Title: *Count the Dots* - Binary Numbers

Subject Area: Computer Science

Grade Level: 2 (suitable for 6 and older)

Related Standards of Learning:

Mathematics: Number – Exploring numbers in other bases. Representing numbers in base two.

Mathematics: Algebra – Continue a sequential pattern, and describe a rule for this pattern.
Patterns and relationships in powers of two.

Classroom Set-up:

1. Unplugged (taught without the students needing a computer),
2. Projector for Powerpoint slides and videos

Objective:

1. Develop Computational thinking (fundamental principles on which computers and networks operate)
2. How can we store information in computers?
3. What is the difference between data and information?
4. How can numbers, letters, words and pictures be converted into zeros and ones?
5. Algorithms and how they are used in Sorting networks to speed up computers

Summary:

Students are taught about how data is stored in computers and use of the binary number system using the Activity: *Count the Dots*. Activity was adapted from csunplugged.org document 2015 Revision. http://csunplugged.org/binary-numbers/. As an additional activity the concept of algorithms and how they are used in Sorting networks (a strategy computers use to sort random numbers into order)
to speed up networks was discussed. Students were then led into an activity to turn themselves into a simple sorting network where they compared the number cards they were holding and sorted themselves into ascending order.

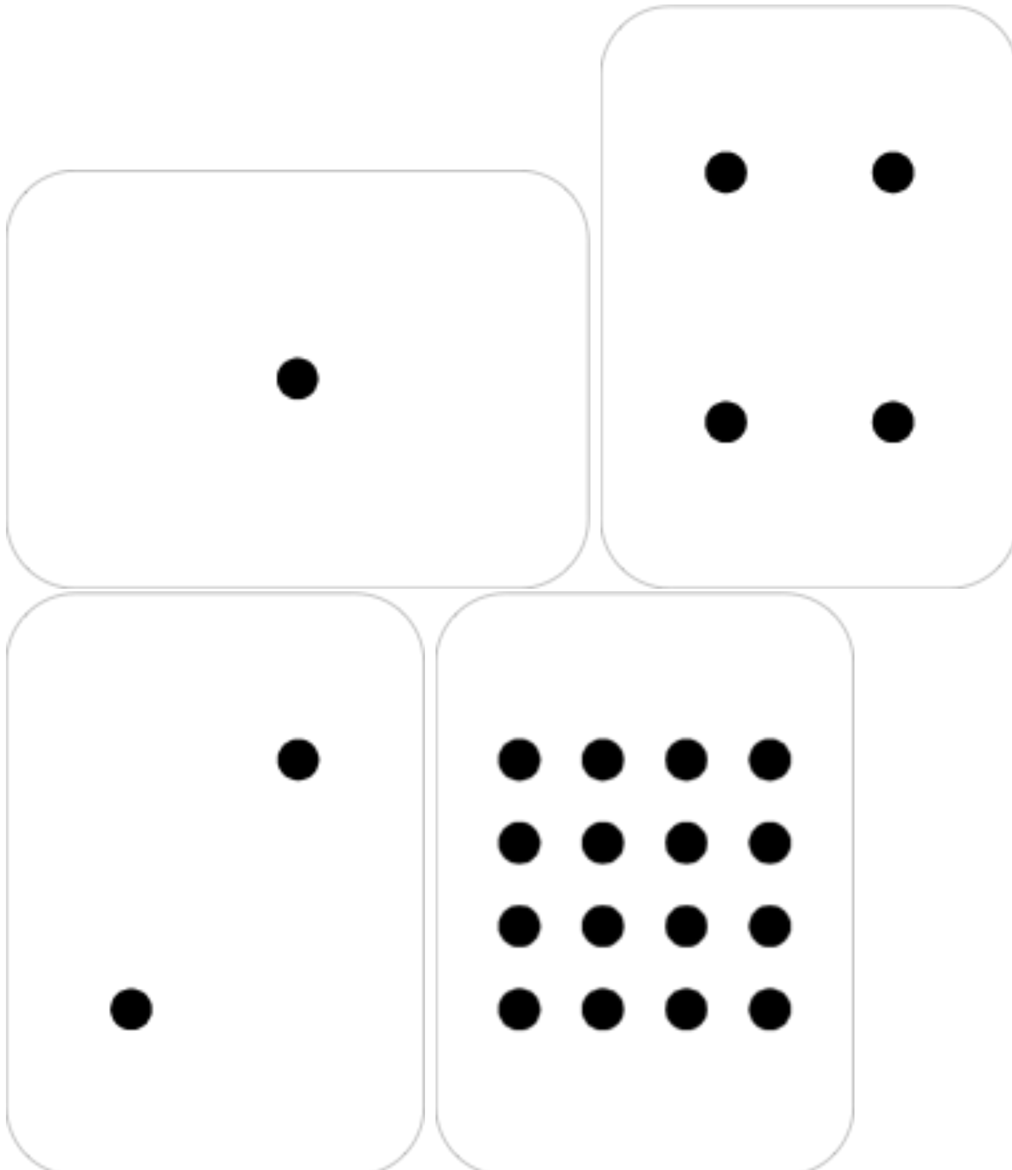
Vocabulary: Binary Numbers, Algorithms, Sorting Networks

