

Binary Numbers Lesson Plan

Overview—*Binary Numbers*

Summary

Data in computers is stored and transmitted as a series of zeros and ones. The goal of this lesson is to demonstrate how ordinary numbers can be represented with only two numbers.

Timeline

What	Time	Where
Demonstration	10	BinaryLessonPlan.docx BinaryWorksheets.docx BinaryDots.pdf
Binary Numbers	5	BinaryWorksheets.docx
What's The Number?	5	BinaryWorksheets.docx
What's It All About	5	BinaryLessonPlan.docx
Go Fish	15	BinaryDeck.pdf
Check Your Understanding	10	BinaryWorksheets.docx

Materials

- ✓ One set of large binary cards for the demonstration. (BinaryDots.pdf)
- ✓ Print one of the following worksheets for each student.
 - Worksheet 1: Binary numbers (especially helpful for 6th graders)
 - Worksheet 3: Check Your Understanding (optional)
- ✓ Print one of the following worksheet for each pair of students.
 - Worksheet 2: What's the Number
- ✓ Print one deck of binary Go Fish playing cards for each group of 4 students. It's good to print these so that the value does not show through.

Additionally, it may be helpful to have several sets of small binary cards for struggling students to use at their desks as a visual aid.

Lesson Preparation

Before diving into the lesson, it is recommended that you watch “[Unplugged: Binary Part 1](https://youtu.be/b6vHZ95XDwU)” which can be found here: <https://youtu.be/b6vHZ95XDwU>. The video will give a brief introduction into binary numbers and how the activities will help introduce the concept of binary numbers to the students.

Introduction- Whole Class

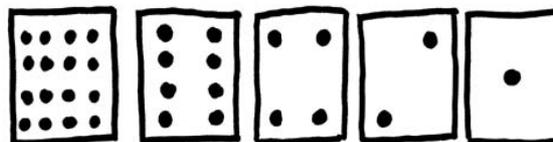
Introduction

It is helpful to demonstrate principles of binary numbers as a class activity, as demonstrated in this video: <https://youtu.be/b6vHZ95XDwU> .

Lesson Vocabulary (you may want to write on board)

- bit
- binary

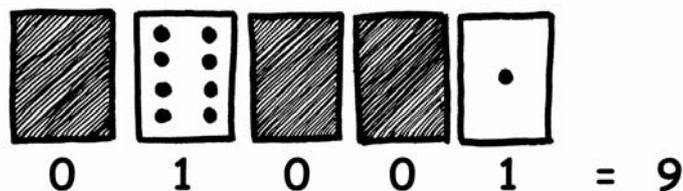
For this activity, you will need a set of five cards, as shown below, with dots on one side and nothing on the other. Choose five children to hold the demonstration cards at the front of the class. The cards should be in the following order:



Start by telling the students that data is stored and transmitted as a series of zeros and ones. Each binary digit is called (ask if any students know) a *bit*. Each student represents one bit. The bit may be either “on” (number visible) or “off” (number turned over).

Binary to Decimal Conversion

Each card has a number of bits on it. We just need to read off the number of dots that are showing to determine what number is represented. 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 children to make 01001. What number is this in decimal? [**answer:** 9] Try a few more until they understand the concept. Examples: What would be 6 in binary? [**answer:** 00110] 17? [**answer:** 10001] 20? [**answer:** 10100]

Counting in Binary

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.

Range of Numbers (continues from Counting in Binary)

Ask the class how many dots would the next card have if we carried on to the left? [**answer:** 32]

The next...? [**answer:** 64]

What's the largest number that can be represented by 5 bits? [**answer:** 31]

Activity 1 – Decimal to Binary

Worksheet 1: Binary Numbers

In the counting dots introduction, students learned how to use cards representing the place value of a binary number to convert between binary and whole (decimal) numbers. This worksheet will provide students a chance to practice this conversion technique on their own.

Since some students will grasp the material more quickly, you might encourage students to help each other as needed, or you might set a fixed time and then go over the solution (depends on your classroom dynamics).

