

The Implementation of Chemdoku and Chemkuro on Chemistry Learning: A Review¹

Sukisman Purtadi dan Rr Lis Permana Sari

Jurdik Kimia FMIPA UNY: purtadi@uny.ac.id

Abstract

The use of games in the classroom provides a means of reviewing material in a stimulating and interactive format. Sudoku and kakuro puzzles have taken the world by storm and their popularity can be used to help students learn a variety of chemical concepts. Chemdoku and chemkuro are sudoku and kakuro implemented on chemistry classroom. Chemkuro and chemdoku has similar rules but differences viewed from the nature of the game, developing easiness, implementation handling, concept range, and student acceptance. The comparison is needed to make a decision which puzzle fit to concept delivered. Chemdoku has some advantages viewed from the nature of the game, developing easiness, implementation handling, concept range, and student acceptance. Yet, teacher creativity can develop chemkuro more interesting and challenging because this puzzle has not been wide developed yet

Key words: game, chemistry learning, chemistry-sudoku, chemistry-kakuro, concept understanding

Background

The chemistry curriculum still includes some material that requires rote memorization, often including distinctions between superficially similar items. Mastering such material is seldom exciting and many students are reluctant to perform these tasks. Therefore, a method that would make these tasks more interesting is desirable. The use of games in the classroom provides a means of reviewing material in a stimulating and interactive format (Koether:2003; Russell, 1999).

There are several examples of puzzles being used in the classroom including wordsearch, letter matrix, and crossword puzzles. (Crute & Myers, 2007). An

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example of puzzle is sudoku. Sudoku puzzles have become quite popular in recent years and routinely appear in media (Crute & Myers, 2007).

The classic sudoku puzzle is a number puzzle consisting of 9×9 grid (or a simpler 6×6 grid), divided into nine 3×3 boxes (or six 2×3 boxes). Some of the numbers are placed in the squares of the grid as “clues”. The object of the puzzle is to fill in the remaining squares of each row, column, and box with the digits 1–9 (or 1–6) so that each row contains all the numbers from 1–9 (or 1–6), each column contains all the numbers from 1–9 (or 1–6), and each 3×3 box (or 2×3 box) contains all the numbers from 1–9 (or 1–6). However, each of the numbers 1–9 (or 1–6) can appear only once on each row, column, and box (Welsh, 2007). A limited number of symbols are strategically placed in the grid as the “givens” for a starting point. Here is the example of sudoku (fig.1)

5	3			7						5	3	4	6	7	8	9	1	2
6			1	9	5					6	7	2	1	9	5	3	4	8
	9	8						6		1	9	8	3	4	2	5	6	7
8				6					3	8	5	9	7	6	1	4	2	3
4			8		3				1	4	2	6	8	5	3	7	9	1
7				2					6	7	1	3	9	2	4	8	5	6
	6						2	8		9	6	1	5	3	7	2	8	4
			4	1	9				5	2	8	7	4	1	9	6	3	5
				8			7	9		3	4	5	2	8	6	1	7	9

Figure. 1. example of *Sudoku* and its solution (Sukisman : 2007)

Again, a completed puzzle has one instance of each number per row, column, and box. Because of this puzzle uses number, it is seen more mathematics. Actually, it is not so mathematic, even to solve the puzzle does not need any mathematic or calculating skill. Perez & Lamoureux, (2007) added that no mathematical skill is required since it relies on “pattern-recognition” and logic to complete the grids.

The puzzle solver must use logic to determine which symbol should appear in each of the remaining spaces. The easiest puzzles only require simple logic or solving by inspection, while progressively more difficult puzzles require more sophisticated or multistep analysis and problem solving. A combination of ruling

out symbols for a particular space to avoid repetition, and determining which symbol is still needed in a particular row, column, or box is a typical strategy of solving by inspection. It is known that there are three process to solve sudoku, namely *scanning*, *marking up*, an analyzing.

