From entanglement to engagement

Physics lessons for today's students

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My projects

1. PhysicsQuest

- Lesson plans
- Quantum research
- Pedagogy

2. STEP UP

- Career profiles
- Conducting interviews
- Profile research

Project 1: What is PhysicsQuest?

- Long-standing APS public engagement initiative
- Publishes four activity-based lesson plans every year
- Focuses on a single theme
- Available for middle and high school teachers to freely access

PhysicsQuest 2024: A Mysterious Matter

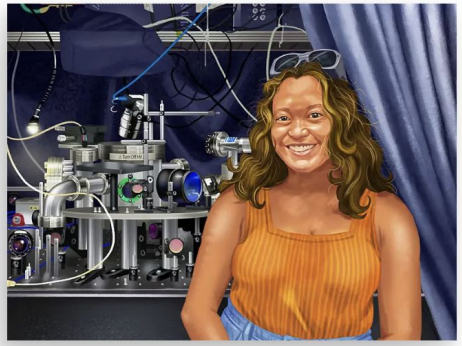
This kit was created in partnership with the American Physical Society's (APS) Division of Plasma Physics (DPP). These lessons show us where we find plasma - the fourth state of matter - in our universe and all around us. The kits introduce students to plasma, its properties, how stars are formed, and how stars can "be bottled" to create clean energy used here on Earth. Together, students will learn about this mysterious matter - plasma.

View PhysicsQuest 2024 →

PhysicsQuest 2023: Making Waves

In collaboration with Little Shop of Physics, APS offers four engaging activities centered around the fascinating world of "waves." Waves are all around us, shaping our world and providing energy, such as the sun's electromagnetic waves. Understanding these waves unlocks the secrets of our universe. These Making Waves activities are perfect for your physics curriculum, serving as captivating prelude activities or post-learning explorations

Discover PhysicsQuest in our learning resources →



International Year of Quantum

Quantum2025.org

- Global initiative celebrating 100 years of quantum science, designated by the United Nations
- Goal: broaden public understanding of quantum
- PhysicsQuest has planned to release eight lesson plans on quantum physics this year

The challenge

- Quantum physics is hard!
- Many teachers lack a background in quantum
- Only 35% of high school physics teachers have a degree in physics or physics education
  - ↳ Much lower for middle school science teachers

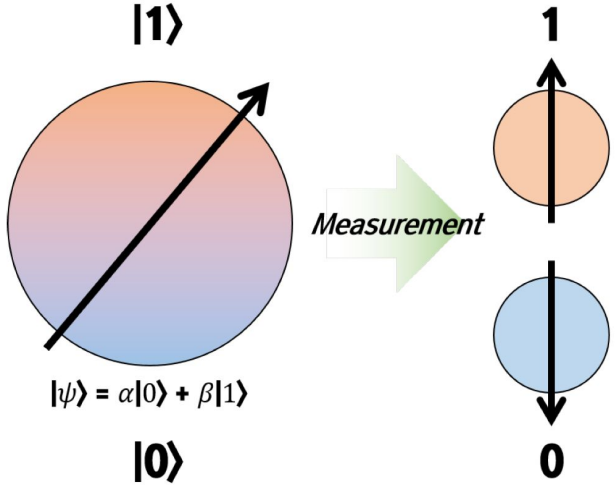
My role

Modify the eight lesson plans to make them:

- Completely accessible to teachers without a quantum background
- Understandable to students
- Flow seamlessly between topics in quantum physics
- Pedagogically sound

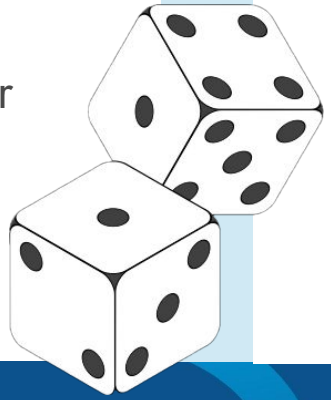
What did this look like?