Worksheet 1 Answer Key:

Number		Binary Number
2		00010
5		00101
3		00011
12		01100
19		10011
8		01000
15		01111

Quick Key:

- 5 = 00101
- 3 = 00011
- 12 = 01100
- 19 = 10011
- 8 = 01000
- 15 = 01111

Activity 2 – Range of values

Worksheet 2: What's the Number?

As part of the whole class discussion, students also learned to reason about the next number in a sequence, the largest possible number, and how many cards are needed to represent various number ranges. This worksheet will reinforce those concepts, with particular focus on the relationship between the number of bits and the range of numbers that can be represented.

Worksheet Introduction

After giving out the bits worksheet, review the range of numbers that can be represented by 5 bits (0 to 31). Explain that in some cases the computer might store more or less than 5 bits. For example, it's common to use 8 bits together. This is known as a *byte*. For smaller numbers, we might want to use less than 5 bits. Or to save space, data might be stored as only one bit (e.g., 0 can mean false and 1 can mean true).

For this activity, students should work with a partner (or group of 3, as needed). The student should challenge their partner(s) to represent a given number using 5-bit binary (includes the leading 0s). Then they should determine whether all 5 bits are needed, or if the number might be represented by fewer bits. Emphasize that all non-leading 0s are needed as *place holders*, just as in the decimal system to represent a number in the hundreds we need 3 digits, to represent a number in the thousands we need 4 digits, etc.

Students who are doing well with this material can challenge each other to represent larger numbers.

Terminology (optional)

Binary- A system where number representation is done through 1's and 0's

Bit – 1 binary number (1 or 0)

Binary string – A sequence of bits

Byte- A binary string with 8 bits

Kilobyte- 1000 bytes

Megabyte- 1000 kilobytes

Gigabyte- 1000 megabytes

What's It All About Discussion – Whole Class

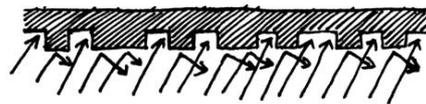
Computers today use the binary system to represent information. It is called binary because only two different digits are used. It is also known as base two (humans normally use base 10). Each zero or one is called a *bit* (**binary digit**). A bit is usually represented in a computer's main memory by a transistor that is switched on or off, or a capacitor that is charged or discharged.



When data must be transmitted over a telephone line or radio link, high and low-pitched tones are used for the ones and zeros. On your phones and flash drives, bits are represented by the direction of a magnetic field on a coated surface, either North-South or South-North.



CDs, DVDs, and Blu-Rays store bits optically—the part of the surface corresponding to a bit either does or does not reflect light.



One bit on its own can't represent much, so they are usually grouped together in groups of eight, which can represent numbers from 0 to 255. A group of eight bits is called a byte.

The speed of a computer depends on the number of bits it can process at once. For example, a 64-bit computer can process 64-bit numbers in one operation, while a 32-bit computer must break 64-bit numbers down into smaller pieces, making it slower.

Ultimately bits and bytes are all that a computer uses to store and transmit numbers, text, and all other information. In some of the later activities we will see how other kinds of information can be represented on a computer.

Computers also store letters and numbers in binary code. A computer needs 7 bits to store all the characters. This allows for up to 128 characters. Usually the 7 bits are stored in an 8-bit byte, with one bit wasted. This is called ASCII (American Standard Code for Information Interchange).

Optional Resources

Game: Binary Numbers: <http://games.penjee.com/binary-numbers-game/>

Video: How Does A Transistor Work?: <https://www.youtube.com/watch?v=IcrBqCFLHIY>

Video: How Does a CPU Work?: https://www.youtube.com/watch?v=cNN_tTXABUA

Video: How Do Circuit Boards Work?: <https://www.youtube.com/watch?v=gUzyd4klMQk>

Activity 3 – Go Fish

Prior to doing this activity, you might want to watch the video:

<https://www.youtube.com/embed/VUguR8q0qMo>

Summary

This activity will extend the concepts of how a computer works by having students practice converting between number systems in a game of Go Fish. Here, students will realize that, although the numbers are *represented* differently, they still convey the exact same meaning.

