MODULE 1 - CS INTRO

LESSON 1.4 - LETTERS OVER THE WIRE

Summary

In this class, students will learn the basic workings of the internet. Millions of computers throughout the world are interconnected and are able to communicate with each other, exchanging information as they do. That information takes the form of bits (0s and 1s) that get sent through wires and other means. Students will get to exchange secret messages (by also learning about binary representation of letters) and find out how that works.

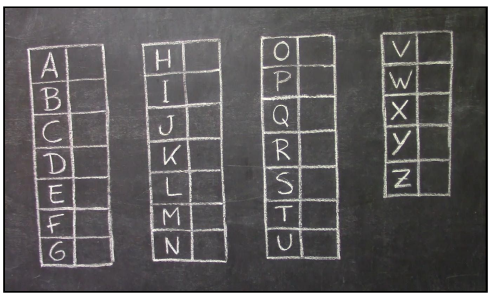
Duration

60-70 minutes.

Materials

- Writing board;
- Pencils or pens for students;
- 'Binary-Decimal-Letter Conversion Exercises' (Note: this is an editable PowerPoint, see point 3 of the '**Preparation**');
- 'Binary-Decimal-Letter Conversion Grids';
- 'Letter-Decimal-Binary' table, to make the teacher's life easier when correcting exercises;
- Two cardboard screens, with adhesive to hold them to each table;
- A sets of cards with secret words on them (e.g., "WE" and "ARE"; "CLASS" and "X");
- 'Internet Box Set' (Note: a schematic will be available on this Lesson's page);
- Blank pieces of paper.

Preparation



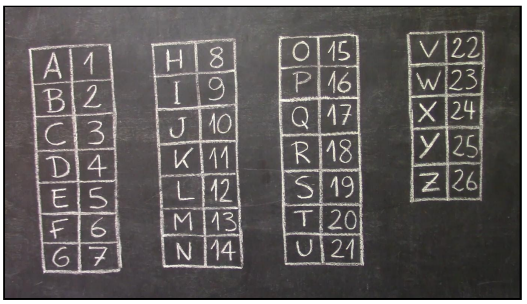
1. Start with traditional seating arrangements, either in rows or in groups, – which are later to be changed, mid-class.
2. Draw a grid on the board with the 26 letters of the alphabet, with an empty space adjacent to each.
3. Have the printouts of 'Binary-Decimal-Letter Conversion Exercises' ready, as they will be

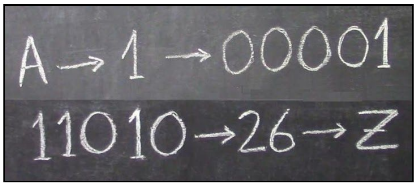
handed out first. This file has two exercises: a letter to decimal to binary conversion, followed by a binary to decimal to letter conversion. Because this file is editable this means you can fill it in with any words/binary numbers you wish (right now it has H-E-L-L-O, as a word, and E-X-A-M-P-L-E, in binary). As a suggestion – a laborious but rewarding one –, you can make tailored exercises, and make the binary numbers spell out each individual student's name in the binary-decimal-letter conversion. Just make sure that each student gets the right sheet (if they have numbers assigned to them in the classroom, just write it on each sheet).

4. You should already bear in mind the changes you'll need to make for the second class setting, which is explained in point 5 of the '**Procedure**'. Also, have the 'Binary-Decimal-Letter Conversion Grids' ready and set them apart for later, along with the two Cardboard screens for the tables and the 'Internet Box Set'.

Procedure

1. Remind the students that they have already learned how to represent numbers from 0-31 using the binary system, i.e., using only 0s and 1s. Make sure they remember the number of bits that they have been working with (5) and then use 'finger binary' to recap the value for each position of the binary digits.





