Wizards of Wright

Lesson: Quantum Computing – Superposition

Background Info for Wizards:	This is **very different** than other WOW! lessons you may present. This kind of topic does not lend itself to multiple, educationally valuable, hands-on activities…but it is an opportunity for understanding a new concept. There is a booklet to work through as a class. It is more valuable if read out loud and together. You should talk with the teacher before beginning about how readers should be chosen in this classroom. The "story" is broken up into very small paragraphs, so each reader can take on as much or as little as necessary.
Materials:	Baggies of 5 binary cards for each group. Quantum Computing booklets for each group to share.
Lesson Time: ***70 minutes***	Introduction: 10 minutes Guided Lesson #1: 5 minutes Student Activity #1: 10 minutes Guided Lesson #2: 5 minutes Guided Lesson #3: 5 minutes Student Activity #2: 30 minutes Conclusion: 5 minutes
Learning Targets:	Students will review the base-10 number system that we use. Students will have a better understanding of the binary system and be able to explain the difference between base-10 and binary. Students will be introduced to quantum computing and see the expected value of quantum computers.

Introduction for Students: 10 minutes	**Say to the students:** Today we will introduce you to the new field of quantum computing. You'll also learn about the quantum concept superposition. There are other concepts called entanglement, and uncertainty that we can cover at another time. We should define quantum. Quantum science is the study of things that are very, very small. This branch of science investigates the behavior of matter and the activities happening inside of atoms. Before you can understand quantum computing, it's important for you to understand that the computers of today still rely on bits and the binary system. Once you have a better understanding of binary code, then you'll see how it is different form quantum computing. Let's talk, for a moment, about base 10 numbers. This is the number system we all use today. It's how we count and understand place value. **Ask students:** Can anyone explain the base-10 system? - In base-10, each digit of a number has an integer value ranging from 0 to 9. Each number position is 10 times the value to the right of it, (this is where the term base-10 comes from). - Numbers greater than 1 appear to the left of a decimal point and have the following place values: Ones, Tens, Hundreds, Thousands, Ten-thousands, Hundred-thousands, and so on. **Say to the students:** Computers also use a number system, but they don't use the base-10 system. Computers use the binary number system, which is base-2. The system we use every day (also called the decimal system) uses 10 digits. The binary system is a system of bits consisting of only 0 and 1 to communicate. It is a way to write numbers using only two digits. In the decimal system each digit's place value increases by a power of ten. In binary, each digit's place value is twice as much as that of the next digit to the right.
Guided Lesson #1: 5 minutes	**Say to the students:** I want you to think about a light switch. In one position, it is on and in another it is off. The binary system plays a fundamental role in the way computers store data. They execute logic and arithmetic operations with two digits or states:

	- 1 or 0 - which also means on or off - which could also mean yes or no, or true or false Inside the computer, alphabet letters and symbols as numbers get converted to the zeros and ones of binary code. Each 0 or 1 is called a bit (short for binary digit). For example, the number 45 is represented by 101101 using 6 bits.
Student Activity #1: 10 minutes	**(Students will be working in small groups for this activity. Groups should be just 2-3 students. Ask the teacher if the groups have already been created. If not, wait while he or she does this.)** **Say to the students:** Let's play with the binary system for a few minutes. Give each group a set of cards and ask them to lay them out in front of them, the same way you lay out yours. (It might be beneficial if you use magnets to put yours on the board.) Explain that one size shows dots…this is when switches or transistors are on, and the blank side is when the transistors are off. Show the students your 5 cards. - Card 1: 16 dots - Card 2: 8 dots - Card 3: 4 dots - Card 4: 2 dots - Card 1: 1 dot **Ask students:** What do you notice about the number of dots on the cards? - Each card has twice as many as the card to its right. **Ask students:** How many dots would the next card have if we carried on to the left? - 32 - The next…? **Say to the students:** We can use these cards to make numbers by turning some of them face down (off) and adding up the dots that are showing. - Show the class that by turning several over, they way to make 6 is keep 2 cards showing. (the 4-dot and 2-dot cards) **Ask students:** How will we show 15? - 8-, 4-, 2- and 1-dot cards

	How about 21? - 16, 4 and 1 **Say to the students:** When a binary number card is not showing, it is represented by a zero. When it is showing, it is represented by a one. **Ask students:** So, how would our computer represent these numbers? - 2? (00010) - 15? (01111) - 21? (10101) **Ask students:** If the binary code was: 01001 (flip the cards) What number is this in decimal? - 9 What would 17 be in binary? - 10001 If you think it's necessary, you can try a few more. Collect the cards.
Guided Lesson #2: 5 minutes	**Say to the students:** This binary system limits computers to doing 1 thing at a time. Meaning that today's computers, while fast, are beginning to use too much time and energy (power) to perform tasks or follow directions. Add storage issues into the mix, and a more efficient path of computing sounds pretty good! That brings us to quantum computing. We are going to learn about how quantum bits, or qubits, will change the computing world completely. **Ask students:** Who can tell me the smallest unit of matter is? - Correct! An atom! **Ask students:** What if you took that atom apart? - Protons, Neutrons and Electrons **Say to the students:** We call this – "science at the subatomic level." This is quantum science! When working with protons, neutrons, and electrons we are working with the subatomic particles. According to the laws of physics, atoms can only be 1 thing or another. But quantum or subatomic particles can be more than 1 thing at a time. Amazing, right? Through the years, we have

	learned just how important these tiny particles are. Thanks to quantum technology, we have better medical devices, lasers, cell phones, and light bulbs. Soon we will add computers to that list!
Guided Lesson #3: 5 minutes	**Say to the students:** Now let's jump into quantum computing. Each group will need a booklet that we will read through. (Pass out the booklets.) To get started, we must take you to our secret laboratory. Don't worry! You won't be alone….
Student Activity #2: 30 minutes	You will work through the booklet as a class. There are points along the way where questions are asked. You can also stop at any point to answer other questions they might have.
Conclusion: 5 minutes	Take some time to review the following topics: - Base 10 numbers - Binary numbers - What does the word quantum mean? - What does the word subatomic mean? - Why are scientists working so hard on quantum computing? What value will it bring?

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