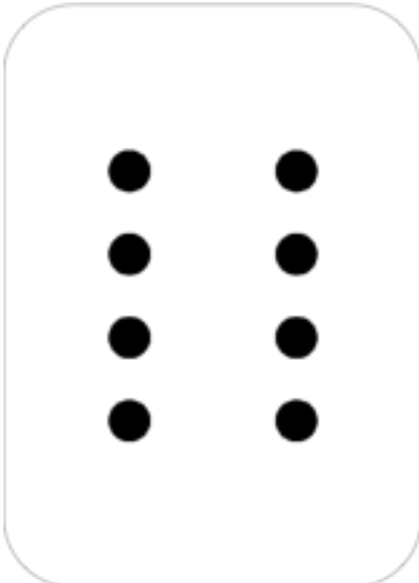
Materials:

Thick poster paper that kids can hold up, black marker. Can be bought at Michaels or any stationery store.

Description: A5- regular paper size
Quantity: 5

You will need to make a set of 5 Binary Cards for the demonstration. See below.

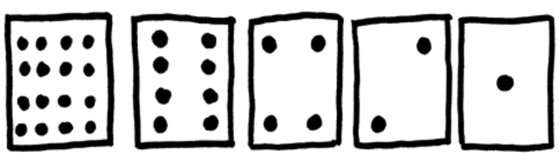




Additional materials for Sorting networks activity: Colored poster paper with large numbers from 1 to 10 (depending on number of students).
Description: A5- regular paper size
Quantity: 10 (depending on number of students participating)

Procedure:

For this activity, you will need a set of five cards, as shown below, with dots on one side and nothing on the other. Choose five students to hold the demonstration cards at the front of the class. The cards should be in the following order:



As you give out the cards (from right to left), see if the students can guess how many dots are on the next card. What do you notice about the number of dots on the cards? (Each card has twice as many as the card to its right.)

How many dots would the next card have if we carried on to the left? (32) The next...? (64)

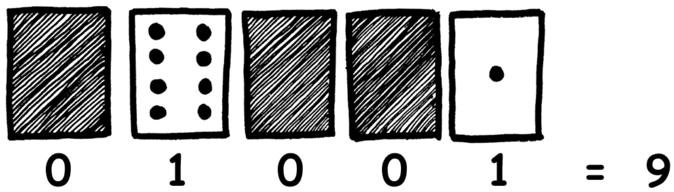
We can use these cards to make numbers by turning some of them face down and adding up the dots that are showing. Ask the students to show 6 dots (4-dot and 2-dot cards), then 15 (8-, 4-, 2- and 1-dot cards), then 21 (16, 4 and 1)... The only rule is that a card has to be completely visible, or completely hidden.

What is the smallest number of dots possible? (They may answer one, but it's zero).

Now try counting from zero onwards.

The rest of the class needs to look closely at how the cards change to see if they can see a pattern in how the cards flip (each card flips half as often as the one to its right). You may like to try this with more than one group.