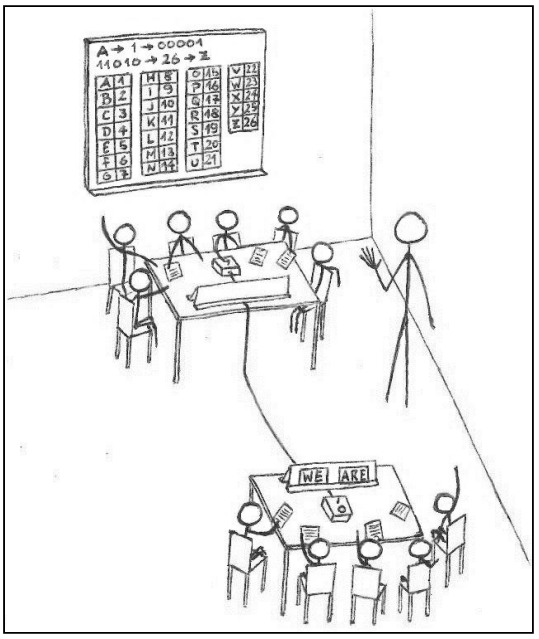
2. After restating that the students can now go from binary to decimal numbers, pose the problem of how to go from these to letters. Students will usually figure out that they will need to number the letters from 1-26 on the board. Add the numbers to the grid and get them acquainted with it by asking them to find letters by their numbers, and vice versa.

3. Explain that, because the students already know how to count from 0-31 using the binary system, they can now go from binary to decimal and then to one of the 26 letters of the alphabet. Exemplify with A, going from the letter to the binary number, and then with Z, going the other way around.

4. Hand out the 'Binary-Decimal-Letter Conversion' exercises and pens, making sure each student gets the sheet with his own individual name spelt in binary. This last exercise is a reliable method to see if any students are cheating off one another (as sometimes they will copy someone else's name) and to offer further explanations when necessary.

5. Retrieve exercises and pens, and tell the students that the second part of the class is dedicated to understanding how the internet works. Ask students to standby while rearranging the classroom setting (or moving to a different part of the classroom if

you have the space for it). There should be two tables facing each other at a distance of at least 4-5 meters. Chairs should be arranged around three sides of the tables, keeping the side that is facing the other table clear. Have half of the students sit around one table and the other half on the other and then bring out the 'Internet Box Set'. Place one of the boxes in one of the tables, ask one of the students to hold onto it while you unroll the wire and take the second box to the other table, where another student will hold the box as well (making sure neither falls in the process). Get the cardboard screens with adhesive and place them at the extremity of each table, with the wire running under them, so that the students on the other table cannot see the other box across the room (while also making it more difficult for the boxes to land on the floor).



6. Tell students that the 'Internet Box Set' is meant to explain how computers communicate with each other through the internet. Each box is like a computer and they are both connected through an electric wire. Go to each box and show how an electric signal can be sent from one box to the other by flipping the switch, which lights up the LED lamp on both sides. Flip the switch multiple times and ask students what they think you are sending when the switch is on and when it is off, which they will usually figure out are 1's and 0's, respectively, i.e., bits. Tell them that they will use those 1's and 0's, or bits, to send secret messages back and forth across the tables.

7. Start off with an example. Tell students that you want to send the word 'CHALK' from one side to the other. This means you will have to send five letters starting with "C". As with the previous letters, have students figure out how to convert "C" first into its decimal counterpart and then to binary ("C→3→00011"). Pose the problem of how to send consecutive 0's and 1's over the wire, seeing that by just leaving the switch off or on you do not automatically know how many 0's and 1's are going across. Help students reach the conclusion that they will have to time the signal! Once they understand this, tell them that to exemplify you will be sending the 5 bits needed for 'C' (00011) from one box to the other, at a rate of one bit per second. Go to one of the tables and grab hold of one of the boxes. Count up from 1 to 5 out loud (holding up your hand and counting with your fingers as well) and ask students to say '0' or '1' depending on whether the signal was off or on when you counted each second. For clarity's sake do the same exercise on both of the tables. There is no need to send

the whole word across but, if necessary, send “H” as well (“H→8→01000”).

8. Now that students understand the process, let them know that you will be giving each table a set of secret words that they will have to send across the wire. A possible combination is giving the cards “WE” and “ARE” to one of the tables, and “CLASS” and “A” to the other, so that in the end, putting both together, the whole message will spell “WE ARE” “CLASS A”, for example. Make sure the students understand that they cannot say the words out loud or show them to the opposite table.

