Lesson 4.1: Counting in Binary

Objectives

In this lesson, students will:
- Gain an understanding of the binary number representation and its relationship to computer storage
- Learn to count in binary
- Learn and practice translating decimal numbers into binary numbers

Agenda

1. Introduction	10 mins
2. Counting from 0 to 20 with Dots	20 mins
3. Translating from Binary to Decimal	15 mins
4. Wrap Up and Reflections	5 mins

Preparation

Printouts as follow:
- Appendix A: 1 for the entire class
- Appendix B: Cut the paper so that students have a smaller version of the demonstration cards. One set per pair of students.
- Appendix C: 1 per student
- View the demonstration video of how to use the cards.

Resources & Links

- Demonstration of how to use the cards to count in binary and convert numbers: https://tinyurl.com/y364gqfv
- Teacher reference video explaining binary: https://tinyurl.com/yxe3wn6n

1. Introduction

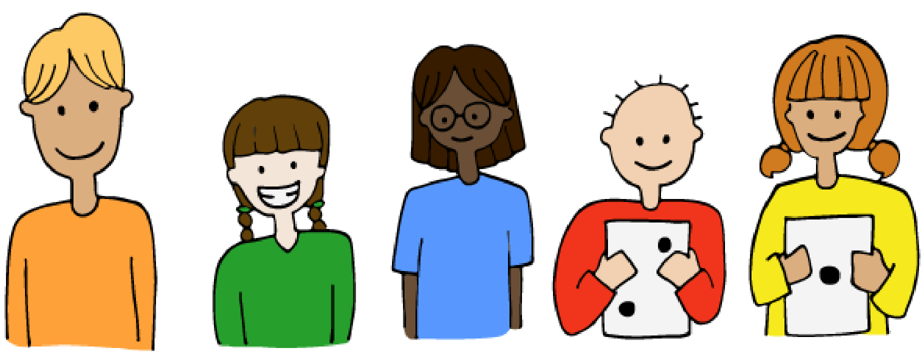
Explain to students that computers can only store data in 2 states: On and OFF or 1s and 0s. Everything inside a computer is stored as a sequence of 0s and 1s. This number system is called binary. So how can we represent big numbers using just 0 and 1? That is what we are going to learn today.

2. Counting from 0 to 20 with Dots

Class Activity:

Explain to students that computers can only store a 0 or a 1 inside a BIT (**B**inary Dig**it**). In order to store more complex information, they combine 8 “binary digits” (or bits) into a **BYTE**. But for this activity, we will only use 5 bits. Each bit will be represented by a card. The card will have dots on one side, and be blank on the other side.

Call for 5 volunteers. Each volunteer is a BIT. Distribute the posters from Appendix A. (one page per student). Each student lines up, in a row, showing their poster. The student with the least amount of dots to the right, ascending order from **right to left.** Explain to the entire class that we are going to try to count from 0 to 20, flipping the cards so that the total number of dots appearing matches the number we are on.



For instance, in order to have 0, all of the 5 students need to flip their posters, showing the back of it, where no dot appears. To get 1, only one student needs to flip their poster:

For the number 2, the second student from the right shows his/her side of the poster with dots, while everyone else hides their dots. Number 3, the 2 last students show their posters (2 dots + 1 dot = 3)

For number 4, we have this configuration:

Continue the exercise until the entire class has counted to 20

Repeat the exercise.

3. Translating from Binary to Decimal

Remind students that each card represents a bit: a tiny piece of memory in the computer that can have the value ON (1) or OFF (0). Now imagine that each card is represented by a bit that can only have the value 0 or 1 (Hiding my dots/Showing my dots). Remember, 8 bits is a byte, which is the way computers group the digits to be able to store large numbers.

If the card is facing up, the bit is set to 1. If the card is facing down, the bit is set to 0. If we write down the 1 or 0 for each card depending on whether the card is facing up or down, we get the binary number.

How do we get the decimal number? We count all the dots that are showing.

<u>Example</u> (Demonstrate using the cards)

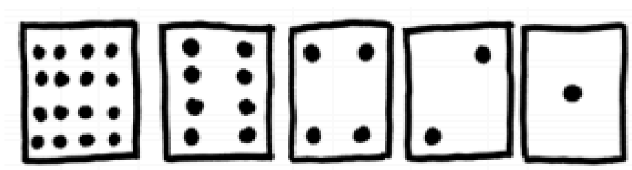
All cards are OFF, how many dots are showing? 0. That means that BINARY number 0 0 0 0 0 is 0 in Decimal.

