.

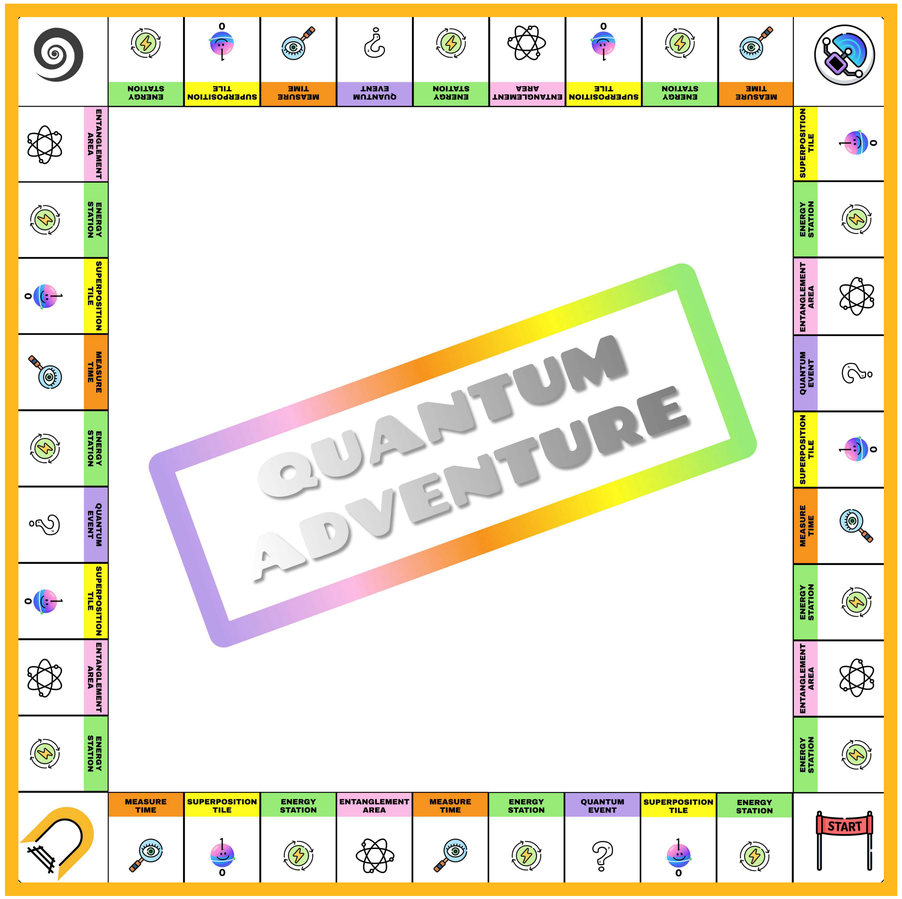


Card System

6 types of cards guide strategy and surprise.

Each card **connects directly to a quantum concept** (superposition, entanglement, measurement, etc.).

Designed with **icons + colors** for fast recognition.



Game Board

40 squares combining energy, superposition, entanglement, and measurement spaces.

Each tile **translates a quantum idea into gameplay mechanics**.

Balanced layout ensures progression, strategy, and unpredictability.

Comparison with Early Prototype

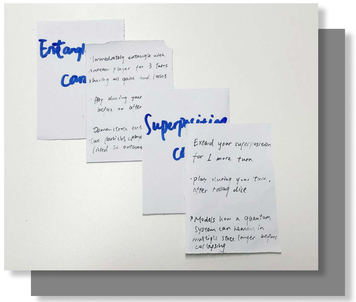
Prototype Issue

The concept of superposition was hard to visualize when using identical tokens

Players often forgot progress because there was no way to track loops

Implemented dual-piece tokens to visually convey two simultaneous states

Added a round counter, making the game easier to follow



The cards were word-heavy and slowed the game

Redesigned the cards with minimal text + clear icons, improving speed and accessibility

Reaction while testing the final version

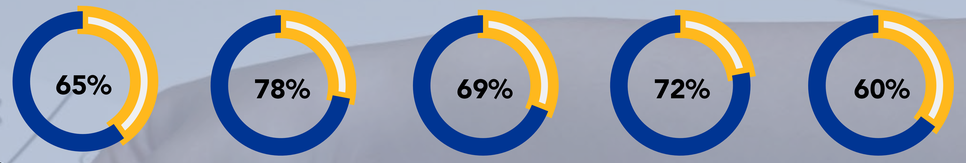
- "Rolling two dice and placing two tokens felt unique — I instantly got the idea of ***being in two states at once***."
- "The collapse mechanic was tense and exciting; every measurement felt like a dramatic moment."