On the other side, because of the puzzle player has to remember the objection of this game, the player has to consider all the number of symbol filled on the box. This process is needed to avoid repetition on row, column, and subgrid. It indicates that to solve the puzzle student has to put the concept into their own memory.

A similar puzzle that stress on logic digging is kakuro. Kakuro is known as cross sums and often referred to as a mathematical transliteration of the crossword. Kakuro plays number to be arranged in such ways that there is no double number comes on columns and rows and the sum of them fit to the number showed on the clues box. The aim of the game is to fill all the blank squares in the grid with only the numbers 1-9 so that the numbers you enter add up to the corresponding clues. A number in the top right corner relates to an "across" clue and one in the bottom left a "down" clue. (krazydad.com/puzzles : 2006).When the grid is filled, the puzzle is complete. How to complete the puzzle can be read on www.kakuro.com.

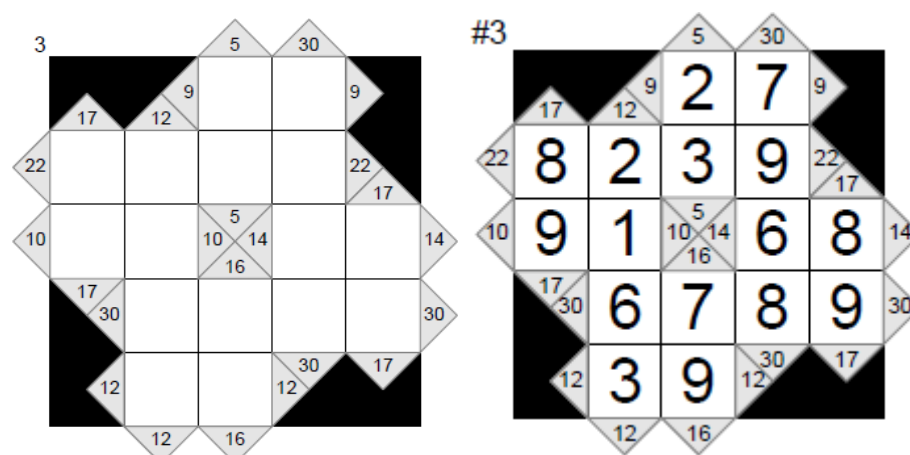


Figure 2. example of kakuro dan it solution (krazydad.com/puzzles : 2006)

Kakuro puzzle grids can be any size, though usually the squares within them have to be arranged symmetrically. As a rule of thumb, the more blank squares a

puzzle contains, the harder it is, however this isn't always true, especially if it is a good quality puzzle (www.kakuro.com).

Sudoku and kakuro puzzles have taken the world by storm and their popularity can be used to help students learn a variety of chemical concepts. This article is aimed to analyze two type of logic puzzle those can be implemented on chemistry learning, namely chemdoku (chemistry-sudoku) and chemkuro (chemistry-kakuro) as a media on enhancing students' concept understanding viewed from their nature, making, implementing, concept range, and student acceptance. At the end, it will give information on logic puzzle developing and implementing on chemistry learning so teacher will know when to use chemdoku and chemkuro

Discussion

Chemkuro and Chemdoku on Chemistry Learning

When students solve a puzzle, they use short term memory certainly. They see symbols and used them. But, the repetition used on this process can fill their cognitive and long term memories. Puzzle solving process it self uses problem solving logic. Thinking process used is not directed by other people. This process raise automatically because the students enjoy to solve the problem. Moursund (2007) mentioned that this process can be applied when they face a bigger problem.

With this long term advantage of puzzle, chemdoku and chemkuro can be tried to be implemented on teaching and learning process, especially on exercise or task. With this implementation, hopefully, task becomes a fun and interesting activity because student can compete and participate into the lesson actively. This method give a feed back directly that does not depend on the teacher.

As mentioned before, mathematic skill is not needed on puzzle solving, it needs "logical pattern" to complete blank grids. The relationship between sudoku and chemistry is tenuous but there is a connection (Perez dan Lamoureux : 2007). Clearly, it is needed a modification to strengthen the connection between chemistry concept and sudoku so that the game has education value. One of this is

adding the chemistry problem into the puzzle like shown on fig.1 and 2 (Sukisman Purtadi, 2009). Both of them does not only play the number and symbol those are not related to the chemistry concept because the problem embedded into them.