- Researching topics within quantum physics
  - Superposition
  - Entanglement
  - Quantum computing
- Looking at each lesson through the lens of a teacher and a student
- Modifying explanations to be simpler while still complete
- Finding supplementary resources to provide teachers for harder concepts



Filling the gap

- Several lessons about quantum computing
- Missing an introduction to the quantum atom
- Made a prequel to Activity 4 to fill the gap
- Uses dice as an analogy for superposition and measurement of electrons



PhysicsQuest 2025 "Tangled" lesson prequel:
Visualizing a probability distribution

Developed by: Rosie Durland - Utah Valley University

Teacher Guide

Students may have seen diagrams of the atom that follow the Rutherford or Bohr model, where the electrons are orbiting the atom. This lesson is a good opportunity to clarify that these "orbiting" models are incomplete. We now know that even a single electron exists in many places surrounding the nucleus at once, and has many different properties at once. When scientists try to measure where the electron is and how it is behaving, the electron "collapses" into a single particle. After measuring electrons in an atom over and over again, a map can be created that shows where the electron is most likely to exist. This is a probability distribution map.

In this activity, students can practice creating a visual probability distribution to better understand the concept of superposition and the electron. This optional activity lesson is best done *before* the Tangled lesson (Activity 4), if students are not yet familiar with the quantum atom.

Intro/hook suggestion:

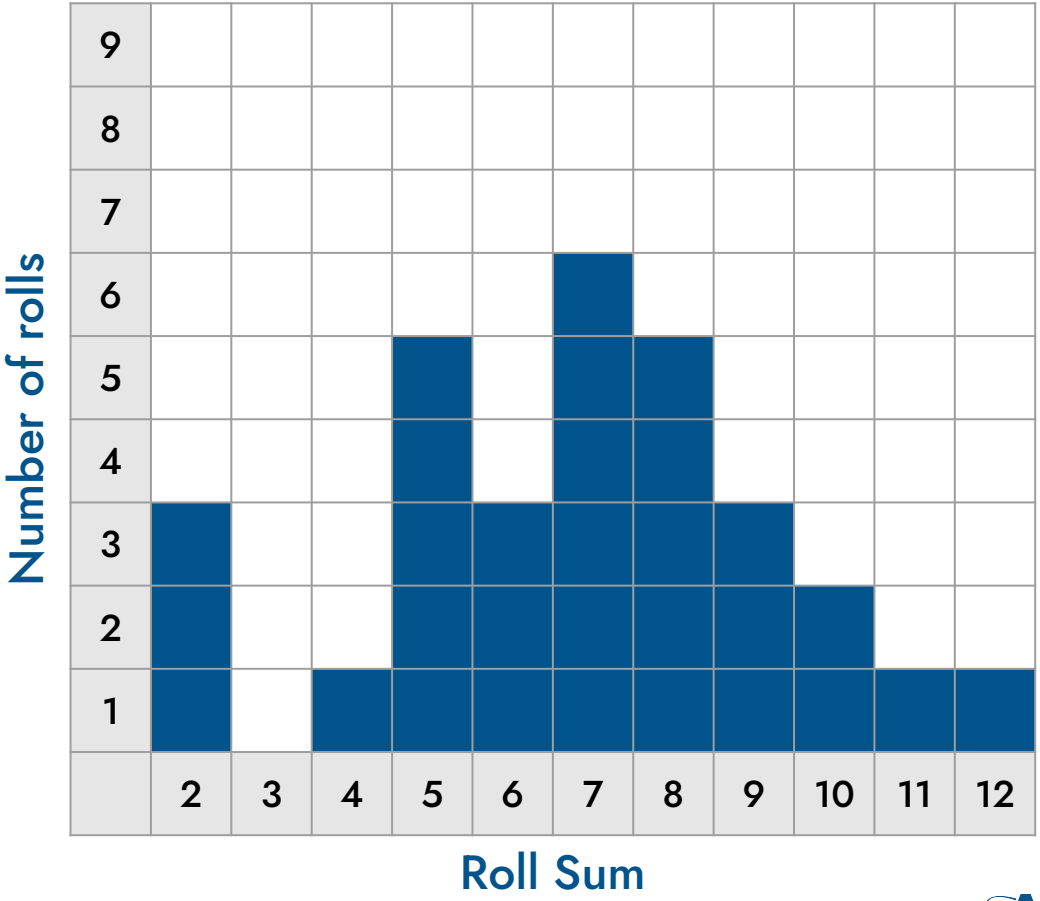
Have you ever played a game where you had to roll dice? Have you ever wished that you could make the dice land on a certain number to help you out? Today, you might get a little better at predicting how dice are going to land, and you'll learn why dice and electrons are related!