9. Group the students in each table into pairs and give them a printout with the ‘Binary-Decimal-Letter Conversion Grids’. This printout has two grids, side by side, both with three columns, but with different orders: one to ‘SEND’ and the other one to ‘RECEIVE’. On the ‘SEND’ side the columns are ordered, Letter→Decimal→Binary, as the students will first have to translate their own message, from letter to binary, using this grid. The ‘RECEIVE’ side, ordered Binary→Decimal→Letter, will be used later to take note of the other table’s secret message, which was translated into binary, by the other group. Get the pairs working together converting their message into binary numbers in the ‘SEND’ grid, and once they are finished, make sure the whole table has a correct version of the conversion (otherwise it will be very difficult to complete the exercise).

10. Once this is done choose one of the tables to be the first to send their message across. They will have to send one letter at a time, in order, to spell out the words in their message. For each letter, they will have to send the respective 5 bits by flicking the switch, on or off, according to the binary number that they are sending, as the teacher counts from 1 to 5 (one bit per second). The students at the other table make note of this same number on the ‘RECEIVE’ grid they have on their printout – so they can later convert it into a decimal, and then into a letter. Make sure that each student gets a chance to send at least one of the letters. It is a good idea to have students help each other, so while one is flicking the switch the others can whisper “0” or “1” to make sure that they are sending the message correctly. The teacher will have to constantly alternate between both tables to see if the message is being both correctly sent and received. Also, make sure to let the students on the ‘RECEIVE’ end know when a different word in the message is going to begin, so they can spare a line

SEND

Letter	Decimal	Binary
W	23	10111
E	5	00101
A	1	00001
R	18	10010
E	5	00101

RECEIVE

Binary	Decimal	Letter
10111		
00101		
00001		
...		
...		

in their grid to tell the words apart. Only when the first table has sent all of the letters and words in their message do the tables reverse roles and the receivers start sending and vice versa (**Attention**: Be ready to repeat the same letter a number of times, as many mistakes are made, especially at the beginning of the exercise; get the students that are receiving the message ready to cross out any binary number that gets mixed up by the other table and to start over, letting both sides know that this is normal and part of the process; also, if a student gets stuck and mixes up the message more than once pass the box on to the next student and let the first one have another go later on, so as to not frustrate the rest of the class with the hold up).

11. When both of the tables have sent their respective messages, it is time to convert the message they received from the other table, following the opposite pattern as before, Binary→Decimal→Letter, on the 'RECEIVE' grid.

RECEIVE

Binary	Decimal	Letter
10111	23	W
00101	5	E
00001	1	...
10010	...	...
00101	...	...

The finished grids to the messages proposed should look like the images below:

SEND

Letter	Decimal	Binary
W	23	10111
E	5	00101
A	1	00001
R	18	10010
E	5	00101

RECEIVE

Binary	Decimal	Letter
00011	3	C
01100	12	L
00001	1	A
10010	19	S
10010	19	S
00001	1	A

SEND

Letter	Decimal	Binary
C	3	00011
L	12	01100
A	1	00001
S	19	10010
S	19	10010
A	1	00001

RECEIVE

Binary	Decimal	Letter
10111	23	W
00101	5	E
00001	1	A
10010	18	R
00101	5	E

12. Once the whole table has correctly deciphered the message they received, give students blank sheets of paper to write the other table's message down in capital letters. They can then hold up the sheets of paper and tell the other table what message they got so they can confirm they got it right.

13. At the end, recap the exercise, so that students fully understand they have just exchanged messages by only sending bits, 0's and 1's, across the wire – just like computers do over the internet. Make the analogy with text messaging to make the point. A further note can be made regarding the speed at which computers communicate bits to each other over the internet – as the speed is considerably higher than 1 bit per second...

SOURCES

- "CS Unplugged - An enrichment and extension programme for primary-aged students", Tim Bell, Ian H. Witten and Mike Fellows, 2015.

- "The Internet: Wires, Cables & Wifi", Youtube, Code.org.