Abstract

Understanding binary representation of numbers is essential for students because digital computers represent all data in binary form. Many students have difficulty understanding binary numbers. This lesson takes the abstract concept of binary representation and creates a more tactile and concrete approach. Using egg cartons, students create a physical representation of binary numbers. The egg cartons become a tool to assist students in mastering the skill of converting between binary and decimal notation.

Aim

To teach students how to interpret binary numbers and how to represent decimal numbers in binary notation.

Objectives

1. Students will be able to convert binary numbers to decimal numbers. (critical)
2. Students will be able to convert decimal numbers to binary numbers. (critical)
3. Students will understand the importance and usefulness of binary numbers. (important)

Context

This lesson was prepared for a grade 10 advanced computer studies course (DIC 2A0). The current unit was the internal representation of numbers.

Rationale

Digital computers represent all data in binary. Therefore, it is critical for students to understand binary notation if they plan to understand the internal representation of numbers and computer arithmetic.

Format

This lesson begins with a large group discussion, including brainstorming and creative problem solving. This discussion is followed by a teacher-centred presentation of information and then a hands-on activity of creating the egg carton representation of binary numbers. The lesson concludes with a worksheet for the students to complete.

Plan

(15 min) Put the students in small groups of 3-4 students and give them the problem of how to represent numbers mechanically. Give them a couple of minutes to brainstorm solutions. As a class examine the proposed solutions and discuss the pros and cons of each one.
(10 min) Explain that modern day computers use a method of representation called binary numbers. Begin by explaining how the decimal system works.
Example: $5632 = 5 \times 1000 + 6 \times 100 + 3 \times 10 + 2 \times 1$
$= 5 \times 10^3 + 6 \times 10^2 + 5 \times 10^1 + 2 \times 10^0$
In the decimal system there are 10 different digits: 0, 1, … 9.
Binary numbers uses base 2. There are only 2 digits: 0 and 1.
Example: $(1011)_2 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$
$= 1 \times 8 + 0 \times 4 + 1 \times 2 + 1 \times 1$

$= (11)_{10}$

Therefore $(1011)_2$ is the binary representation for eleven.

(15 min) Hand out one egg carton to each student. Cut the egg cartons in half and then attach them with tape so that it forms one long row of 12 cups. Label the cups with the powers of two. (make sure the students label from right to left)

Hand out bingo chips, or ping pong balls or markers of some type. Explain to the students that a cup can contain **at most** one marker. If a marker is in the cup it represents a one, if there is no marker in the cup it represents a zero. To determine the decimal representation of the binary number, add up the numbers of the cups that have markers in them. To determine the binary representation of a decimal number, begin on the left side and place a marker in the cup of the largest number that is smaller than your decimal number. Subtract this number from the decimal number and then find the cup with the largest number that is smaller than the result of this subtraction. Keep repeating this process until the remainder is zero.

Try a few examples together:

Convert to decimal:

i. 101011 ii. 110011

Convert to binary:

i. 681 ii. 2347

(20 min) After working through these examples, hand out the following worksheet for the students to complete using their egg cartons as tools to assist them. Whatever is not finished in class will be assigned for homework.

Working with Binary Numbers

A. Convert to decimal:	B. Convert to binary:
1. 10	1. 5
2. 1111	2. 21
3. 10011	3. 42
4. 1101101	4. 119
5. 111111100	5. 132
6. 1100110111	6. 548
7. 10000000001	7. 2000
8. 101010101010	8. 3100

C. Determine the binary number and the decimal number for the following pictures
(an "X" indicates that there is a marker in the cup and a "0" indicates that there is no marker in the cup)

1. 0 0 0 0 0 0 X 0 X X X 0
2. 0 0 0 0 0 X 0 X 0 X 0 X
3. 0 X 0 X 0 0 X 0 X X 0 0
4. 0 X 0 0 0 0 X 0 0 X 0 X
5. X 0 X X X 0 X X X 0 X 0