0	0	0	0	0

Using the same technique, we can figure out that 0 0 0 0 1 (BINARY) = 1 (Decimal)

0	0	0	0	1

All cards facing up is 1 1 1 1 1 in binary. Using 5 bits, it is the largest number we can represent. What is the number in decimal? It will be 31 because there are 31 dots.



1	1	1	1	1

Let's consider the binary number: 0 0 1 0 0 - What does it translate into in decimal?

0	0	1	0	0

0 0 1 0 0 (BINARY) = 4 (DECIMAL)

4. Student Activity: **Translating from Binary to Decimal**

Distribute the binary cards from appendix B (or make them create the cards using paper and markers) and appendix C. Using their cards, they convert the binary numbers into decimal numbers.

Answers:
1 1 1 0 0 = 16 + 8 + 4 = 28
1 0 1 1 1 = 16 + 4 + 2 + 1 = 23
0 0 1 1 1 = 4 + 2 + 1 = 7
1 0 0 1 0 = 16 + 2 = 18
0 0 1 0 1 = 4 + 1 = 5

5. Wrap Up and Reflections

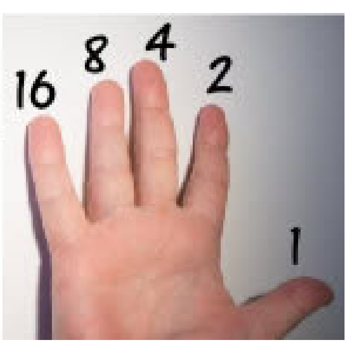
Collect the binary student cards as they will use them again in the next lesson.

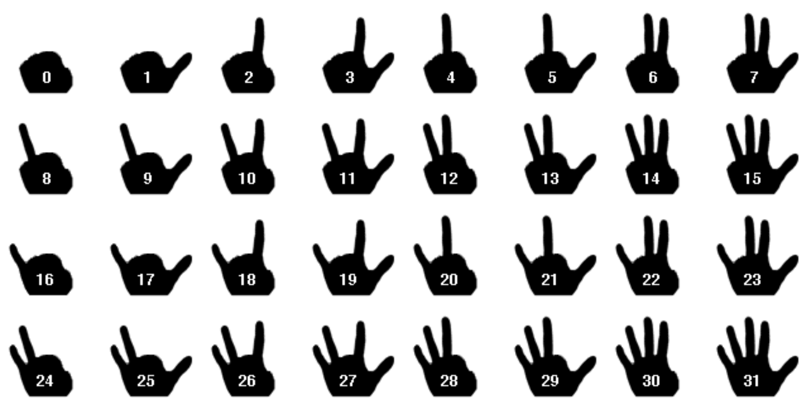
Reflection Points as a Class Discussion:

• What did you learn from this activity?
• When students were standing in front of the class and flipping their "bit", what did you notice about the frequency of turning the cards?
    ○ Who had to flip their card more often as we counted from 0 to 20?
    ○ Who had less work?
• What number representation do computers use?

Extension:

Counting in binary using your fingers: Using one hand, one could think you can count to 5 only, correct? Well, with the super power of counting in binary, you can count up to 19. Imagine that each of your fingers is a bit, representing some dots. 1 dot for the thumb, 2 dots for the index etc...





