Computer Science Unplugged

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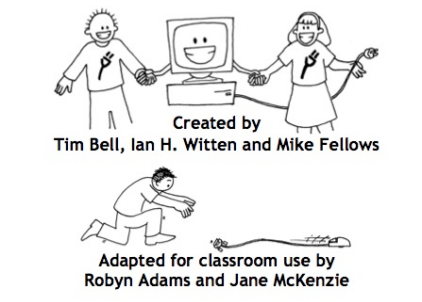
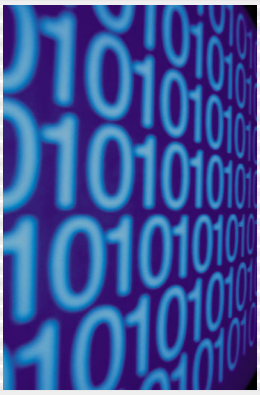
Computer Science Unplugged



- CS Unplugged is a book of activities that illustrate computer science principles without using a computer.
- Activities are short and are designed to be easily integrated into classes and include exercises and lesson plans for teachers.

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

- What numerical property do you see in the dots on the cards?
- Display the cards so the following number of dots are showing:
  - 6
  - 15
  - 21

COUNT THE DOTS

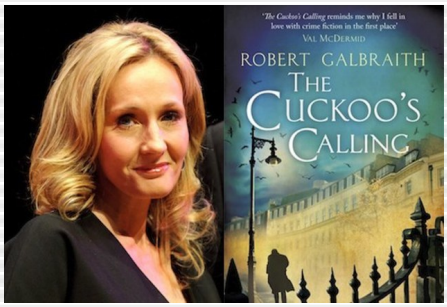
- When a binary number card is **not** showing, it is represented by a zero. When it **is** showing, it is represented by a one. This is the binary number system (base 2).
- What are the following binary numbers?
  - 01001_2
  - 10011_2

COUNT THE DOTS

- What is the highest number we can represent using 6 cards?
  - $111111_2 = 63$
- What is the lowest number we can represent using 6 cards?
  - $000000_2 = 0$
- Count from 0 to 63 in binary.

COUNT THE DOTS

HAPPY BIRTHDAY, ROBERT GALBRAITH!



Born July 31, 1965

COUNT THE DOTS

- Letters are represented in computers in binary also!
- 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

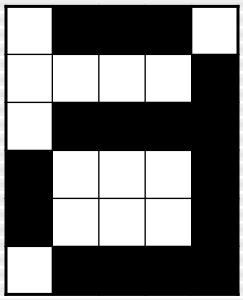
10000	P
01111	O
10000	P
00000	_
10100	T
00001	A
10010	R
10100	T
10011	S

COLOR BY NUMBERS

- Computer screens are divided up into a grid of small dots called *pixels* (**pic**ture **el**ements). In a black and white picture, each pixel is either black or white.
- Computers store drawings, photographs and other pictures using only numbers.
- The following activity demonstrates how a computer image can be stored efficiently.

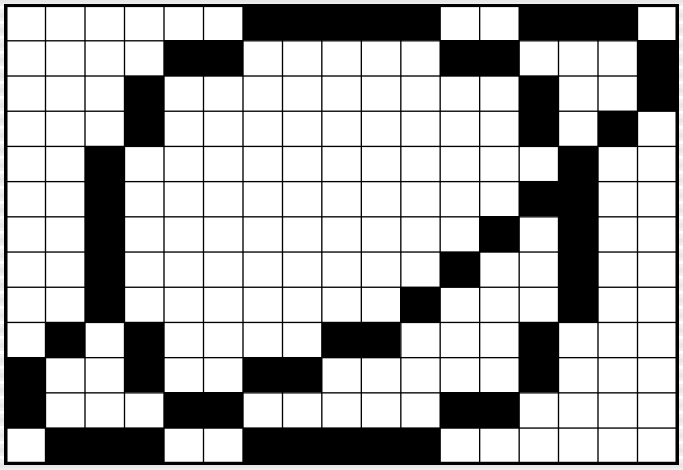
COLOR BY NUMBERS

- The letter a has been magnified to show the pixels. When a computer stores a picture, all that it needs to store is which dots are black and which are white.



1,3
4,1
1,4
0,1,3,1
0,1,3,1
1,4

COLOR BY NUMBERS



6,5,2,3
4,2,5,2,3,1
3,1,9,1,2,1
3,1,9,1,1,1
2,1,11,1
2,1,10,2
2,1,9,1,1,1
2,1,8,1,2,1
2,1,7,1,3,1
1,1,1,1,4,2,3,1
0,1,2,1,2,2,5,1
0,1,3,2,5,2
1,3,2,5

COLOR BY NUMBERS

- This technique is called run-length encoding.
  - Fax transmission
  - Compression of images
- Color encoding
  - Use two numbers per run
    - First number is how many pixels as before
    - Second number is what color (1=red, 2=green, ...)

CARD FLIP MAGIC

- When data is stored on a disk or transmitted from one computer to another, we usually assume that it doesn't get changed in the process. But sometimes things go wrong and the data is changed accidentally.
- This activity uses a magic trick to show how to detect when data has been corrupted, and to correct it.

CARD FLIP MAGIC

CARD FLIP MAGIC

- This exercise illustrates even parity.
- When computer data is transmitted to another computer, extra bits are added so that the number of 1s is even.
- The receiving computer can detect if something gets messed up during the transmission and can correct it if there is one error.
- What happens if there are two errors?