Part 1: Histogram data

Students roll a pair of dice 30 times, which can be done in groups or as a class. If you're short on time, do it as a class. The student guide includes a chart for them to compile their data. Physical dice is preferred (rather than an online generator), because it's easier for students to visualize the superposition. Have students predict what the roll will be each time; this can be done informally, or written down. Making predictions is just intended to show that as the pattern emerges, it gets a little easier to predict the outcome of the roll, but you can never predict with 100% certainty.

Sample distribution

- Students roll a pair of dice 30 times
- Dice are in “superposition” before they land
- Can’t know the outcome of a single roll, but the behavior does add up to a pattern



Visualizing probability with color

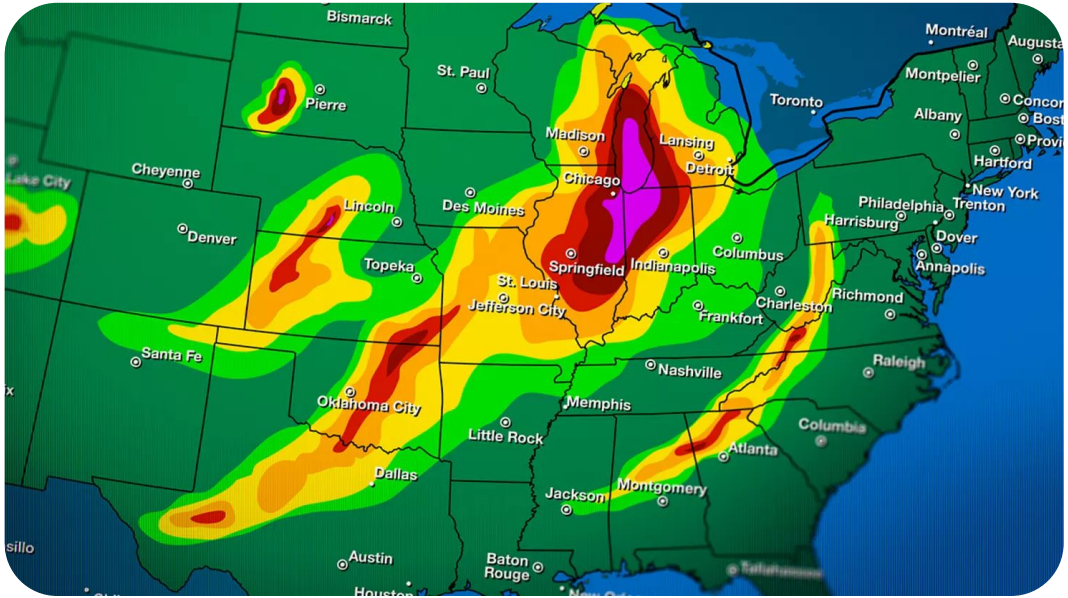
Sample distribution:

