Learn Binary Bingo Lingo

Activity Rundown:

Has anyone ever wondered how computers really work? I am sure many of us know about the concept or coding and programming, but how do they actually know what we want them to do? Well, throughout the course of this activity we will explain just that! While also playing a fun game of bingo with a few of your friends or family.

You will need:

- Sticky notes
- Binary Cue cards (see background)
- Coloured paper (cardstock if you have it)
- Dot stickers in different colours (or whatever you have similar)
- Bingo sheets
- Counters or erasable markers (pencil works too)
- A small prize
- Binary table (With numbers up to 31)

Let's do it!

1. First, we must learn about the binary number system. The depth of the explanation will be completely up to you! (See background information, especially the guiding questions.)
2. Another way of teaching binary, which may be best for those that are a bit younger is as follows:
   - (You can do this with dots on paper or a white board if you have one)
   - Draw one dot. How many dots would you have if you doubled this amount? (Two -draw another dot on the piece of paper.)
   - How about if I doubled it again? (Four - draw two more dots on the paper)
   - Keep going until you get to 16 things in total.
   - We can actually represent any number by adding up some of these doubles. (1, 2, 4, 8, 16…) Take a look at our counting cue cards (found below).
   - Get them to try and make 5, 10, 11, 8… just for some practice.
3. Another way: talk about plain old counting. Count out loud FROM ZERO up to ten, writing the numbers on the paper as you go.

- When you get to ten, ask yourself what's different about ten compared to all the other numbers so far. (It's two digits.) Why can't we express ten as a single digit? (Because we don't have any more numbers).
- Think about this: we use the digits 0 - 9 to represent quantities, but when we have *more* than 9 things, we have to start using the digits in combination.
- What do we call the second column that we have to add for 10? (The tens column!)
- We are going to try counting in a different way. What if we only had digits up to 4?
- 0, 1, 2, 3, 4, ….
- When counting in base 5, 5 is represented as 10.
- Now onto binary.

4. Print out a set of Cue Cards for whoever would like to play. These cards look like this (can be found below in background):

Front	┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ (16)	┬ ┬ ┬ ┬ ┬ ┬ ┬ ┬ (8)	┬ ┬ ┬ ┬ (4)	┬ ┬ (2)	┬ (1)
Back					

5. Order the cards from biggest to smallest (so they should end up in the order above).
6. Green is the same as a 1, and red is the same as a 0 in binary. So, say I have a binary number that is 01010, I would turn my cards over so that they are in the same pattern. Since my first number is a 0, I turn my first card (or biggest one) to the red size. The second number is a 1, so I turn my second card (eight) to the green side, showing the eight dots. Next, a 0 so it's red. And then a 1, green. Last, I have a 0 so it's red. So right now, I should have red, green (eight), red, green (two), red. To find out what the number is, I add up the dots on all the cards that are green. In this case,

I would get 10 (8 +2 = 10). Using these cards, they will be able to figure out the binary representation of any number up to 31.

7. To practice learning binary numbers, play a game of Bingo.
8. How it's going to work: Those playing will get Bingo cards with numbers written "normally" on them. The announcers or whoever would like to call out the numbers, will call out numbers in binary, and those playing will have to convert (using their cue cards) back to decimal (or normal numbers) in order to figure out if they have that number on their card.
9. You can use a pencil or anything you can find around the house to mark off your sheet.
10. Decide with everyone playing beforehand what determines the end of the game (blackout, one line, two lines, only a diagonal line… etc. You can also decide this based on how much time you have). Especially with younger children, after each number is called out and they have a chance to convert it to decimal, make sure that everyone knows what the number was.
11. Here you can discuss some of the applications of binary in the real world. Compare 0's and 1's to turning a light on and off using a switch. It's really easy to tell if you have a 0 (off) or a 1 (on). Talk about how in a computer, *everything* is stored as a sequence of 0's and 1's, which is a lot easier than having "switches" that can go ten different directions. Also, having just "on" and "off" prevents us from making mistakes.

