



Binary, Bits, and Bytes—Oh My!

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Overview

Topic: Electrical Circuits, Codes, Base Ten, Base Two, Place Value, Binary Logic, and Ordered Pairs. This lesson will explore the technology of a computer to discover how it processes information using bits, bytes, and binary coding to create text, graphics, audio, and video productions. Ideally, this should be used as part II in an instructional plan that begins with another NTTI lesson called Go Ahead, Make My Sandwich! (available through www.wvpt4learning.org)

Time Allotment

Three 60-minute periods

Media Components

Math Vantage: The Language of Mathematics,

#21, Digitizing with Binary Power

TV/VCR with remote control

Overhead projector or computer with projection device

Small individual microscopes and/or a video microscope for both teacher and students (optional)

Computer for teacher

Computers for individual students in lab setting, if possible

Website: mtl.math.uiuc.edu/non-credit/compponn/bits/index2.html

Learning Objectives

The student will be able to:

- describe and demonstrate open and closed electrical circuits
- create binary patterns using concrete objects
- write his/her name in binary code
- write numbers in Base Ten

- write numbers in Base Two
- locate and identify a pixel using a grid
- locate ordered pairs on a grid
- describe and demonstrate how graphics are digitized

(This lesson addresses Va. SOL Computer Technology 5.1, 5.2, 5.3; Math 3.1, 3.21, 3.24, 4.1, 4.18, 4.21, 5.20; and Science 4.3.)

Materials

For the teacher:

- manipulative objectives, such as candy (see below)
- battery-powered toy
- marking pens
- stapler and staples
- transparencies for worksheets

Per student:

- plastic zipper bag filled with candy used as manipulative objects (Mike and Ikes and Smarties—approximately 8 pieces per letter in the student's name)
- scissors
- pencil

Student Handouts:

- ASCII chart (use with worksheet #1)
- worksheet #1 Binary Pattern



GE Fund



- worksheet #2 Ten's Chart
- worksheet #3 Binary Table
- worksheet #4 Pixels
- worksheet #5 Flip Book

Teacher Preparations

Preview and cue *Math Vantage* videotape to opening sequence as noted in Learning Activities section. Copy attached worksheets onto overhead transparencies, or prepare to use them with a computer projected through a projection device. Also make copies of the worksheets for students to use. If students are going to access any site on the Internet, it should be added to the bookmarks on the students' and teacher's computers ahead of time, or it should be a hotlink on the school's website where it is easily accessible to the students. Display the objectives for the lesson. List the lesson's vocabulary on the board or elsewhere in the classroom where a growing vocabulary of relevant terminology is listed: analog, ASCII, bits, bytes, binary code, circuits, digital, digits, and pixels.

Focus For Media Interaction

Today we will begin a unit of study about computers and how they work. Specifically, we want to find out about the code that the computers use. Before we begin, I want to find out what you already know about computers and how they work. What kinds of things can be done with a computer? (Encourage answers such as: play video games; write, send, receive, and read email; send or receive a facsimile (FAX); do research on the Internet; create a web page; watch video clips; listen to music; do homework, etc.) So you are telling me that computers can create numbers, letters, pictures, video, and audio? Did you know that computers do all this using only two numbers? Can you guess which two numbers? (1,0) Do you know why these two numbers are used? Throughout the next few days, we will be watching a video about how computers work. Then we will be doing some activities using computers as well as some hands-on activities in the classroom to find out more about these two num-

bers, what they're called, and how they can be used to create sound, video, text, and numbers in computers. As I read the objectives for the lesson, you will get some ideas about what kinds of things we will be learning.

Time Cues

To synchronize your VCR with the time cues that are included with this lesson, zero/reset your time counter at the very beginning of the program, before the introduction and titles. Time cues are expressed as "minutes:seconds;" for example, 3:15 means three minutes and fifteen seconds.

Pause vs. Stop

When using a video interactively with students, teachers need to decide when to use **PAUSE** and when to use **STOP**. **PAUSE** the video when the anticipated discussion or activity will take less than two minutes. **STOP** for longer periods. Pausing for too long at one time can cause video heads on the VCR to become clogged which may require cleaning to correct.