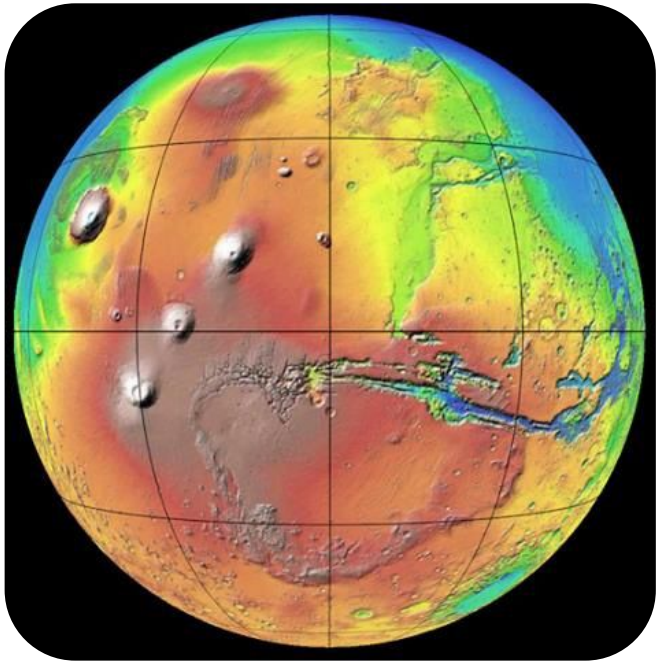
Key:

Less likely → More likely

Why use color?

Color-coded data is really useful for things that we want to talk about *spatially*





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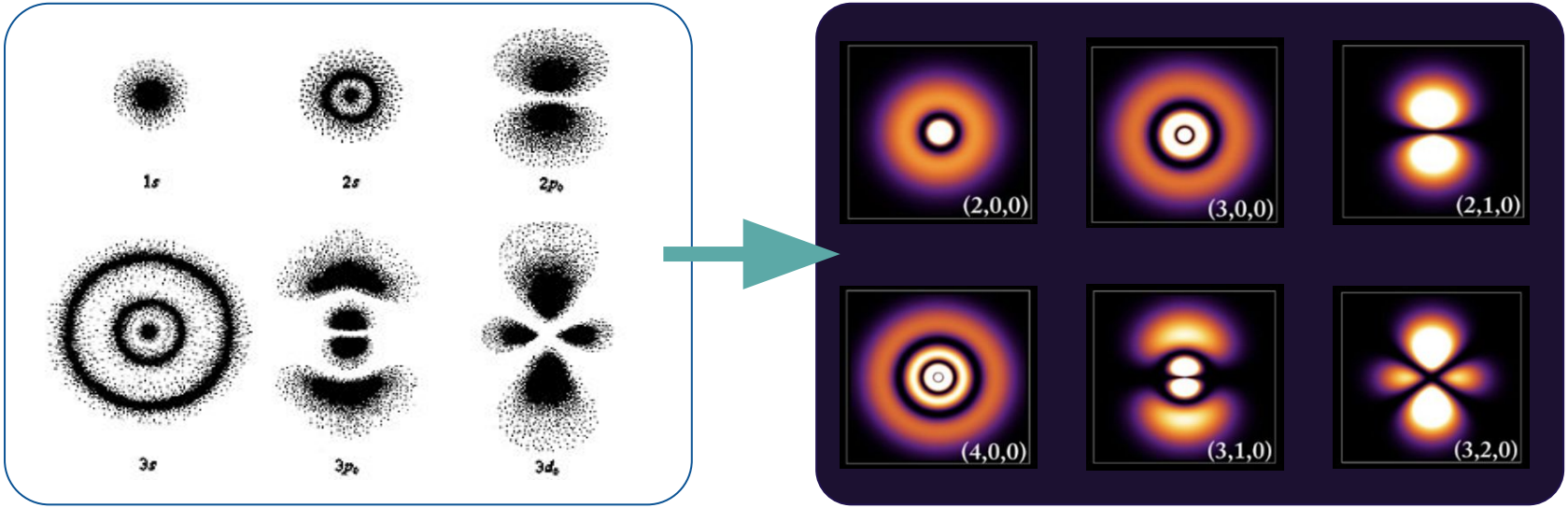
Spatial probability distribution