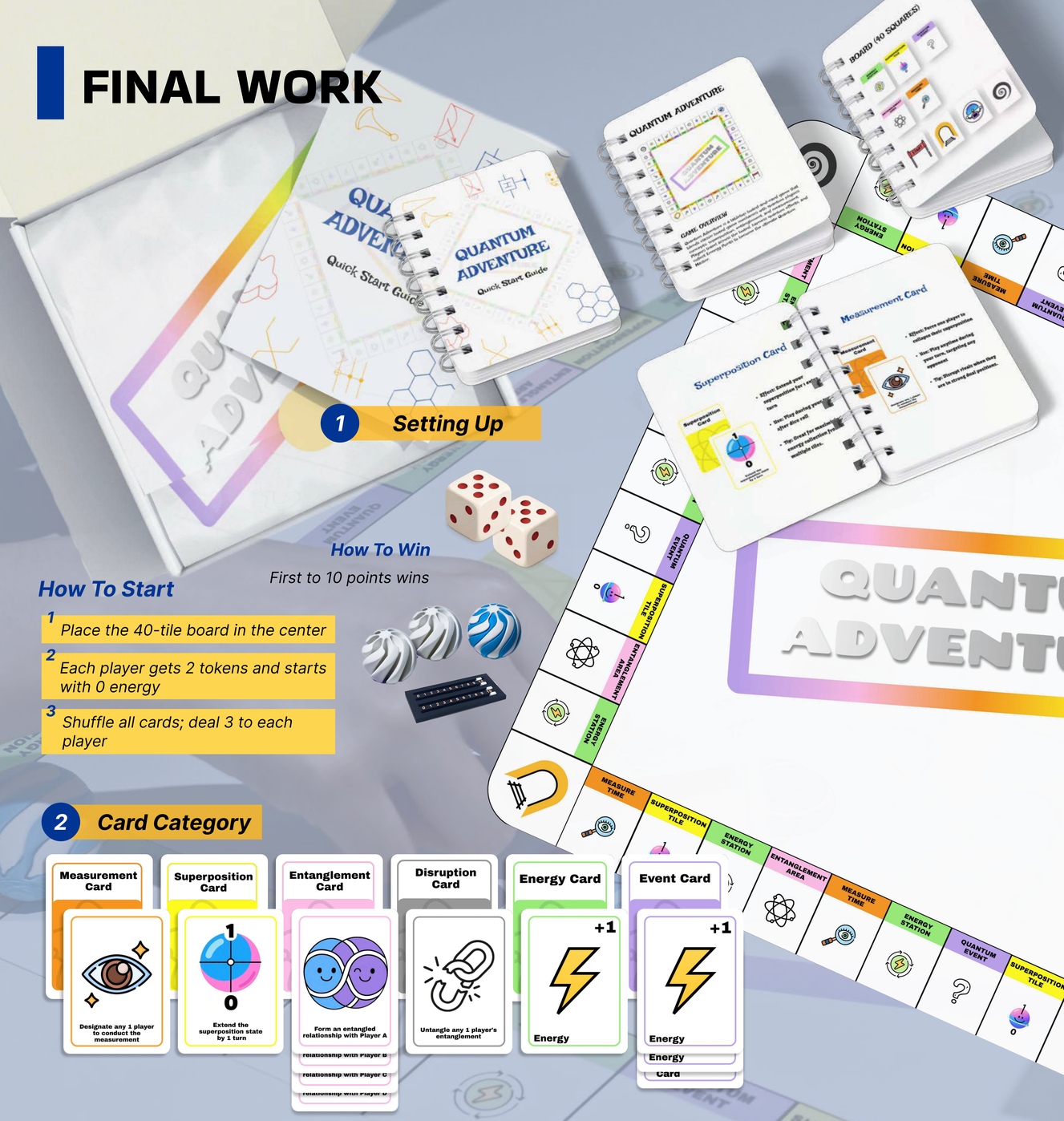
- "Entanglement added a fun twist — I liked how I sometimes benefited from another player's move, but also had to deal with their risks."

- "The Quantum Event cards were my favorite part — unpredictable but still balanced, like real quantum uncertainty."
- "The combination of cards and board effects gave me multiple ways to play — I felt in control even with randomness involved."

FINAL WORK

During the final game test, participants find it easier to connect terms to quantum logic and strategic gameplay, indicating better understanding towards each 5 quantum concepts





1 Setting Up

How To Start

1. Place the 40-tile board in the center
2. Each player gets 2 tokens and starts with 0 energy
3. Shuffle all cards; deal 3 to each player

How To Win

First to 10 points wins

2 Card Category

3 Board Spaces

Superposition Tile

- Grants a Superposition Shield (immune to one measurement) — modeling how a system can remain in superposition without collapsing until observed.

Entanglement Area

- Entangle with another player for 3 turns, sharing gains and losses — mirroring quantum entanglement where two particles' states are linked

Quantum Event

- Draw a random event card with boosts or penalties — reflecting quantum fluctuations and unpredictability in physical systems.

Measure Time

- Roll 1 die to keep one token and remove the other — simulating wavefunction collapse, where measurement forces one definite outcome.

Energy Station

- Gain +1 energy point for each token — representing how particles store and exchange quantum energy in different states.