Introductory Activity

Lesson 1

Students sit in a circle, close enough to hold hands. The teacher reviews electrical circuits and how some things are good conductors of electricity and others aren't. Students are asked if the human body is a good conductor of electricity. To find out, the teacher demonstrates how a battery powered toy works when the positive and negative nodes are touched at the same time and the circuit is completed. Then, the students are asked to hold hands. Two students sitting side by side hold the toy. One of the two students touches the positive node while the other student touches the negative node thus completing the circuit and causing the toy to make a noise. Students are asked to see what happens when the circle is broken by two students disconnecting hands and then reconnecting hands. This experience demonstrates the circuit being either ON or OFF.

Next, a student is asked to record the pattern that the noise makes as it is turned ON and OFF. The student is to write the digit “1” when the sound is heard and the digit “0” when the sound is off. Repeat this procedure until the student has an eight-digit pattern. (example 00001010) Using the ASCII chart, discover the letter that the eight-digit pattern represents. Explain that students are going to use the information from this activity to find out how a computer processes information.

To give you more information about electrical circuits and how they are used with computers, we will be going to a site on the Internet called “Math Teacher Link; Computers and How They Work.” The Internet address for this site is: mtl.math.uiuc.edu/non-credit/comconn/bits/index2.html (If students are going to this site or any site on the Internet, it should be added to the bookmarks ahead of time or should be a hotlink on the school’s website where it is easily accessible to the students.) Once we have arrived at this site, we are going to go to the link called “Binary Information.” I will demonstrate how to turn the light bulbs ON and OFF. Watch to see the numbers displayed as I turn them ON and OFF. See if you can turn on the combination of bulbs to show your age. In the second activity, we will turn the bulbs ON and OFF and as we do, we are going to pay attention to the 1s and 0s as they are displayed underneath the picture. By the time we are finished, we should have a good idea of bits, bytes, and binary code or the ASCII code.

Learning Activities

Lesson 2

1. **CUE** the tape to start at the beginning of the program, before the title is displayed. This is about seventeen seconds into the video where the computer sign is displayed in the store. **FOCUS:** You have already told me that computers can display numbers and letters as well as play videos and music. Now let’s find out how it’s done. **PLAY** and **PAUSE** when the girl says, “The best way is to digitize.” **FOLLOW UP:** Did you find out how computers do so many things? (digitize) Who can tell what digitize mean?

2. **FOCUS:** Continue to watch to find out what the girl means by digitizing. **FAST FORWARD** the tape 4 seconds to the title, “Digitizing With Binary Power.” **PLAY** and **PAUSE** when the girl says, “Oakland to San Francisco Bay Bridge.” **FOLLOW UP:** What word did she use to describe the process of getting from Oakland to San Francisco? (shortcut) Then, would you assume that digitizing is a shortcut?

3. **FOCUS:** Find out what she describes as digits and why they are considered to be shortcuts. (a few symbols can be used to represent any number or value we can think of) **RESUME. PAUSE** when the girl says, “with tally mark symbols like these.” **FOLLOW UP:** What is the word digit used to represent? (fingers, to show how many) What digits do you use every day? (0 - 9) Which civilizations first used a counting system like the one we use today? (Ancient Egyptians and Chinese)

(Background Information: Digit, as used here, is a finger representing an amount when counting. However, it originated with the Latin word digitus which was a measurement representing the breadth of the index finger, which is about 3/4 inch.)

4. **FOCUS:** Do all people use the same symbols for numbers? Do they count and group in the same way? Watch to find out different ways people have counted and grouped numbers in the past.” **RESUME. PAUSE** when the girl says, “five left over.” **FOLLOW UP:** Who can describe another way people have grouped and counted numbers? (Encourage students to elaborate on their answers about the Egyptians, Babylonians, and Mayans and how they counted in sets of 5, 10, 20, 60, 100)

5. **FOCUS:** Today, are there other ways to count besides the place value system we use? Watch to find out at least three other ways to count? **RESUME. PAUSE** when the girl says, “we call it binary code.” **FOLLOW UP:** Did you notice that the girl referred to the way we group numbers and count as base ten? How many digits are used in base ten? (10) Who can name the base ten digits? (0-9) Who can tell us another base we can use for counting? (different bases such as by 12s for count-

ing by dozens, or by 60s when counting seconds, minutes, and hours, or base 2 which she called binary code) If base ten uses ten digits, how many digits would you expect to be used in base two?