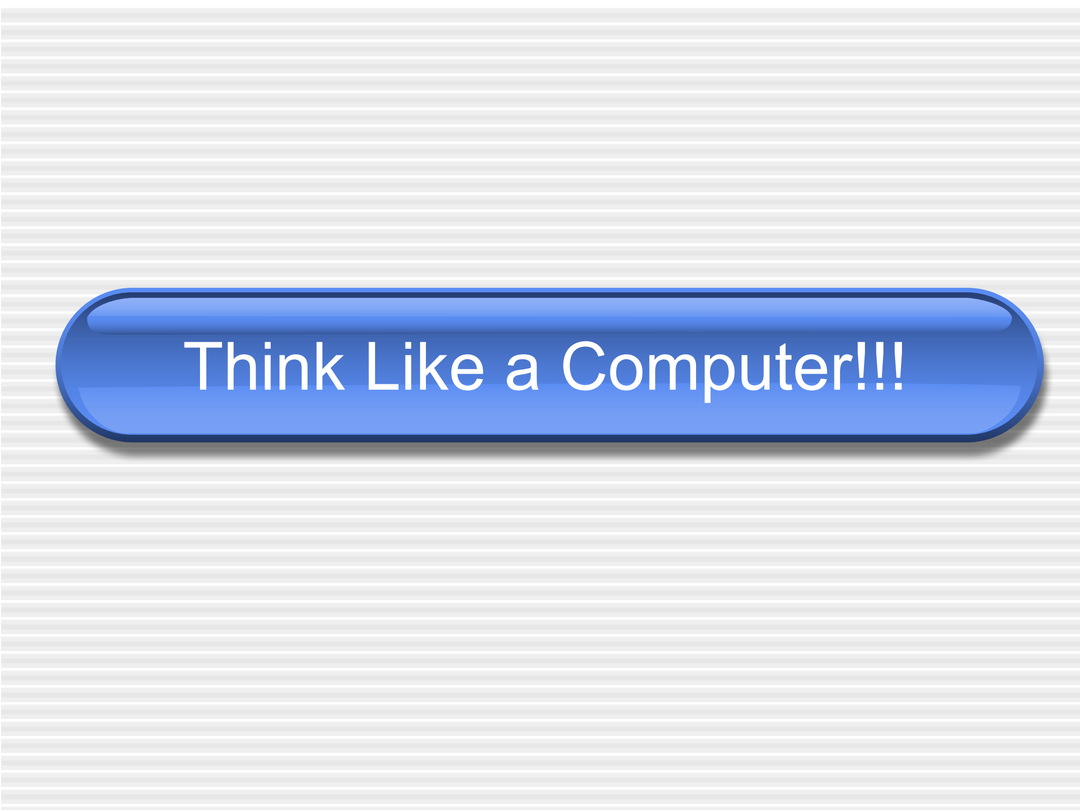
When a binary number card is **not** showing, it is represented by a zero. When it **is** showing, it is represented by a one. This is the binary number system.



Ask the students to make 01001. What number is this in decimal? (9) What would 17 be in binary? (10001)

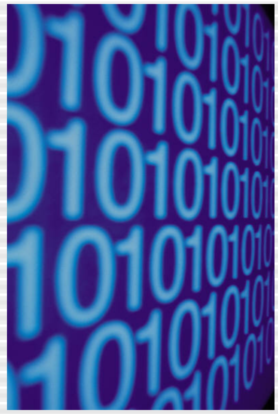
Try a few more until they understand the concept.

Slide deck to go along with lesson.



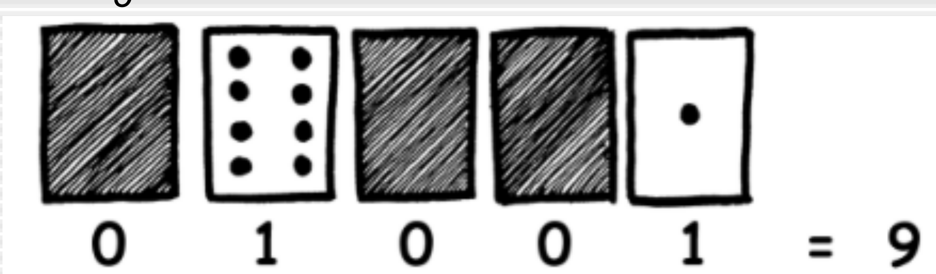
COUNT THE DOTS

- Data in computers is stored and transmitted as a series of zeros and ones.
  - How can we represent words and numbers using just these two symbols?



COUNT THE DOTS

- Display the cards so the following number of dots are showing:
  - 9



COUNT THE DOTS

- When a binary number card is **not** showing, it is represented by a zero. When it **is** showing, it is represented by a one. This is the binary number system (base 2).
- What are the following binary numbers?
  - 01001_2
  - 10011_2

COUNT THE DOTS

- What is the highest number we can represent using 5 cards?
  - $11111_2 = 31$
- What is the lowest number we can represent using 5 cards?
  - $00000_2 = 0$
- Count from 0 to 31 in binary.