Credits: csunplugged.org

Appendix A

Poster Cards

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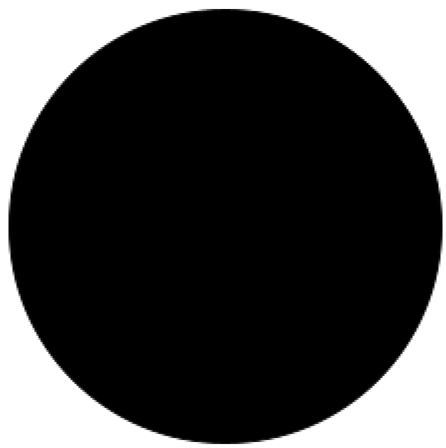
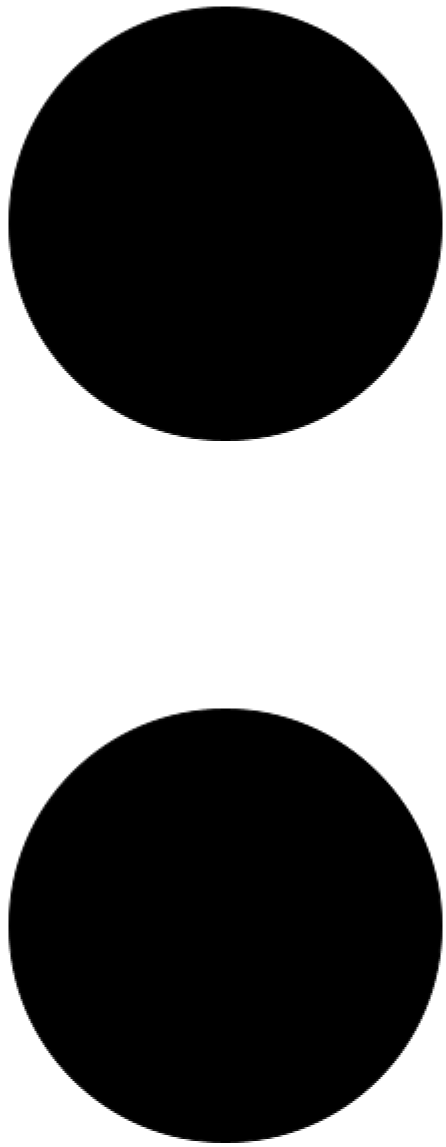
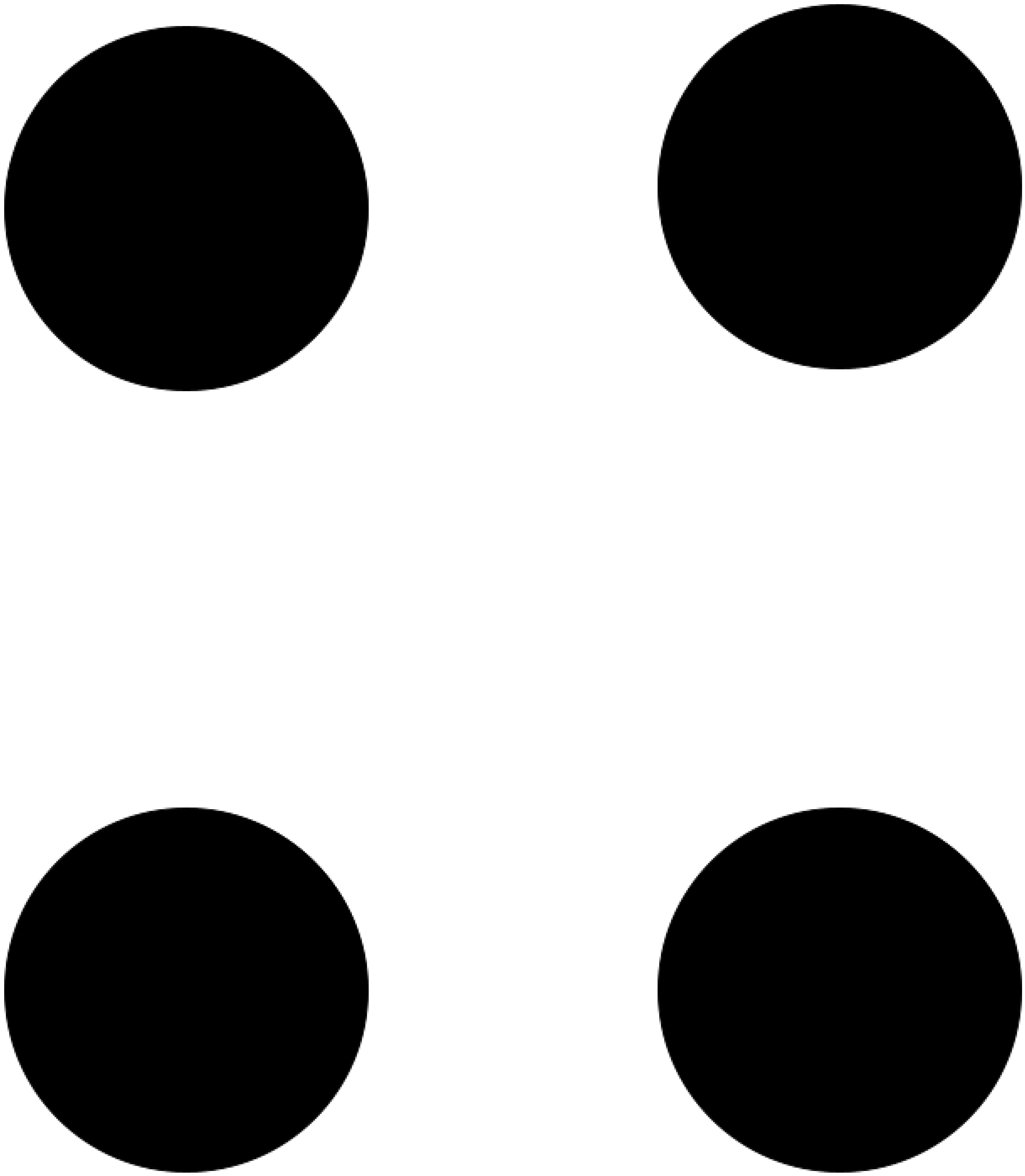