STRUKTUR ATOM

PETUNJUK

Isi kotak kosong dengan lambang unsur yang telah tersedia dengan ketentuan sebagai berikut :

- Tidak boleh terjadi pengulangan satu sub grid
- Tidak boleh terjadi pengulangan pada satu baris
- Tidak boleh terjadi pengulangan satu kolom

$\begin{smallmatrix} 28 \\ 14 \\ \text{Si} \end{smallmatrix}$	$\begin{smallmatrix} 39 \\ 19 \\ \text{K} \end{smallmatrix}$	$\begin{smallmatrix} 23 \\ 11 \\ \text{Na} \end{smallmatrix}$	$\begin{smallmatrix} 40 \\ 20 \\ \text{Ca} \end{smallmatrix}$	$\begin{smallmatrix} 32 \\ 16 \\ \text{S} \end{smallmatrix}$	$\begin{smallmatrix} 40 \\ 18 \\ \text{Ar} \end{smallmatrix}$	$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$	$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$	$\begin{smallmatrix} 35 \\ 17 \\ \text{Cl} \end{smallmatrix}$
$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$	$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$			$\begin{smallmatrix} 23 \\ 11 \\ \text{Na} \end{smallmatrix}$	$\begin{smallmatrix} 28 \\ 14 \\ \text{Si} \end{smallmatrix}$		$\begin{smallmatrix} 32 \\ 16 \\ \text{S} \end{smallmatrix}$	
$\begin{smallmatrix} 40 \\ 20 \\ \text{Ca} \end{smallmatrix}$			$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$	$\begin{smallmatrix} 35 \\ 17 \\ \text{Cl} \end{smallmatrix}$	$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$	$\begin{smallmatrix} 39 \\ 19 \\ \text{K} \end{smallmatrix}$	$\begin{smallmatrix} 28 \\ 14 \\ \text{Si} \end{smallmatrix}$	
$\begin{smallmatrix} 35 \\ 17 \\ \text{Cl} \end{smallmatrix}$	$\begin{smallmatrix} 40 \\ 18 \\ \text{Ar} \end{smallmatrix}$	$\begin{smallmatrix} 40 \\ 20 \\ \text{Ca} \end{smallmatrix}$	$\begin{smallmatrix} 28 \\ 14 \\ \text{Si} \end{smallmatrix}$	$\begin{smallmatrix} 39 \\ 19 \\ \text{K} \end{smallmatrix}$	$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$	$\begin{smallmatrix} 23 \\ 11 \\ \text{Na} \end{smallmatrix}$	$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$	$\begin{smallmatrix} 32 \\ 16 \\ \text{S} \end{smallmatrix}$
		$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$		$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$		$\begin{smallmatrix} 40 \\ 18 \\ \text{Ar} \end{smallmatrix}$		$\begin{smallmatrix} 40 \\ 20 \\ \text{Ca} \end{smallmatrix}$
	$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$		$\begin{smallmatrix} 40 \\ 18 \\ \text{Ar} \end{smallmatrix}$		$\begin{smallmatrix} 23 \\ 11 \\ \text{Na} \end{smallmatrix}$			$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$
$\begin{smallmatrix} 39 \\ 19 \\ \text{K} \end{smallmatrix}$				$\begin{smallmatrix} 30 \\ 15 \\ \text{P} \end{smallmatrix}$	$\begin{smallmatrix} 40 \\ 20 \\ \text{Ca} \end{smallmatrix}$	$\begin{smallmatrix} 35 \\ 17 \\ \text{Cl} \end{smallmatrix}$	$\begin{smallmatrix} 40 \\ 18 \\ \text{Ar} \end{smallmatrix}$	$\begin{smallmatrix} 28 \\ 14 \\ \text{Si} \end{smallmatrix}$
	$\begin{smallmatrix} 35 \\ 17 \\ \text{Cl} \end{smallmatrix}$	$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$	$\begin{smallmatrix} 23 \\ 11 \\ \text{Na} \end{smallmatrix}$		$\begin{smallmatrix} 32 \\ 16 \\ \text{S} \end{smallmatrix}$			$\begin{smallmatrix} 39 \\ 19 \\ \text{K} \end{smallmatrix}$
		$\begin{smallmatrix} 28 \\ 14 \\ \text{Si} \end{smallmatrix}$		$\begin{smallmatrix} 40 \\ 18 \\ \text{Ar} \end{smallmatrix}$		$\begin{smallmatrix} 32 \\ 16 \\ \text{S} \end{smallmatrix}$		$\begin{smallmatrix} 27 \\ 13 \\ \text{Al} \end{smallmatrix}$