Materials

Each group of four students will need a deck of binary playing cards

Introduction

We just learned that data in computers is stored as a series of zeros and ones. Our binary cards helped us to see a pattern so we could determine how many cards are needed to represent various number ranges.

What if you were creating a game with a deck of cards? A normal deck has several cards with no numbers (Ace, Jack, Queen, and King). How could we represent these face cards using only binary numbers? [**answer:** there may be multiple ideas, but one is to represent face cards as numbers, e.g., Jack could be decimal 10/binary 01010, etc.]

How many bits would we need to represent all values in a full deck of cards? [**answer:** there are 56 cards in a deck, so we'd need 6 bits if we represent cards as 0 to 56. Or we might use 4 bits for the face value (4 bits allows for 0 to 15, and there are 14 cards of each type) and a separate 2 bits for the suit (2 bits allows for 0 to 3, which is exactly the number of distinct values that we need).

If necessary, review converting between decimal and binary number systems.

Discussion

This activity will reinforce student's ability to convert between binary and decimal values by playing Go Fish.

We will be using a special deck of playing cards where each number is represented in binary form instead of decimal notation. Thus, the card that would normally say "8" now reads "1000."

There are a few minor differences in how a normal Go Fish game would be played, and how we will play today in the classroom. The rules of Go Fish (including our tweaks) are below:

1. Students should get into groups of 4 or 5. Shuffle the deck of binary playing cards.
2. Each student should be dealt 5 cards face down (each student can look at his/her own cards. If possible print on card stock so other students can't see what's printed on the card).

3. One student starts by asking another student if they have a certain card using only decimal names for values. For example, a student may ask "Sally, do you have any 5's?" **Note:** Students should *not* ask "Sally, do you have any 0101's?" as that defeats the purpose of practicing converting between the binary and decimal number systems!
4. If the student does have the requested card, they must give it up to the asker. The asker can then place their pair of cards face up on the table. If the student does not have the card, the asker must draw a card from the deck.
5. Since we are playing binary Go Fish, you only need a pair of cards to form a set (e.g., you only need two 5's to place the set down, so two students could have a set of 5's). Unlike traditional Go Fish, students do not play off of other student's pairs.
6. Students continue game play until the deck has been exhausted. If a student runs out of cards before then, they should draw another 5 cards from the deck.
7. The student with the most binary pairs wins.

Extension

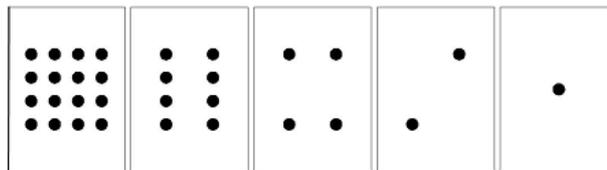
The binary go fish cards could also be used as flash cards. The flash cards could be used to help students who are still struggling with converting from binary to decimal.

Optional worksheet – Check Your Understanding

You may choose to end the activity with either Binary Go Fish or worksheet 3. This worksheet can be used as a final assessment for you to determine whether students understood the material, as it tests whether students can convert between decimal and binary and also whether they can reason about the number of bits required to represent ranges of numbers.

Worksheet 3 Answer Key

Check Your Understanding



1. What is the next number in the sequence?

00001 00010 00011 00100 **00101**

2. What decimal number is represented by 01011?

11

3. How would you write the number 20 in binary?

10100

4. What is the largest number you can represent using five cards (i.e., five bits)?

31

5. What is the largest number you could represent if you had only three cards?

7

6. How many cards (bits) would you need to represent the number 63?

6

Quick Key

1. 00101 (the pattern is 1, 2, 3, 4, so the last number should be 5)
2. The number is 11
3. 10100 is 20 in binary
4. 31 is the largest number you can represent with 5 bits
5. 7 is the largest number you can represent with 3 bits
6. 6 bits would let you store values from 0 to 63