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A Case Study for Developing the Mathematical Creativity in CNUE of Korea[1]

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This paper will present two activity cases for developing mathematical creativity at The Center for Science Gifted Education (CSGE) of Chongju National University of Education of Korea. One is 'the magic card mystery'; the other is 'mathematicians' efforts to solve equations'.

Keywords: mathematical creativity, magic card mystery, 17C Korean mathematicians' hypothesis, Al-Khwarizmi's geometric puzzle, Cardano's equation
ZDM Classification: H10
MSC2000 Classification: 97D40

INTRODUCTION

The Korea Science Foundation and Ministry of Science and Technology have helped to establish the Centers for Science Gifted Education in 23 universities since 1998 (Shin & Han 2000, pp. 81–84). Also, the Ministry of Education has established a special school and classes for gifted children since March 2002, as described in the Gifted and Talented Education Act of 2000.

We have made an effort to realize a gifted education in mathematics, science, and information technology. The Center for Science Gifted Education (CSGE) of Chongju National University of Education was established in 1998 with the financial support of the National Science Foundation and Ministry of Science and Technology of Korea. We now have talented education programs for 5th, 6th, 7th, and 8th, graders.

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We have a number of programs for Super Saturday, Summer School, Winter School, and Mathematics and Science Gifted Camp in Chongju National University of Education. Each program is suitable for 90 or 180 minutes of class time. The types of tasks developed can be divided into experimental, group discussion, open-ended problem solving, and exposition and problem solving tasks. Let me show a couple activity cases for developing mathematical creativity.

MAGIC CARD MYSTERY

Table 1. Magic Card

1	3	5	7
9	11	13	15
17	19	21	23
25	27	29	31
33	35	37	39
41	43	45	47
49	51	53	55
57	59	61	63

2	3	6	7
10	11	14	15
18	19	22	23
26	27	30	31
34	35	38	39
42	43	46	47
50	51	54	55
58	59	62	63

4	5	6	7
12	13	14	15
20	21	22	23
28	29	30	31
36	37	38	39
44	45	46	47
52	53	54	55
60	61	62	63

8	9	10	11
12	13	14	15
24	25	26	27
28	29	30	31
40	41	42	43
44	45	46	47
56	57	58	59
60	61	62	63

16	17	18	19
20	21	22	23
24	25	26	27
28	29	30	31
48	49	50	51
52	53	54	55
56	57	58	59
60	61	62	63

32	33	34	35
36	37	38	39
40	41	42	43
44	45	46	47
48	49	50	51
52	53	54	55
56	57	58	59
60	61	62	63

1. Purpose

Understanding the binary system which underlies the magic card mystery and creating another magic card using the same principle.

2. Preparation Activity

(1) Play the magic card game of as follows:

A: Think of any number between 1 and 63.
B: O. K.
A: Is that number on the 1st card?
B: Yes.
A: Is that number on the 2nd card?
B: No.
A: Is that number on the 3rd card?
B: No.
A: Is that number on the 4th card?
B: No
A: Is that number on the 5th card?
B: Yes.
A: Is that number on the 6th card?
B: Yes.
A: That number is 49 because 1+16+32 = 49. (So to speak, 110001(2) = 49)
B: Oh!

(2) Students to think about the principle of making the magic card

3. Exploration Activity

20007 in the decimal system means 2×10^n ($n = 4$) $+ 7 \times 1$, in which we use such 10 numerals: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. 10001 in the binary system means 1×2^n ($n = 4$) $+ 1 \times 1 = 17$, in which we use such 2 numerals as 0 and 1.