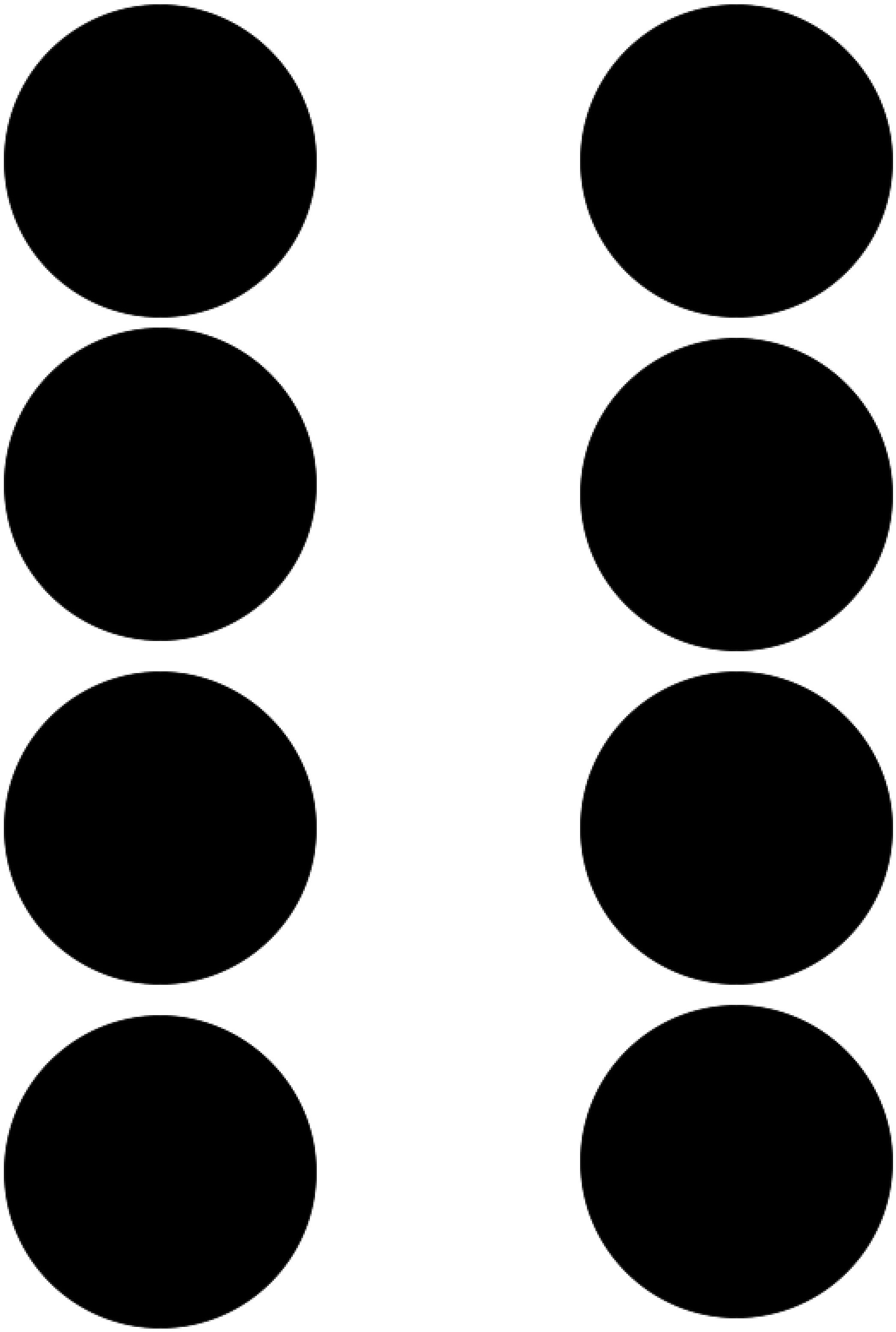
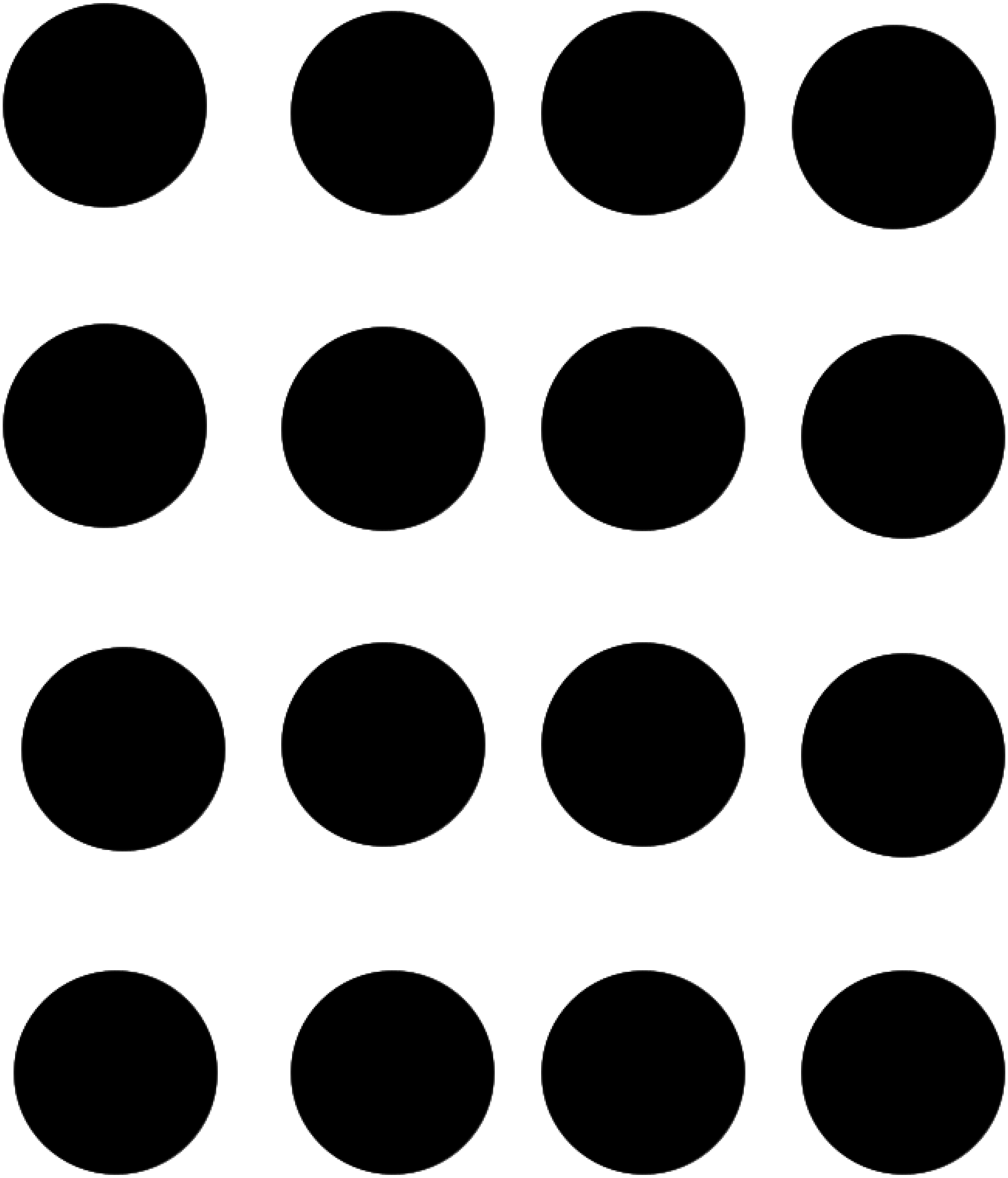




