Binary counting

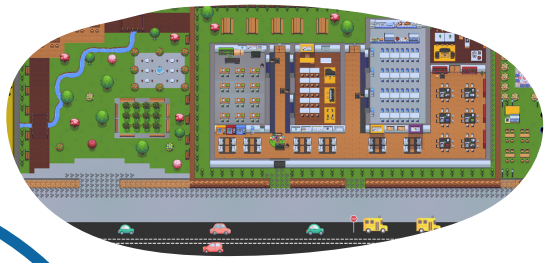
unplugged QUEST

In the BINARY COUNTING challenge children will learn to count like a computer (using the binary number system) offline. The binary number system is a base-2 one. An understanding of binary numbers, the binary system, and how to convert between binary and decimal is essential for anyone involved in computing, coding, and networking. In other words, children will be taught to count by using only the numbers 0 and 1. In addition, children will learn how to make words with binary numbers.

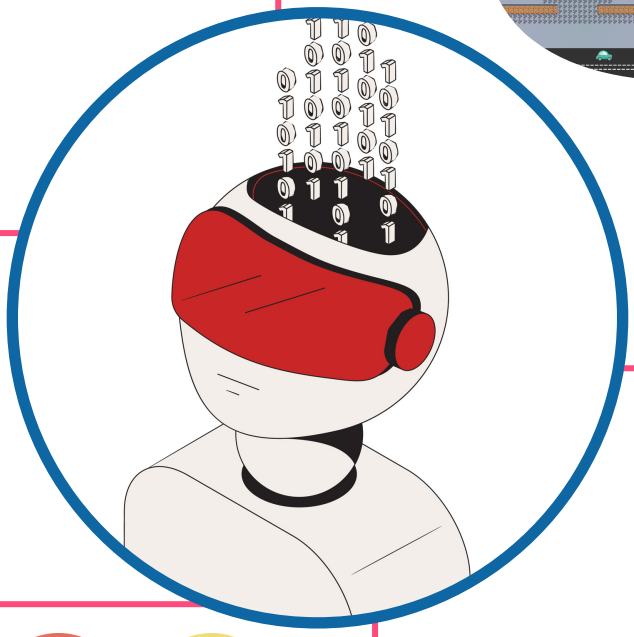
Printable resources attached: Big binary cards, small binary cards, worksheets

Additional material needed: Pencils, scissors

Onboarding - Welcome to the Unplugged Universe

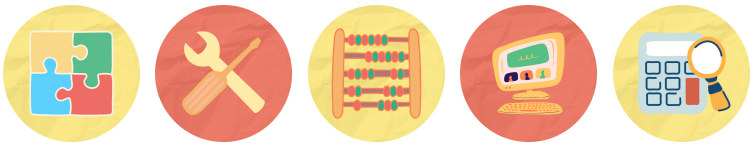


Total duration: 30 - 45 min.



Linked SDGs

Learning objectives



Reasoning | Acquiring tools and methods | Understanding numbers and calculations | Being informed in the digital world, mobilising digital tools | Calculating

Game modalities

- 8 - 12 years old
- Work in group/alone
- In the classroom
- At home

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Pedagogical interest and topics targeted

Approach programming: In the future, it is just as important to be able to program as to be able to speak a language, because our society becomes more automated and digitized. Programming prepares children to obtain skills they can use when they are adults.

Skills which can be learnt from programming:

- Creative and logical thinking
- Spatial awareness
- Problem-solving ability
- Structure
- Collaborate

Learn about the binary system: The binary number system plays a central role in how information of all kinds is stored on computers. Understanding binary can lift a lot of the mystery around computers, because at a fundamental level they're really just mathematical machines that operate on digital information, meaning the information is either 'off' or 'on'. This is represented in computing with the binary number system, which only uses 0 and 1. These binary digits are called bits in computing. So, in computing 0 = off and 1 = on. This allows computers to use a series of 'switches' to make decisions based on a series of logical decisions (this is what a computer programme or 'code' is).

The **binary numeral system** is a way to count using only two digits: 0 and 1. In binary, each digit's place value is twice as much as that of the next digit to the right (since each digit holds two values). In decimal - the system that humans these days normally use - each digit holds ten values, and the place value increases by a power of ten (ones, tens, hundreds, etc.). The place value of the rightmost digit, in either case, is 1.

Understand numbers and calculations: Numbers and calculations are very important in daily life. When children use math, they become familiar with the properties of numbers and how to calculate them. When they use it in an active way, it stimulates the senses and mobility. It brings about the development of problem-solving skills and resilience which result in better physical performance. Solving math problems requires relational skills, but it also increases self-confidence, stimulates abstract thinking and helps develop attitudes.

Reasoning: Reasoning is the capacity to solve problems. Our ability to reason allows us to use knowledge to understand the world. . When a child learns to reason and to argue, it will improve their behaviour and communication skills. They will have their own opinion and draw their own conclusions from certain situations. This accelerates cognitive and emotional development.