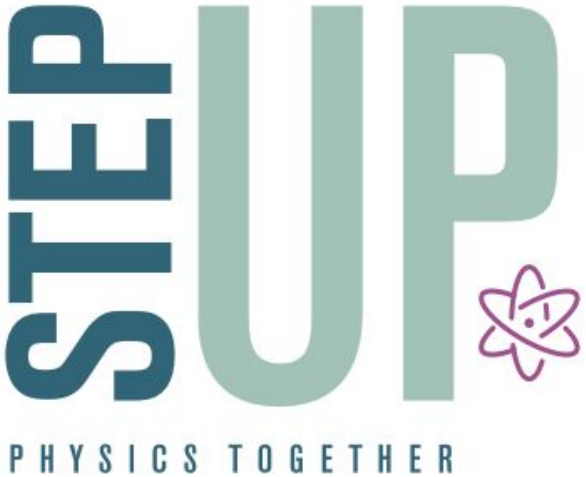
Students create a probability density diagram for the electron

Final adjustments

- Revised the remaining lessons for
  - Clarity
  - Conciseness
  - Grammar
  - APS style guideline requirements
- Unified the structure of each activity

Project 2: What is STEP UP?

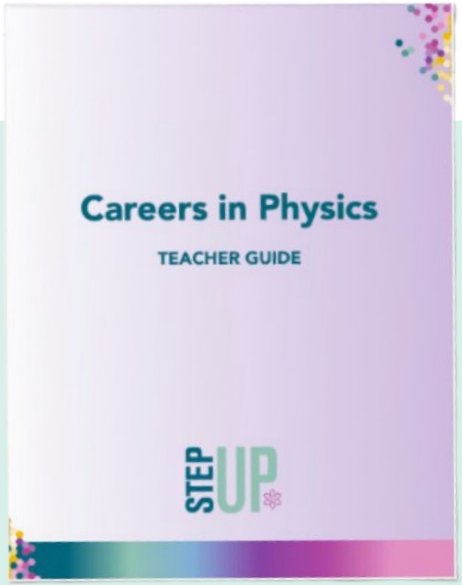
- Community of educators, researchers, and professional societies
- Goal: increase the number of women and other under-represented groups majoring in physics
- How?
  - Women in Physics lesson
  - Careers in Physics lesson
  - Everyday Actions guide
- Implement resources in the classroom



APS

Careers in Physics lesson

- Students take a 2-question survey about their interests and work values
- Matches students with profiles
  - Real people who studied physics
  - Now pursuing careers related to the student's interests
  - Helps students see the pathways available to them in science



The challenge (#2)

- The Careers in Physics profiles needed expanding
  - More types of science communication
  - More tradespeople/ industry professionals
  - More musicians

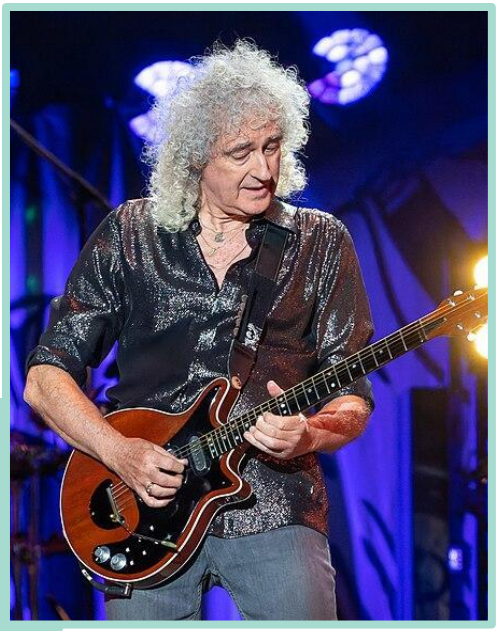
My role (#2)

- Reach out to possible participants
- Do background research
- Conduct interviews
- Produce complete profiles

My profiles

Shalma Wegsman

Podcast host of *Why This Universe?* and freelance science journalist



Brian May

Rock guitarist for *Queen* and Ph.D. astrophysicist

Takeaways/what I learned

PhysicsQuest

Creating activity-based lessons takes a lot of thorough planning

You can teach quantum concepts as early as middle school

I really enjoy unifying documents to a style guide and each other

STEP UP

People who study physics go on to do so many amazing things

I enjoy the human aspect of hearing about people's journey through science

I want to be a high school physics teacher more than ever!

Thank you!

Special thank you to **Nicole Schrode**, Allie Lau, Meg Healy and Claudia Fracchiolla for their support and mentorship this summer.