6. FOCUS: Now, let's find out how binary code works. Watch to see if you can name two binary codes that have been used in the past. **RESUME. PAUSE** after the sentence "this is a binary code." **FOLLOW UP:** What were the two codes shown? (Morse code and high and low drum beats) Can you think of any other codes that use only two symbols? (traffic light, light switch)

7. FOCUS: Let's find out what binary code has to do with computers. How many digits does a binary code use? Watch to find out what the digits represent. **RESUME. PAUSE** when Ellen's name is spelled vertically and the binary code for each letter is displayed. Alert the students to remember how this looks because they will be writing their names in the same way later. **RESUME. PAUSE** when the girl says "tells its circuits exactly what to do." **FOLLOW UP:** Who can name the two digits used in binary code? What do the "1" and "0" represent? (ON and OFF)

8. FOCUS: Find out how information becomes digitized and why digital information is used. **RESUME. PAUSE** when the man says "analog to digital converter chip." **FOLLOW UP:** What did you discover? Why do you think this process might be helpful? (an analog to digital converter chip is used to change information into numbers)

9. FOCUS: Your answers might be right. Let's see if you have a good idea about what digitizing allows us to do. **RESUME. PAUSE** when the girl says "fit on a compact disk." **FOLLOW UP:** Were you right? How is digitizing a shortcut? (put the entire encyclopedia on a compact disk instead of using a set of 22 books)

10. FOCUS: What three kinds of information can be digitized? **RESUME. PAUSE** when the girl says "inside the computer." **FOLLOW UP:** Who can name three kinds of information that can be digitized? (text, sound and images) Who can tell us how sound is digitized in a computer? (Sound is spoken

or played, it becomes electrical when it enters a microphone, then becomes digitized inside a computer.)

11. FOCUS: Now let's watch to find out how images become digitized. What do you predict will happen? (elicit responses) **RESUME. PAUSE** when the woman says, "to digitize it." **FOLLOW UP:** Were your predictions correct? When did the video become digitized? (inside the computer) How did this happen? (Live action becomes electrical when it's recorded. Then it becomes digitized inside a computer.)

12. FOCUS: Other than recording sound and video, find out another way we can use digital information. **RESUME. STOP** when the girl says "on and off." **FOLLOW UP:** Who can name other ways digitized information is used? (grocery store, clocks, watches, phones, VCR, microwave, TV, security system, checking out books in a library, etc.)

Culminating Activities

Lesson 3

Summarize what students have learned during the past two lessons: When information is put into a computer it is translated into a series of 1s and 0s called binary code. This code is made up of only two digits "1" and "0." These are called binary digits or bits. Eight bits are arranged into a pattern, which the computer interprets as a byte of information. Microchips, which process information inside a computer, contain millions of tiny transistors that work like on/off switches. In order to talk to a microchip, a program is translated into 1s and 0s. Remember, in an electrical circuit, "1" is on and "0" is off. Small transistors turn electrical current on and off translating the information so that the computer understands it. We are going to do four activities using binary code to help us understand how letters, numbers, and (pictures) are digitized.

1. Letters

Each student will create his/her name in ASCII or binary code. They will need worksheet #1, the ASCII chart, and a plastic bag containing Mike and

Ikes and Smarties. Each student will write his/her name vertically on the left side of worksheet #1 and then create a pattern with the candies using eight bits for each letter in his/her name. Remind the students about how Ellen wrote her name in the video earlier. Demonstrate this on the overhead projector before the students begin. After forming the candy pattern for each letter in his/her name, the student will write the binary code for each letter. (Ex: 01001101) The student may eat the candy at the end of all the activities.

2. Numbers

Each student will complete the patterns for each number on worksheet #2. Before students begin, the teacher might need to review place value in base ten. (use transparency for worksheet #2) Then the teacher should show students how place value in base two is similar. One difference is that in base ten, each place value is ten times greater than the preceding place value, moving from right to left. (example: 10000, 1000, 100, 10, 1). In base two, each place value is double the amount of the preceding place, moving from right to left. (example: 16, 8, 4, 2, 1). Use worksheet #3 to write Binary numbers. At another time the website for “Binary Finger Counting” www.dnaco.net/~ivanjs/binary.html can be used to reinforce place value when working with Binary numbers.

