Study of the Effect of a Visual Representation on Students' Abilities to Chemical Calculations

Marat Akhmetov, Natalya Pilnikova, Galina Ksenofontova

Ulyanovskyi Teachers' Professional Skills Advancement Institute, Russian Federation
maratakm@ya.ru

Keywords: visual representation, chemical calculations

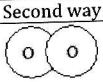
Chemical calculations are difficult for many students, but in researches the problem isn't examined enough? The purpose of our investigation is to study the influence of visual representation on students' ability to solve chemical problems.

We are of opinion that a teacher should discuss with students different ways of calculations problem solving. We have compared two ways of representation during chemical calculations in our research. According to the first way, students were to use only calculating formulas. According to the second way they could use visual models and reasoning.

In our research we tried to find answers to next questions: "Which way do students prefer for chemical calculations? Which way is better to improve students' skills in calculations?"

Pedagogical experiment was provided by two teachers from two schools. One of these schools is in Chelyabinsk. This is an ordinary secondary school. Another school is in Ulyanovsk. It is a gymnasium. The teacher from Chelyabinsk school was acquainted with visual representations in chemical calculations, but the teacher from Ulyanovsk gymnasium didn't know it. At the lessons students of the 8-th grade got directions, which contained descriptions of two ways for chemical calculations? We can see examples of these directions in the table 1.

Table 1. Instruction for calculations

<table>
<tr><th colspan="3">Problem 1. Find the mass of $15\cdot10^{23}$ molecules of the oxygen (O_2)</th></tr>
<tr><th colspan="2">First way</th><th>Second way</th></tr>
<tr><td>Data:
N (O_2) =
$=15\cdot10^{23}$
(molecules)
m(O_2) – ?</td><td>Solution:
m=M·n, $n=\frac{N}{N_A}$
M(O_2)=16·2=32 (g/mole)
n(O_2)=($15\cdot10^{23}$ mole):
($6\cdot10^{23}$ molecules/mole)=2,5 mole
m(O_2)=32g/mole·2,5mole=80 g
Result: m(O_2)=80 g</td><td> 
16 + 16
32
Consequently,
$6\cdot10^{23}$ molecules of oxygen O_2 have mass 32 g
$15\cdot10^{23}$ molecules have mass x g
$x=\frac{15\cdot10^{23}molecules\cdot32g/mole}{6\cdot10^{23}molecules/mole}=80\ g$
Result: m(O_2)=80 g</td></tr>
</table>

At the first lesson "Mole. Molar mass" students got the instructions for following calculations: 1. Find the mass of $15\cdot10^{23}$ molecules of the oxygen (O_2); 2. How many molecules are there in 11 g of the carbon-dioxide gas (CO_2)? Students were to choose only one of the two ways: 1. Find the mass of $12\cdot10^{23}$ molecules of nitrogen (N_2); 2. How many molecules are there in 27 g of water (H_2O)?

At the second lesson "Molar volume of a gas" students also got two different instructions for solving the following problems: 1. Which volume $1.8\cdot10^{23}$ molecules of hydrogen sulfide (H_2S) are there under normal conditions? 2. Find the mass of 33.6 l of the ammonia (NH_3) under normal conditions. Then students did sums by themselves: 1. What volume has $1.5\cdot10^{23}$ molecules of chlorine-gas (Cl_2) under normal conditions? 2. Find the mass of 11.2 l of oxygen (O_2) under normal conditions.

As the experiment showed students' choice of ways of calculating to a considerable degree depended on the teacher's explanations. But we could find some relation, a visual ways of representation can improve student's ability in doing sums better than using formulas only. At the second lesson most of the students preferred visual way of representation for calculations. We can see these regularities in the table 2.

Table 2. Results of the students' chemical problems' solving

Teacher	Lesson 1 "Mole. Molar mass"				Lesson 2 "Molar volume of the gas"		
	Way	Choice	Problem	Right solving	Choice	Problem	Right solving
1	1	11 (46%)	1	8 (73%)	9 (38%)	1	7 (78%)
			2	7 (64%)		2	5 (56%)
	2	13 (54%)	1	12 (92%)	15 (62%)	1	13 (87%)
			2	10(77%)		2	10 (67%)
2	1	68 (96%)	1	54 (79%)	58 (69%)	1	47 (81%)
			2	52 (76%)		2	54 (93%)
	2	3 (4%)	1	3 (100%)	26 (31%)	1	26 (100%)
			2	3 (100%)		2	26 (100%)

A similar educational experiment at Chelyabinsk secondary school in the 11-th grade showed that only 20% of students had chosen the second visual way of calculations. On the question "Why?" students replied that they got accustomed to use formulas.

Conclusions and implications. Our research showed that students' choice of ways depended on both the teachers' explanations and students' own personal experience. The main conclusion is that the visual representations are necessary to develop students' calculating skills. We think that using of formulas is necessary to develop students, but they should use visual methods and reasoning (method of proportion) before. We've created new technology to teach students for chemical calculations which we are ready to implement.

References

1. Akhmetov, M., Isaeva, O., Piinikova, N. (2009) Using visual method for students training in chemistry. *Starptautiskas, Zinetniski Metodokas Konferences "Kimijas Izglitiba – 2009" Paksti Krajums, Riga, 2009. gada 6.–7. novambris.* – pp. 190-195
2. Johnstone, A.H. (2000).Teaching of chemistry – logical or psychological? *Chemistry Education Research and Practice in Europe*, 1(1), 9-15.
3. Onwu, G. O. M. & Randall E. (2006). Some aspects of students' understanding of a representational model of the particulate nature of matter in chemistry in three different countries. *Chemistry Education Research and Practice,* 7 (4), 226-239
4. Wood, C. (2006). The development of creative problem solving in chemistry. *Chemistry Education Research and Practice,* 7 (2), 96-113.