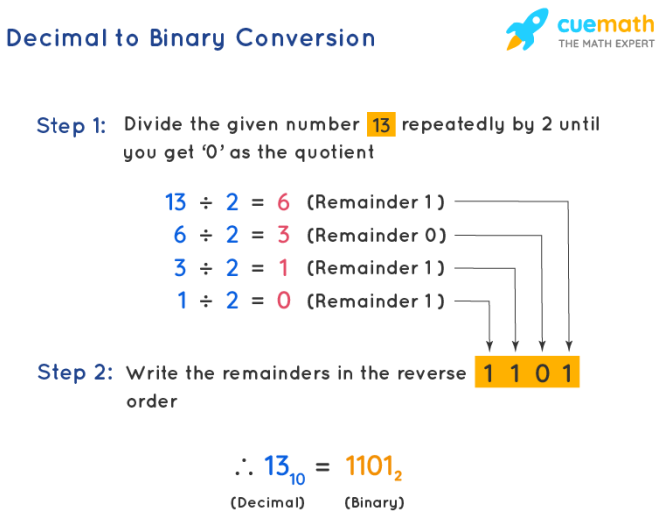
Game rules

Game narrative: In this game, children will be shown how to count like a computer. They will learn the difference between the binary number system and the decimal number system. The decimal number system uses 10 digits, from 0 to 9. But the binary number system is a base-2 digit system, Binary means that we can only use 0 and 1 to count, the digit with the lowest value is written on the right and the one with the highest value on the left. The numbers 0 and 1 can be compared with yes or no, true or false, on or off. which is very useful in electronics and computers since they can either conduct (1) an electrical signal or not (0). In this game, children will be taught to convert binary numbers to decimals and vice versa. Additionally, They will also try to make words in binary numbers, and translate binary numbers into words. They will achieve this by transcribing numbers and looking up which letter they match in an alphabet table. This way they will get an understanding of how a computer counts and saves data.

How to convert decimal into binary numbers: To convert numbers from decimal to binary, the given decimal number is divided repeatedly by 2 and the remainders are noted down till we get 0 as the final quotient. The following steps are considered as the decimal to a binary formula that shows the procedure of conversion.

- Step 1: Divide the given decimal number by 2 and note down the remainder.
- Step 2: Divide the obtained quotient by 2, and note the remainder again.
- Step 3: Repeat the above steps until you get 0 as the quotient.
- Step 4: Write the remainders in such a way that the last remainder is written first, followed by the rest in the reverse order.
- Step 5: This can also be understood in another way which states that the Least Significant Bit (LSB) of the binary number is at the top and the Most Significant Bit (MSB) is at the bottom. This number is the binary value of the given decimal number.

Let us understand this with an example: Convert the decimal number 13 to binary. We will start dividing the given number repeatedly by 2 until we get the quotient as 0. We will note the remainders in order. After noting the remainders, we will write them in such a way that the Most Significant Bit (MSB) of the binary number is written first, followed by the rest. Therefore, the binary equivalent for the given decimal number 13 = 1101.



Game rules

Game rules:

- 6 children will come forward. Each of them has to hold a big binary card
- Let the children take turns coming forward
- Try to change decimal numbers into binary numbers
- Solve the worksheets individually

Role of the teacher and game organisation

- Explain the rules
- Hand out the big binary cards to 6 children
- Choose random numbers that the children should make with the binary cards and try that again a few times
- Hand out the small binary cards to the class
- Hand out the worksheets
- Correct the worksheets

Game rounds

Round 1 - Classical work

Before starting the activity **the teacher opens a discussion on numbers**, posing questions such as:

- Why are we transforming numbers into binary form?
- Why do computers work with binary numbers? Why is it more useful?
- What other examples in real life can we find in binary form? (it is highly relevant to connect this with real-world applications, as girls might feel detached from this activity if it gets too theoretical).

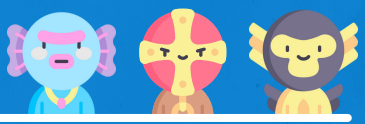
The teacher chooses 6 children from the class to come forward. These children each get a big binary card to hold in front of them. The other children stay in their seats.

The teacher chooses **a number under 5.** The 6 children in the front **should make a sum with the numbers on the big cards**. The sum must be the number that the teacher has chosen. The right numbers will now be turned to the class. The other cards are turned to the other side so that a blank page is seen. **The blank page means in binary/computer language '0' and the numbers mean '1' in binary/computer language.** This way the children made a **decimal number binary**. The teacher writes the answer on the board. The teacher then chooses **a number under 10** and the other steps are repeated. Every group of 6 children can try a few times, After that, the numbers get bigger and other children will come forward. After practising a few times, it's time for individual work.

Round 2 - Individual work

All the children get small binary cards and must take a pencil to resolve **3 worksheets (super easy, easy, difficult)** that they get from the teacher. **They have to solve these assignments individually**.

In these worksheets, they have to **change the numbers from binary to decimal and vice-versa**. They also may try to **write words or names in binary**, or **translate the binary code into words**. They can use the small binary cards to put on the worksheets, so it can help them solve the exercises. They will also have **a table with the alphabet linked to numbers so they can convert words too**. When a child is ready with the first assignment, the teacher checks the worksheet and gives another one. The first worksheet is an easy one, but **it will progressively get more challenging**.