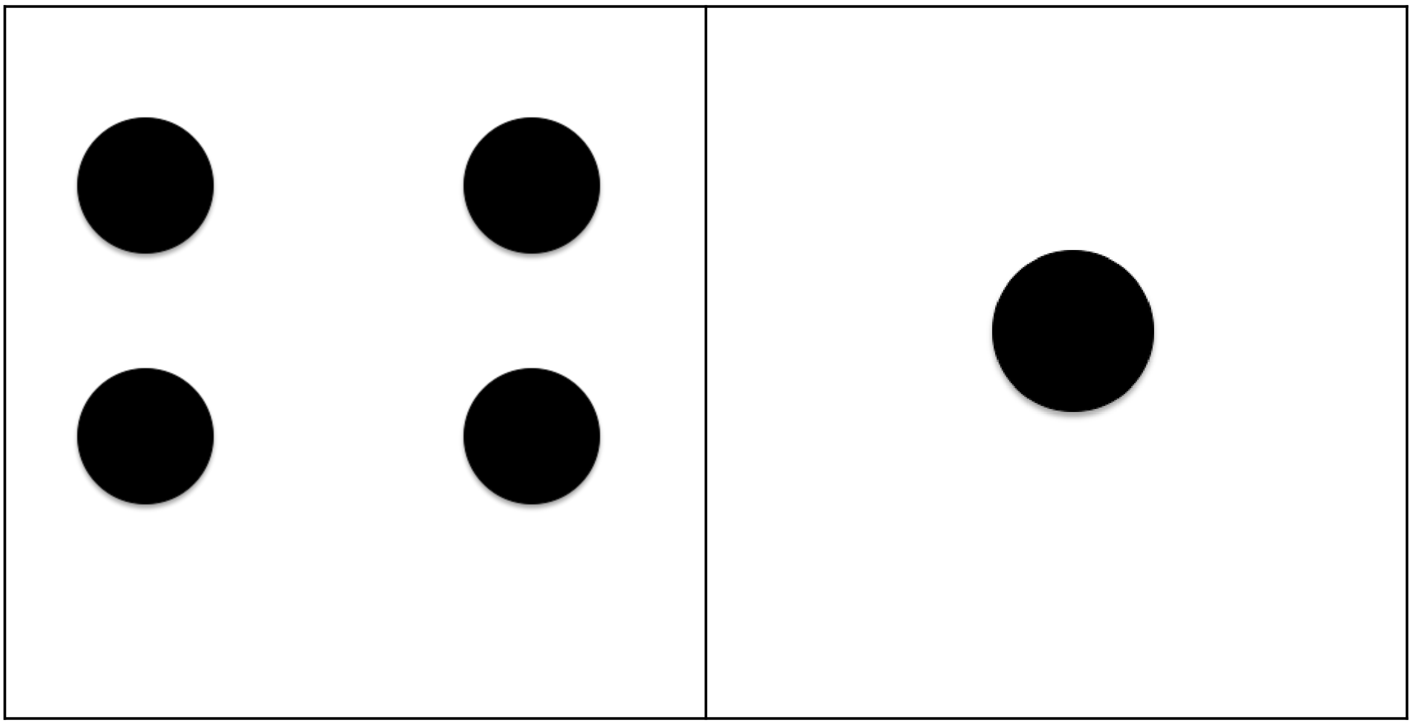


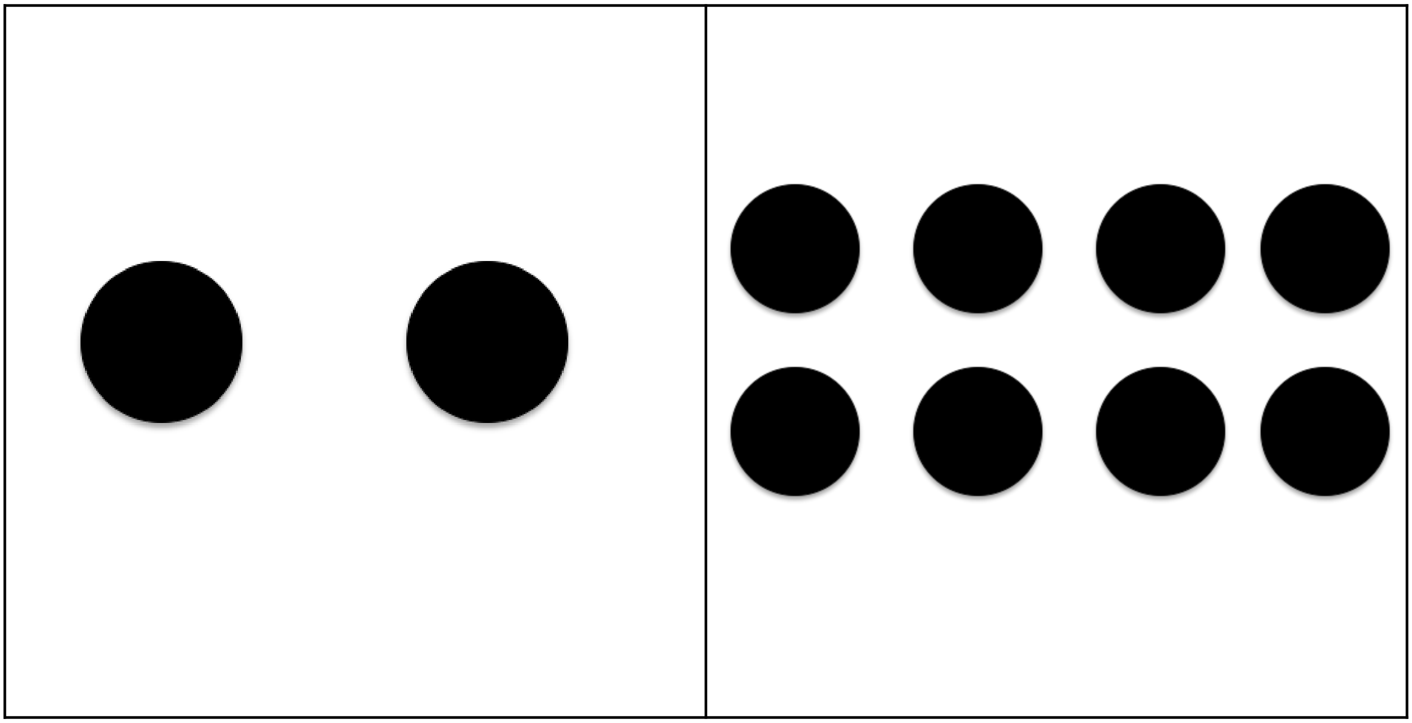


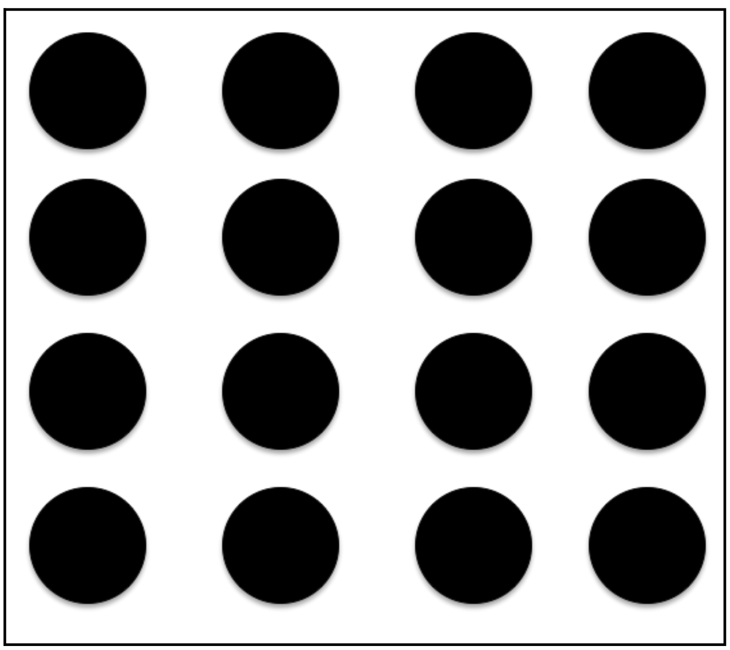


Appendix B

Student Cards







Appendix C

Binary to Decimal

BINARY NUMBER					DECIMAL
1	1	1	0	0	
1	0	1	1	1	
0	0	1	1	1	
1	0	0	1	0	
0	0	1	0	1	