<Problem>
Find the principle of making 6 magic cards by way of the following table (Table 2).
Some students found the principle of making 6 magic cards as follows:

(1) On the 1st card, there are such numbers as 1, 3, 5, …, 63 which have 1 in the place value of 1 in the binary system of notation.
(2) On the 2nd card, there are such numbers as 2, 3, 6, 7, …, 62, 63 which have 1 in the place value of 2 in the binary system of notation.
(3) On the 3rd card, there are such numbers as 4, 5, 6, 7, …, 60, 61, 62, 63 which have 1 in the place value of 2^n ($n = 2$) in the binary system of notation.
(4) On the 4th card, there are such numbers as 8, 9, 10, 11, 12, 13, 14, 15, …, 56, 57, 58, 59, 60, 61, 62, 63 which have 1 in the place value of 2^n ($n = 3$) in the binary system of notation.
(5) On the 5th card, there are such numbers as 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, …, 48, 49, …, 60, 61, 62, 63 which have 1 in the place value

of 2^n ($n = 4$) in the binary system of notation.

(6) On the 5th card, there are such numbers as 32, 33, ..., 63 which have 1 in the place value of 2^n ($n = 5$) in the binary system of notation.

Table2. Decimal Number and Binary Number

Decimal	Binary	Decimal	Binary	Decimal	Binary
1	1	22	10110	43	101011
2	10	23	10111	44	101100
3	11	24	11000	45	101101
4	100	25	11001	46	101110
5	101	26	11010	47	101111
6	110	27	11011	48	110000
7	111	28	11100	49	110001
8	1000	29	11101	50	110010
9	1001	30	11110	51	110011
10	1010	31	11111	52	110100
11	1011	32	100000	53	110101
12	1100	33	100001	54	110110
13	1101	34	100010	55	110111
14	1110	35	100011	56	111000
15	1111	36	100100	57	111001
16	10000	37	100101	58	111010
17	10001	38	100110	59	111011
18	10010	39	100111	60	111100
19	10011	40	101000	61	111101
20	10100	41	101001	62	111110
21	10101	42	101010	63	111111

4. Enrichment Activity

(1) Making 5 magic cards

Students were very interested in the binary system, which underlies the magic card mystery. Every student made 5 magic cards as follows:

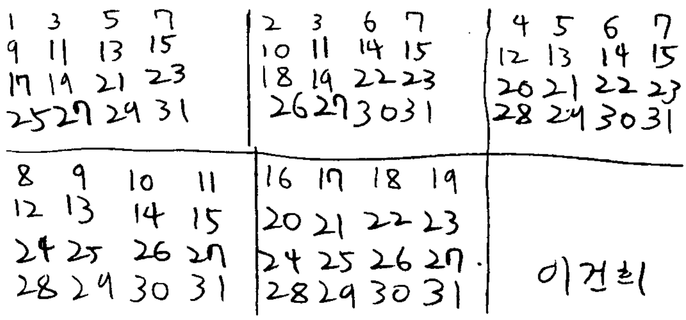


Figure 1. 5 Magic Cards

(2) Making 7 magic cards.

(Abbreviation)

MATHEMATICIANS' EFFORTS TO SOLVE EQUATIONS

1. Purpose

Developing creative problem-solving ability by exploring the old Korean mathematicians' creative ideas to solve simultaneous equations, Al-Khwarizmi's geometric puzzle, and Cardano's resolution of $x^n + 9x = 26$ ($n = 3$).

2. Preparation Activity

Chicken and Rabbit

<Problem>

I know that there are 18 animals in the barnyard. Some are chickens and some are rabbits. I counted 50 legs in all. How many of the animals are chickens and how many are rabbits?

(1) Simultaneous equations (8th graders in Korea)

x: number of chickens
y: number of rabbits

$$x + y = 18 \qquad \text{(a)}$$
$$2x + 4y = 50 \qquad \text{(b)}$$

(1)′ Half of the Legs (17C Korean mathematicians)

If all of the animals stood with half of the number of their legs, the number of their legs would be 25. The difference of the number between 25 and 18 is 7 which is the number of rabbits. We can identify creativity of their hypothesis by following solution of simultaneous equation:

$$\text{(b)/2:} \quad x + 2y = 25 \qquad \text{(c)}$$
$$\text{(c)} - \text{(a):} \quad y = 7, \quad x = 11$$

(2) If all of them were rabbits (some 5th graders in CSGE)

