Teaching Binary Number Concepts using Mathematic Magic Card Trick

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Abstract: Mathematic Magic Card Trick is a creative mind-reading trick based on binary system that uses 5 tables. The tables are constructed from a principle of conversion between decimal and binary system. This magic cards can be used as an induction set before teacher starts introducing the binary system. This can make classroom fun and meaningful.

1. Introduction

Many students do not like Mathematics. They may feel that Mathematics is difficult and not fun. Children are curious and they love to have fun with exciting things around them. Appropriate activities can be found to stimulate them to have fun and love to learn Mathematics. In the modern digital world, the concept of binary number is very important. In order to understand how software computer works and how to program the computer, we have to know the basic concept of binary number. Mathematic teachers also find that teaching of conversion of decimal number to binary number or binary number to decimal is very difficult. Using a mathematic card trick is one of the teaching techniques to arouse curiosity and to make the lesson more fun and meaningful [1].

2. Related Idea

In the former time when digital weighing device is not available, people were using a traditional weighing scale with weights of different known values as shown in Figure 2.1. The traditional weighing scale consists of two plates or containers suspended at equal distances from a fulcrum. One container holds an object of unknown mass, while known masses are added to the other plate until static equilibrium is achieved and the container level off, which happens when the masses on the two containers are equal.



Figure 2.1 A traditional weighing scale with different known weights.



Figure 2.2 Showing the weighing scale using combination of known weights to balance.

In the real practical way, this can be seen as an example in Figure 2.2. Suppose we want to weigh a mass with 3 grams of weight. We have to use 2 weights of 1gram and 2grams to balance the weighing scale. The maximum weight of this weighing scale is 1g + 2g + 4g + 8g = 15 g. The unknown weight can be from 1g to 15g. In order to balance the unknown

weight of mass we have to use the combination of weights among 1g, 2g, 4g and 8g to balance the scale.

3. Making Magic Card

We create five magic table cards based on the above idea of combination of numbers. The number of the upper-left corner of each card will represent the combination numbers: 1, 2, 4, 8, 16.



Figure 3.1 Showing 5 magic table cards with representing numbers 1, 2, 4, 8, 16 at the left upper corner of each card.

This magic card trick is like a mind reader game [2]. There will be 2 players in the game. The first player can choose any number or a birth date from 1 to 31. Then the first payer has to pick up the cards so that the sum of the combination numbers 1, 2, 4, 8, or 16 equals to the birthdate. The numbers 1 to 31 in the right tables in the **Figure 3.1** are the birthdate. The second player can tell the number the first player has chosen from the card(s) the first player picked up.

						Mag	ic Ta	ables	5								E 16	D 8	C 4	B 2	A 1	[E 16	D 8	C 4	B 2	A 1
	Table A					Table B					Table C				1				_	1		16	1	0	0	0	0	
Г	1	2	5	7	1	2	3	6	7	ור	4	5	6	7	1	2				1	0		1/	1	0	0	0	1
	'	3	5	ľ		2	5	ľ	1		4	5	•	· ·		3			_	1	1		18	1	0	0	1	-
	9	11	13	15		10	11	14	15		12	13	14	15		4			1	0	0		19	1	0	0	1	1
	17	19	21	23	1	18	19	22	23	1	20	21	22	23	1	5			1	0	1		20	1	0	1	0	0
																6			1	1	0		21	1	0	1	0	1
	25	27	29	31		26	27	30	31		28	29	30	31		7			1	1	1		22	1	0	1	1	0
													8		1	0	0	0		23	1	0	1	1	1			
	Table D Table E											9		1	0	0	1		24	1	1	0	0	0				
		[8	9	10	0 11		[16	17	18	19	1			10		1	0	1	0		25	1	1	0	0	1
				-			_						-			11		1	0	1	1	[26	1	1	0	1	0
			12	13	14	1 15	`		20	21	22	23				12		1	1	0	0	[27	1	1	0	1	1
			24	25	26	6 27	7		24	25	26	27				13		1	1	0	1		28	1	1	1	0	0
			28	29	30	0 31			28	29	30	31	1			14		1	1	1	0		29	1	1	1	0	1
		l						l	_,			1				15		1	1	1	1	ĺĺ	30	1	1	1	1	0
																·						' I	31	1	1	1	1	1

Figure 3.2. Showing how to fill the numbers into the tables.