CARD FLIP MAGIC

- Here is an example of parity in real life:

```
1 X 10 =  10
4 X  9 =  36
2 X  8 =  16
5 X  7 =  35
9 X  6 =  54
3 X  5 =  15
7 X  4 =  28
6 X  3 =  18
7 X  2 =  14
          226 / 11 = 20 remainder 6
          Checksum Digit = 11 - 6 = 5
```

CARD FLIP MAGIC

- More parity:

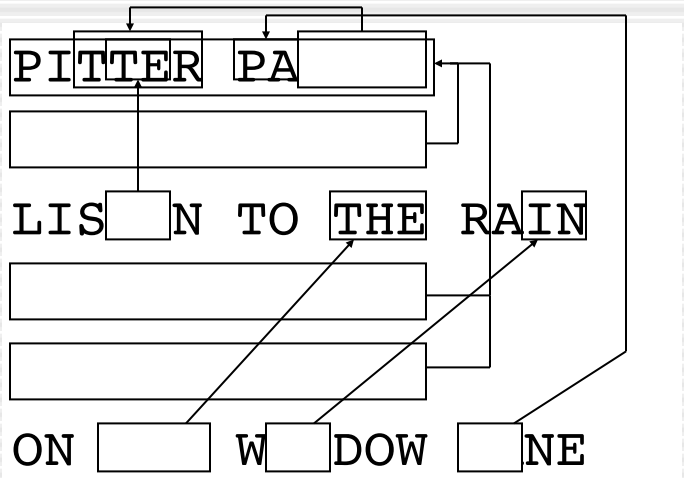
YOU CAN SAY THAT AGAIN!

- Since computers only have a limited amount of space to hold information, they need to represent information as efficiently as possible. This is called compression.
- By coding data before it is stored, and decoding it when it is retrieved, the computer can store more data, or send it faster through the Internet.
- This exercise illustrates how a children's rhyme can be compressed.

YOU CAN SAY THAT AGAIN!

```
PITTER PATTER
PITTER PATTER
LISTEN TO THE RAIN
PITTER PATTER
PITTER PATTER
ON THE WINDOW PANE
```

YOU CAN SAY THAT AGAIN!

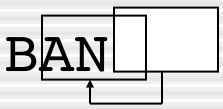


BEFORE:
78 letters

AFTER:
29 letters

YOU CAN SAY THAT AGAIN!

- The arrows and boxes are presented with 2 numbers.
- PITTER PA(7,4)
  - 7: count back 7 positions
  - 4: copy 4 letters/spaces
- Sometimes boxes point back to a box with a blank inside.



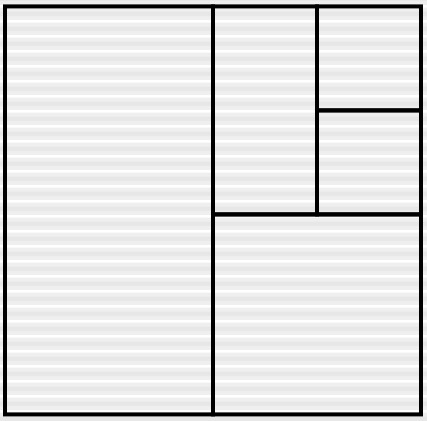
YOU CAN SAY THAT AGAIN!

- The storage capacity of computers is growing at an unbelievable rate.
  - In the last 25 years, the amount of storage provided on a typical computer has grown about a million fold.
- We can *compress* the data so that it takes up less space.
  - This exercise uses Ziv-Lempel coding, or LZ coding, invented by two Israeli professors in the 1970s.
  - ZIP files, GIF images

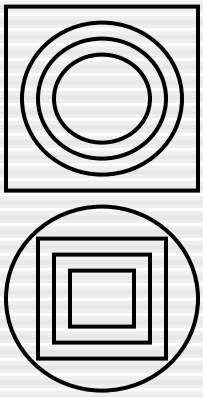
MARCHING ORDERS

- Computers are usually programmed using a "language", which is a limited vocabulary of instructions that can be obeyed.
- One of the most frustrating things about programming is that computers always obey the instructions to the letter, even if they produce a crazy result.
- This activity gives kids some experience with this aspect of programming.

MARCHING ORDERS

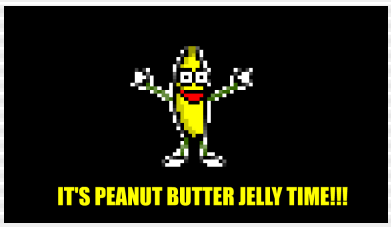


MARCHING ORDERS



MARCHING ORDERS

- A great way to illustrate why algorithms need to be precise is Tom's famous Peanut Butter & Jelly Sandwich algorithm!



MARCHING ORDERS

Input: slices of bread, jar of peanut butter, jar of jelly

1. Pick up some bread.
2. Put peanut butter on the bread.
3. Pick up some more bread.
4. Open the jar of jelly.
5. Spread the jelly on the bread.
6. Put the two parts together to make your sandwich.

- Output?

CS UNPLUGGED

- The basic edition of Computer Science Unplugged has 12 classroom exercises for you to use with your students.
- Each exercise has a number of extensions, activities and background information.
- All activities can be done without the use of computers, but they all demonstrate fundamental principles used in computers today.

CS UNPLUGGED

- The teacher's version of Computer Science Unplugged is available online at `http://www.csunplugged.org`
  - The book is FREE to download and use!
- Additional material will be published soon to add even more activities, including video to demonstrate how to use these activities effectively in your classroom.

Computer Science Unplugged

10100 01000 00001 01110 01011

11001 01111 10101

(THANK YOU!)