COUNT THE DOTS

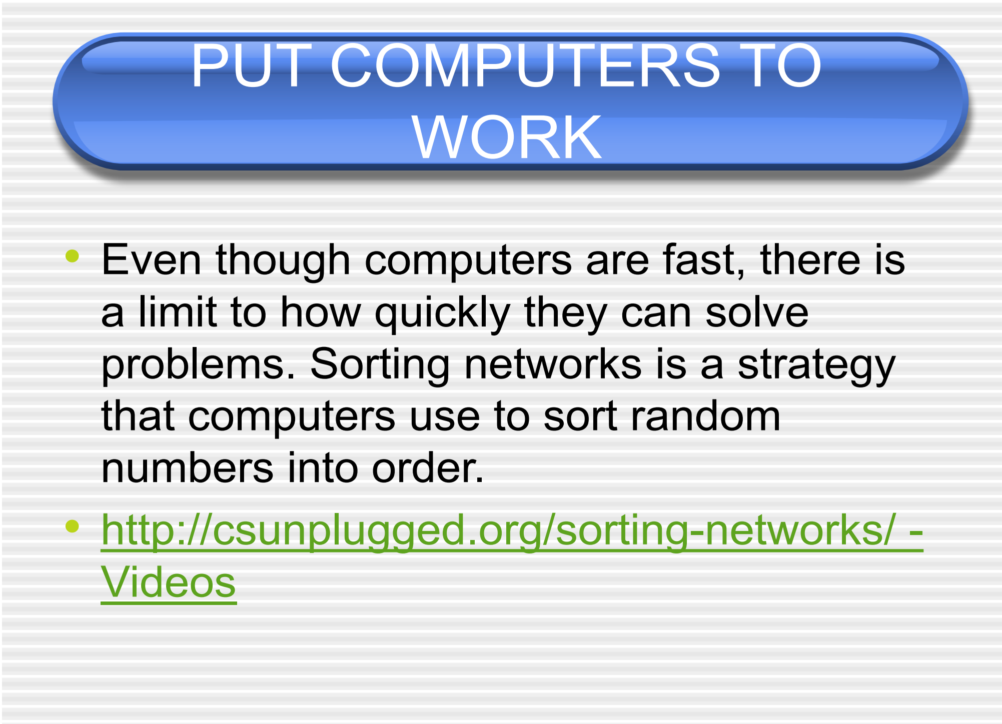
- Letters are represented in computers in binary also!
- blank 0 00000_2

blank	0	00000_2
A	1	00001_2
B	2	00010_2
C	3	00011_2
...		
Z	26	11010_2

COUNT THE DOTS

blank	0		
A	1	N	14
B	2	O	15
C	3	P	16
D	4	Q	17
E	5	R	18
F	6	S	19
G	7	T	20
H	8	U	21
I	9	V	22
J	10	W	23
K	11	X	24
L	12	Y	25
M	13	Z	26

01001	I
00011	C
00101	E
00000	_
00011	C
10010	R
00101	E
00001	A
01101	M



As an additional activity, I introduced the concept of algorithms and how they are used in sorting networks along with showing the video (see last slide). We also played the sorting network game. The students were given a set of colored A5 sized cards with numbers from 1 to 10. They were then asked to line up in random order holding up their cards. They then moved along a line, comparing numbers as they go and sorting themselves into ascending order from 1 to 10.

Discussion:

The first 10 minutes was spent on an interactive discussion with students on what computers are used to do today and the differences between data and information. See below

How can we store information in computers?

The word computer comes from the Latin *computare*, which means to calculate or add together, but computers today are more than just giant calculators. They can be a library, help us to write, find information for us, play music and even show movies. So how do they store all this information? Believe it or not, the computer uses only two things: zero and one!

What is the difference between data and information?

Data is the raw material, the numbers that computers work with. A computer converts its data into information (words, numbers and pictures) that you and I can understand.

Let's learn about binary numbers!

We then did the binary numbers activity.

We followed that by a discussion on Algorithms. See below

Algorithms – Putting Computers to work

Computers operate by following a list of instructions set for them. These instructions enable them to sort, find and send information. To do these things as quickly as possible, you need good methods for finding things in large collections of data, and for sending information through networks.
An *algorithm* is a set of instructions for completing a task. The idea of an algorithm is central to computer science. Algorithms are how we get computers to solve problems. Some algorithms are faster than others, and many of the algorithms that have been discovered have made it possible to solve problems that previously took an infeasible length of time—for example, finding millions of digits in pi, or all pages that contain your name on the World-Wide Web, or finding out the best way to pack parcels into a container, or finding out whether very large (100-digit) numbers are prime.

Followed this up with Sorting network game.

References/Sources:

Activity was adapted from csunplugged.org document 2015 Revision.
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