The trick is to take the pile of cards that contains their number and simply add the upper-left corner number from each card. The sum of these values will be that was chosen.

We can fill in the numbers into the cards by following the **Figure 3.2**. For example, if the persons choose number of his birthdate 1, we write "1" in the right table of "A" row. If the number of birthdate is 23, we have to write "1" in the table of row "A", "B", "C" and "E" and the rest will be "0". From the complete 2 right tables of Figure 4, we will consider each row of A, B, C, D and E. For example, in row A we have to find the corresponding decimal numbers where the number "1" is in the row.

In this case, there will be numbers 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29 and 31. Take the number to put into the table A of the card. In the row C, the corresponding decimal numbers, where the number "1" appears, are 4, 5, 6, 7, 12, 13, 14, 15, 20, 21, 22, 23, 28, 29, 30 and 31. These numbers will be put into the table C of the card.



4. Playing the mathematic magic card trick

Figure 4.1. Showing how to play the mathematic magic card trick

If the first player was born on the 11th and chooses the number 11. He has to choose the cards that contain the number 11. In this case, the cards A, B and D will be taken. The second player notices the numbers at the upper-left corners of each card then add them together to get the chosen number 11 as shown in **Figure 4.1**.

5. Conversion between decimal and binary number

The numbers at the upper-left corners are in the series of 2^n , where n = 0,1,2,3,4,... The number 1,, 31 in the 2 right tables in the Figure 4 are decimal numbers which have corresponding binary numbers in the 2 right tables. The tables in the **Figure 4.1** can be used as conversion tables between decimal numbers and binary numbers. The conversion between decimal and binary numbers can be seen in **Figure 5.1**.



Figure 5.1. Showing conversion between decimal and binary numbers

6. Another Similar Binary Number Trick

Fake Coins

This activity is a good sample for explanation of Binary number idea. Teacher can introduce this activity or similar to the students in the classroom to stimulate their interest as well as their creativity. The condition of the idea is setup so that the student can work out individually or in a group.



Figure 6.1 Fake coin activity

The activity is shown in **Figure 6.1**. There are four bags filled with gold coins. Some of the bags contain all fake coins, some of the bags contain all genuine gold coins. Genuine gold coin weighs 10 grams each. Fake gold coin weighs 9 grams each.

You are allowed to use the weighing machine only once, how can you find out which bags contain fake coins?



Figure 6.2 Take out coins from different bags.

From Figure 6.2, take out
1 coin from bag A;
2 coins from bag B;
4 coins from bag C and
8 coins from bag D.
Weigh all the 15 coins together.
If all are genuine coins, they should weigh 150g.
If they weigh less then 150g, we can find out which bags contain fake coins by referring to the table. The solution table can also be learnt by using Geometer's Sketchpad [3].

Total	Lighter	А	В	С	D		
weight	by	1 coin	2 coins	4 coins	8 coins		
149g	1g	х					
148g	2g		х				
147g	3g	х	х				
146g	4g			х			
145g	5g	Х		х			
144g	6g		Х	Х			
143g	7g	Х	Х	Х			
142g	8g				Х		
141g	9g	Х			Х		

7. Conclusion

Starting with mathematic magic card trick will arouse curiosity in the classroom. Children are curious and they love to have fun with exciting things around them. This activity can be found to stimulate them to have fun and love to learn Mathematics. Then we follow by basic principle so that they can understand the lesson easily and remember the content longer.

References

- [1] Gardner, Martin (1978), Aha! Insight! New York, Scientific American, Inc.
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