3. Pictures

Using a grid, (worksheet #4), each student will complete a picture of vertical and horizontal pixels by following commands of ON and OFF, given by the teacher. If the pixel identified to the student is ON, he marks it with a “1.” If the pixel identified to the student is OFF, he marks it with a “0.” The student then leaves the pixels with a “1” blank and fills in the pixels with a “0.” When the student has finished, the picture should be revealed. An example of commands to be given is A1-ON, B1-OFF, C1-OFF. If a microscope is available, let the students view a picture at its highest magnification in order to see the pixels.

4. Animations or Video

Students will create a simple flipbook to see how video is communicated. Use worksheet #5. Once the computer has translated each movement of an

animation or video into separate graphics or pictures, it then puts them back together one at a time in a flipbook fashion. Let the students cut out and staple the two happy faces along the top edge. Curl the top sheet using a pencil to roll the paper into a cylinder. Remove the pencil leaving the paper in a curl. Lay the pencil on its side and use it to quickly to smooth the top page from top to bottom. The top page will flip back into its curl giving the appearance of motion with the two pictures. Let the student use the other two circles to create another animation.

Assessment

Check mastery of learning objectives throughout the lesson’s activities. Review vocabulary mastered during lesson. Using the Binary Chart that the students created (worksheet # 3), at the bottom of the page, have the students write the Base Ten equivalents for numbers written in binary code. For extra credit, they can then write the binary code for each of the Base Ten numbers. Students can then check their answers, or practice beforehand, using the conversion application at the “Binary Converter” web site: javascript.internet.com/calculators/binary-converter.html

Community Connections

Divide the class in half. Direct half the class to make a list of things that do not use digital information in their everyday lives. Direct the other half to compile a list of things that use digital information. Invite a technician or a parent who works with computers to talk to the class about the lists they have created and score them on the number of correct items on each list. Ask the class to make predictions about what they think will be digitized by the same time next year. Save this list for next year’s class to see how accurate the previous class was.

Cross-Curricular Extensions

Art: Each student uses graph paper to create a picture using only black and white to color the pixels. Another challenge for interested students would be to create ASCII Art. Go to these websites for instructions:

ASCII Art – lizard.crosswinds.net/ascii-art/ascii-art_FAQ.html#art

ASCII Animation – www.asciimation.co.nz/

Language Arts: Each student develops a code and uses it to write a message. Students trade messages with other students to see who can decode the messages fastest.

Math: Students can learn to count on their fingers using the place value system for Binary Numbers. The “Binary Finger Counting” site has some very good illustrations for how to do this:
www.dnaco.net/~ivanjs/binary.html

Physical Education: Play the game Red Light - Green Light. Students stand side by side at a starting line. They are allowed to move toward a finish line when the person who is it calls “Green Light.” Students must freeze their movement when “Red Light” is called. If a student is caught moving when the student who is “It” calls “Red Light,” he/she must return to the starting line. Play continues until one of the students crosses the finish line.

Social Studies: Each student reads about and researches the history of one major invention, inventor, mathematician, scientist, or a significant happening in the development of computers to produce a time line. Each student then creates a one page PowerPoint display of his/her research. The students’ displays are then compiled into one PowerPoint production that is shared with the class and other classes. These sites would be helpful for conducting research:

TechWeb – www.techweb.com/encyclopedia/

Webopedia – webopedia.internet.com/

Technology: Students locate sites on the Internet that explain or explore binary code and how computers work.