Topic 1 - Learning binary numerical system

- https://kids.kiddle.co/Binary_number
- https://info.thinkfun.com/stem-education/6-unplugged-coding-activities-for-hour-of-code
- https://teachyourkidscode.com/learn-binary-numbers/
- https://blogs.glowscotland.org.uk/glowblogs/computingscience/2021/08/06/binary-understanding-how-computers-work-and-challenge-in-numeracy/
- https://classic.csunplugged.org/activities/binary-numbers/

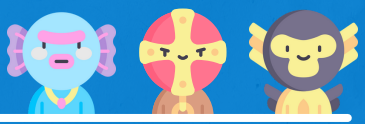
Topic 2 - Numbers and calculations

Some useful materials to **introduce converting binary into decimal numbers** and visa versa could be found here:

- https://www.ducksters.com/kidsmath/binary_numbers_basics.php
- For **converting binary numbers into words**, check here: https://www.sciencefriday.com/educational-resources/write-your-name-in-binary-code/
- **Convert text into binary code** - https://study.com/learn/lesson/kinesthetic-intelligence-skills.html
- Learn how to **convert text into a binary code**: https://www.sciencefriday.com/educational-resources/write-your-name-in-binary-code/

Topic 3 - Reason

See binary puzzles to teach reasoning in a fun way here: https://www.sciencekiddo.com/teach-kids-binary/



1

2

4

8

16

32

Printables – Small binary cards

1	1	1
2	2	2
4	4	4
8	8	8
16	16	16
32	32	32

Worksheet: Binary Counting: Super easy

4	2	1

2. Binary to decimal

111 =

101 =

011 =

2. Decimal to binary

7 =

3 =

4 =

3. Write like a computer

1	2	3	4	5	6	7	8	9	10	11	12	13
a	b	c	d	e	f	g	h	i	j	k	l	m
14	15	16	17	18	19	20	21	22	23	24	25	26
n	o	p	q	r	s	t	u	v	w	x	y	z

Write 'bad' in binary

.....

Translate this binary code into words

001 – 011 - 110

.....

010 – 110 - 100

.....

Worksheet: Binary Counting: Easy

16	8	4	2	1

1. Binary to decimal

11111 =

10101 =

01110 =

2. Decimal to binary

7 =

23 =

30 =

3. Write like a computer

1	2	3	4	5	6	7	8	9	10	11	12	13
a	b	c	d	e	f	g	h	i	j	k	l	m
14	15	16	17	18	19	20	21	22	23	24	25	26
n	o	p	q	r	s	t	u	v	w	x	y	z

Write your own name in binary

.....

.....

Translate this binary code into words

00100 – 01001 - 00111 – 01001 – 10100 – 00001 – 01100 – 00101

.....

10111 – 01111 – 01100 - 10110 – 00101 – 01110

.....

Worksheet: Binary counting: Difficult

16	8	4	2	1

1. Binary to decimal

1111111111 =

1010101010 =

1111100000 =

2. Decimal to binary

1000 =

500 =

750 =

3. Write like a computer

1	2	3	4	5	6	7	8	9	10	11	12	13
a	b	c	d	e	f	g	h	i	j	k	l	m
14	15	16	17	18	19	20	21	22	23	24	25	26
n	o	p	q	r	s	t	u	v	w	x	y	z

Translate this binary code into words

10100 – 00101 – 00011 – 01000 – 01110 – 01111 – 01100 – 01111 – 00111 – 11001

.....

01001 - 10011 10011 – 10101 – 10000 – 00101 – 10010 –

.....

00011 – 01111 – 01111 – 01100

.....

Character	Binary Code	Character	Binary Code	Character	Binary Code	Character	Binary Code	Character	Binary Code
A	01000001	Q	01010001	g	01100111	w	01110111	-	00101101
B	01000010	R	01010010	h	01101000	x	01111000	.	00101110
C	01000011	S	01010011	i	01101001	y	01111001	/	00101111
D	01000100	T	01010100	j	01101010	z	01111010	0	00110000
E	01000101	U	01010101	k	01101011	!	00100001	1	00110001
F	01000110	V	01010110	l	01101100	"	00100010	2	00110010
G	01000111	W	01010111	m	01101101	#	00100011	3	00110011
H	01001000	X	01011000	n	01101110	$	00100100	4	00110100
I	01001001	Y	01011001	o	01101111	%	00100101	5	00110101
J	01001010	Z	01011010	p	01110000	&	00100110	6	00110110
K	01001011	a	01100001	q	01110001	'	00100111	7	00110111
L	01001100	b	01100010	r	01110010	(	00101000	8	00111000
M	01001101	c	01100011	s	01110011	)	00101001	9	00111001
N	01001110	d	01100100	t	01110100	*	00101010	?	00111111
O	01001111	e	01100101	u	01110101	+	00101011	@	01000000
P	01010000	f	01100110	v	01110110	,	00101100	_	01011111