Background:

Binary Number System

This number system can be used to represent any number, but only uses two digits: 0's and 1's. The system is base-2 instead of base-10 (or decimal), which is what our regular number system is. (The reason we use base-10 is because we have 10 fingers!)

In the decimal system, we use something called place value. For example, when writing a number, you have the ones column, the tens column, the one hundred columns, and so on. You can think of any number as being the sum of each digit multiplied by the place value of that column.

Also note: since our system is base-10, we only have distinct digits for numbers up to 9 (or 1 less than 10). This is important to remember for later.
For example:
517 = 5*100 + 1*10 + 7*1   or 517 = (5 hundreds) + (1 ten) + (7 ones)

Binary works much the same way, except it is arguably simpler. The place value of each column is now a power of 2. So, the first column is still the ones column, but the second column is the twos column. The third column is the fours column, and next is the eights column. Since this is binary, we only have two digits that we can use: 0 and 1. For younger age groups, you could make up a group of aliens and explain that they only have two fingers, instead of ten. Because of this, the only digits they know how to use are 0 and 1, but they still can write any number.

For younger students, you could maybe make up an alien that only has two fingers for the explanation of why a number system might have two digits instead of ten.

Digit	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1
Place Value	16	8	4	2	1

For example: [Converting from binary to decimal]
Say we have a binary number, 1101. Using the place value chart above, we get…
01101 base-2 = 0*16 + 1*8 + 1*4 + 0*2 + 1*1 = 13 base-10
Or, we could say: 01101 base-2 = (1 eight) + (1 four) + (1 one)

Adding in Binary (For older students)
Simple addition examples:

Base 10	0 + 0 = 0 (zero)	0 + 1 = 1 (one)	1 + 1 = 2 (two)
Binary	0 + 0 0 (zero)	1 + 0 1 (one)	1 + 1 10 (two)

Adding in binary works exactly the same way as it does in base 10 in terms of carrying. (As you can see in the third column).

For example : [Base-10]

Carries		1	
Number A		3	7
Number B	+	2	6
Answer...		6	3

For example: [Binary]

Carries		0	1	
Number A		0	0	1
Number B	+	1	0	1
Answer...		1	1	0

Guiding Questions for Introducing Binary (Adapted from: http://www.garlikov.com/Soc_Meth.html)

Note: this might only work with the grade 5-6 group since some of the grade 3-4 group won't even know how to multiply and might not have as much intuitive "number sense". Tell them that you're going to teach them the code used by computers everywhere, but that you're not going to outright tell them anything about it - only ask them questions. Tell them that they can shout out answers for this instead of raising their hands.

1. How many is this? (Hold up ten fingers)
2. Who can write that on the board? (Get them to do this a few different ways… 10, IIIIIIIIII, 卌 卌, ten, X…)
3. Talking about "ten": what is this? (The word ten)
4. What are written words made up of? (Letters)
5. How many letters are there, and how many words can you make out of them? (26, lots!)

6. Talking about “10”: what is this way of writing numbers made up of? (Digits or numerals)
7. How many numerals/digits are there? (Ten… 0123456789) Have them list the numerals in order and write them on the board.
8. How come we have ten digits? Do you think it could be because we have ten fingers? (Yep.)
9. What if we were aliens with two fingers? How many digits would we have? (Two)
10. How many numbers do you think we could write out of two digits? (The kids will likely think there is a problem, or that we wouldn’t be able to write very many numbers)
11. Why is there a problem/why couldn’t we write not many numbers? (They might say that we wouldn’t be able to write more than two numbers…)
12. Well, let’s see what the aliens could do about this problem. Here’s the digits we wrote down earlier (pointing to the ones written on the board). If we only had two digits and we did it like this, what digits would we have? (0 and 1)
13. Okay, now what can we write as we count, starting at zero?
    (0 Zero
    1 One
    … They probably won’t get any farther than this)
14. Is that all we can do? What do we do on this planet when we run out of digits at 9? (We write down one zero (10))
15. Why? (They’ll likely say “I don’t know, that’s just how you write ten.”)
16. You have more than one digit here, and you have already used both of them - how can you use them again? (You put the 1 in a different column)
17. What do you call the new column that you put it in? (The tens column)
18. Why do you call it that?/What do the 1 and 0 mean when written in these columns? (We have 1 ten and no ones)
19. But why is this a ten? Why is this (point to it) the tens column?
20. I’m sure there’s a reason. What was the first number that needed a new column for you to be able to write it? (...Ten!)
21. Maybe that’s why it’s called the tens column. What is the next number that needs a new column? (100) And what is that column called? (The hundreds column)
22. After you write down 19, what has to change to write down twenty? (1 to a 2 and 9 to a 0)