3-D Dictionary – www.maran.com/dictionary/a/index.html

Net Lingo – www.netlingo.com/inframes.cfm

Internet Sites:

3-D Dictionary —

www.maran.com/dictionary/a/index.html

ASCII Animation — www.asciimation.co.nz/

ASCII Art — lizard.crosswinds.net/ascii-art/ascii-art_FAQ.html#art

Binary Converter — javascript.internet.com/calculators/binary-converter.html

Binary Finger Counting —

www.dnaco.net/~ivanjs/binary.html

Math Teacher Link; Computers and How They Work — mtl.math.uiuc.edu/non-credit/compcn/bits/index2.html

Net Lingo — www.netlingo.com/inframes.cfm

Tech Web — www.techweb.com/encyclopedia/

Webopedia – webopedia.internet.com/

About the Author

Judy Critchfield received her BS in Elementary Education at Tennessee Technological University and a Masters in Education from George Mason University. She also received certification as a Library Media Specialist at George Mason University. She has taught both first and second grades and worked as a School Library Media Specialist at both elementary and middle schools in Woodbridge, Va. She has been a Master Teacher since 1997 and was honored to have received the NTTI Teacher of the Year Award in 1998. Her other successes include writing and receiving fourteen grants over the past 18 years totaling approximately \$25,000 for books and technology for schools. She is a freelance writer who has had poetry, articles, and ideas published in family and educational journals and now plans to write children's books. She retired in September 2002, after 34 years of teaching in Prince William County Schools.

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ASCII TABLE

Character	Decimal Number	Binary Number	Character	Decimal Number	Binary Number
blank	32	0010 0000	^	94	0101 1110
!	33	0010 0001	_	95	0101 1111
"	34	0010 0010	'	96	0110 0000
#	35	0010 0011	a	97	0110 0001
\$	36	0010 0100	b	98	0110 0010
A	65	0100 0001	c	99	0110 0011
B	66	0100 0010	d	100	0110 0100
C	67	0100 0011	e	101	0110 0101
D	68	0100 0100	f	102	0110 0110
E	69	0100 0101	g	103	0110 0111
F	70	0100 0110	h	104	0110 1000
G	71	0100 0111	i	105	0110 1001
H	72	0100 1000	j	106	0110 1010
I	73	0100 1001	k	107	0110 1011
J	74	0100 1010	l	108	0110 1100
K	75	0100 1011	m	109	0110 1101
L	76	0100 1100	n	110	0110 1110
M	77	0100 1101	o	111	0110 1111
N	78	0100 1110	p	112	0111 0000
O	79	0100 1111	q	113	0111 0001
P	80	0101 0000	r	114	0111 0010
Q	81	0101 0001	s	115	0111 0011
R	82	0101 0010	t	116	0111 0100
S	83	0101 0011	u	117	0111 0101
T	84	0101 0100	v	118	0111 0110
U	85	0101 0101	w	119	0111 0111
V	86	0101 0110	x	120	0111 1000
W	87	0101 0111	y	121	0111 1001
X	88	0101 1000	z	122	0111 1010
Y	89	0101 1001			
Z	90	0101 1010			

Name

Binary Pattern

Byte

worksheet #1

BINARY TABLE

Name _____ Teacher _____

Complete the table below. Remember that binary numbers are written using only two digits, 0 and 1.

Decimal									Binary
Base Ten	128	64	32	16	8	4	2	1	Base Two
0	0	0	0	0	0	0	0	0	0000000
1	0	0	0	0	0	0	0	1	0000001
2	0	0	0	0	0	0	1	0	0000010
3	0	0	0	0	0	0	1	1	0000011
4	0	0	0	0	0	1	0	0	0000100
5	0	0	0	0	0	1	0	1	0000101
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									

Crack the code by writing the Base Ten number for each Binary Number below.

- | | | |
|-------------------|-------------------|-------------------|
| 1. 0000011 = 3 | 2. 0000101 = ____ | 3. 0001111 = ____ |
| 4. 0000110 = ____ | 5. 0001100 = ____ | 6. 0000111 = ____ |

Extra credit: Write the Binary Number for each Base Ten number below.

- | | | |
|------------------|---------------|---------------|
| 1. 12 = 00001100 | 2. 17 = _____ | 3. 13 = _____ |
| 4. 7 = _____ | 5. 5 = _____ | 6. 11 = _____ |

PIXELS

Mark the pixels that are "OFF" with a zero. Mark the pixels that are "ON" with a one. Color all the pixels with a zero black. Do not color the pixels with a one. When you are finished with the class activity, create your own picture using ones and zeroes.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2															
3															
4															
5															
6															
7															
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9															
10															
11															
12															
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14															
15															

Worksheet #4