If all of the animals were rabbits, the number of their legs would be 72. The difference of the number between 72 and 50 is 22 which mean that some of them are not rabbits but chicken, and the numbers of chickens are 11 and rabbits are 7. We can identify creativity of their hypothesis by following solution of simultaneous equation:

$$\text{(a)} \times 4 - \text{(b):}\ 2x = 22$$
$$x = 11, \quad y = 7$$

(3) If all of them were chickens (some 5th graders in CSGE)

If all of the animals were chickens, the number of their legs would be 36. The difference of the number between 36 and 50 is 14 which mean that some of them are not chickens but rabbits, and the numbers of rabbits are 7 and chickens are 11. We can identify creativity of their hypothesis by following solution of simultaneous equation:

$$\text{(b)} - \text{(a)} \times 2\text{:}\ 2y = 14$$
$$x = 11, \quad y = 7$$

3. Exploration Activity

Al-Khwarizmi's Geometric Puzzle

<Problem>

Using the figure 2, explain in words the rule proposed by Al-Khwarizmi (825 A. D.) to solve the equivalent of the equation $x^n + 10x = 39$ ($n = 2$) which corresponds to the formula:

$$x = \sqrt{(25 + 39)} - 5 = 8 - 5 = 3$$

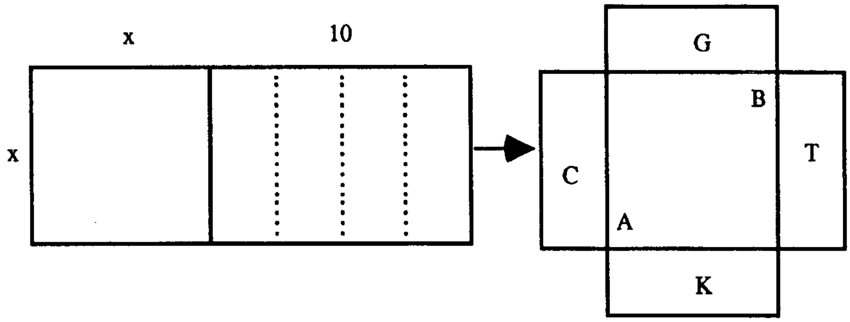


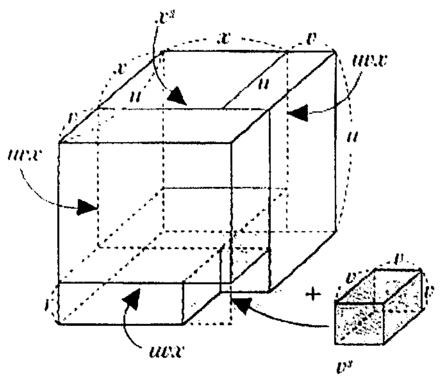
Figure 2. Al-Ahwarizmi draws only the figure on the right

4. Enrichment Activity

Cardano's resolution of $x^n + 9x = 26$. ($n = 3$)

<Problem>

Using the figure 3, explain why Cardano's resolution of $x^n + 6x = 20$. ($n = 3$) is $x = 2$.



$x=u-v$라고 할 때

$x^3+3uvx=u^3-v^3$

$\begin{cases} p=3uv \\ q=u^3-v^3 \end{cases}$

여기서 $u^3=X$, $v^3=Y$라고 하면

$\begin{cases} 27XY=p^3 \\ X-Y=q \end{cases}$

→ $27X^2-27qX-p^3=0$

Figure 3. $p = 9$, $q = 26$

CONCLUSION

Mathematical creativity is the ability to solve problems and/or to develop thinking in structures, taking into account the peculiar logical-deductive nature of the discipline, and the fitness of the generated concepts to be integrated into the core of what is important in mathematics (Ervynck 1991). Firstly, students who found the principle of making 6 magic cards could be regarded as creative problem solvers. Secondly, the ideas of Korean mathematicians from the 17C, some 5th graders at CSGE, Al-Khwarizmi from the 9C, and Cardano from the 16C for solving mathematical problems could be regarded as very creative.

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