23. So that means there are two tens and no ones because two tens is how many? (Twenty)
24. What’s the first number that needs a fourth column? What column is that? (1000, thousands)
25. Okay, let’s go back to pretending that we are two fingered aliens. We have 0 (zero) and 1 (one). What could we do to write two if we do the same thing we did over here (point to the tens column) to write the next number if we have run out of numerals? (Guide them towards the answer “start another column”)
26. What would we call this new column? (Twos column! Since the first number we need for it is two!)
27. So what do we put in the twos column? How many twos are there in two? (One)
28. And how many ones extra? (Zero)
29. So then two looks like this… (write on the board, 10), right? (Yeah, but that looks a lot like 10…)
30. Only because you didn’t learn it like the aliens did! They learn it that way in preschool, just like you learn to call one zero “ten”, they learn to call it “two”. How long does it take a kid in preschool to learn how to read numbers, especially if they have more than one column?
31. Is there anything obvious about calling “one zero” ten, or do you have to be taught to call it ten? (Taught it)
32. So since we’re two-fingered aliens today, I’m teaching you different. What is one, zero here? (Two) It’s kind of hard to see it though, right?
33. So what number comes next? (Three)
34. How would we write three in alien? (It’s 11, you might have to guide them through it… We have a 1 in the twos column because we have one two, and we need 1 extra… so we put a 1 in the ones column)

    So we have:

    0 zero
    1 one
    10 two
    11 three
35. Now we’re out of numerals again. How do we get to four? (Start a new column) What do we call it? (The fours column - label the columns as you write the numbers)
36. So, how would I write four? (100)

37. Next? (101)
38. Now let's add one more to it to get six. Write down the addition on the board like this:

    101
    + 1

We have to be careful though, because we can't write the digit 2, we only have zero and one. So we need to carry…? (one)

39. And we get? (110)
40. Why is this six? What is it made of? (Look at the columns: it has one four, and one two… which is six).
41. So what would seven be? (111)
42. And we are out of digits again. How would we write eight? (New column, 1000.)
43. (Keep going up to ten.) So now how many numbers do you think we can write using just a one and a 0? (All of them!)
44. So who actually uses this stuff? (Nobody… or maybe aliens)
45. Well, actually, you use it everyday. Where would you use it?
46. What about a light switch? How many positions does it have? (Two)
47. What would you call these? (On/off or up/down)
48. What if we assigned them numbers, what would you call them? (Hopefully they say 0 and 1, not 1 and 2, but guide them towards the 0 and 1 answer.)
49. It turns out computers have lots of tiny parts inside them that work a lot like switches, where one way represents 0 and the other way represents 1. Electricity can flip these switches on and off really fast, but at the end, the computer translates all the zeros and ones back into normal numbers and letters so that humans can read them and know what all the answers are.

References:

1) http://www.exploringbinary.com/how-i-taught-third-graders-binary-numbers/
2) http://matheducators.stackexchange.com/questions/4367/how-to-teach-binary-numbers-to-5th-graders
3) http://www.garlikov.com/Soc_Meth.html

Reach out!

We would love to hear from you about all the amazing STEM projects you are doing at home! Show us your finished products on any of the following social media platforms by tagging us or by using the following hashtags. We hope these projects have brought some excitement to your day during these difficult times.

Let us know how we did! Please click here to fill out a short survey on how well we did and what you would like to see more of in the future. Thank you!

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