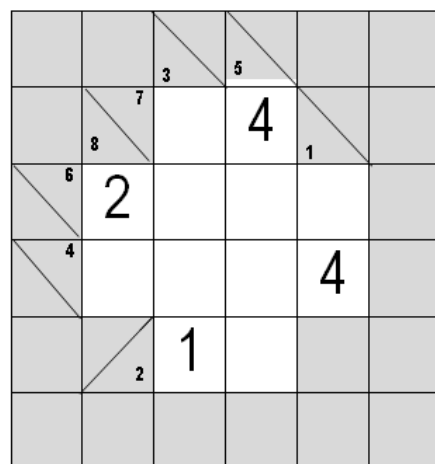
SOAL

Tentukan

- a. Jumlah proton, netron, dan elektron masing-masing unsur
- b. Letak unsur dalam Tabel Periodik Unsur
- c. Isotop, isoton, dan isobar



Figure 3. Example of chemdoku for atomic structure concept



Soal

1. Pada pembakaran magnesium dengan 12 gram oksigen dihasilkan 24 gram magnesium oksida. Berapa gram magnesium yang terbakar?
2. Perbandingan massa besi dengan massa belerang dalam besi(II) sulfida adalah 7:4. Berapa gram zat yang tersisa jika 7 gram besi direaksikan dengan 7 gram belerang?
3. Berapa gram zat yang tersisa jika 73 gram besi direaksikan dengan 32 gram belerang?

4. Rumus molekul urea adalah $\text{CO}(\text{NH}_2)_2$ ($M_r=60$). Tentukan massa unsur C dalam 120 gram urea.

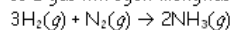
5. Senyawa oksigen dan nitrogen membentuk lima senyawa berbeda, yaitu senyawa A, B, C, D dan E dengan data sebagai berikut:

Massa N	Massa O	Rumus Senyawa
28	16	N_2O
28	32	N_2O_3
28	48	N_2O_5
28	64	N_2O_7
28	80	N_2O_9



Pada senyawa senyawa nitrogen dioksida, perbandingan massa nitrogen dengan oksigen adalah p : q. Tentukan p+q.

6. Pada temperatur dan tekanan yang sama, direaksikan 33 L gas hidrogen dengan 11 L gas nitrogen menghasilkan gas amoniak. Persamaan reaksinya:

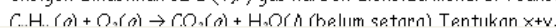


Tentukan volum gas amoniak yang terbentuk.

7. Gas hidrogen direaksikan dengan gas oksigen membentuk 8 L (T, P) uap air. Persamaan reaksinya: $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$

Berapa L (T, P) jumlah gas yang dibutuhkan pada reaksi tersebut?

8. Pada reaksi antara 4 L (T, P) senyawa hidrokarbon C_xH_y dan 18 L (T, P) gas oksigen dihasilkan 12 L (T, P) gas karbon dioksida menurut reaksi



Tentukan x+y.

Figure 4. Example of chemkuro for stoikiometri concept

Chemistry problems can come after (like the one shown on chemdoku) or before (shown on chemkuro) puzzle.

Embedding numbers of problems that more than they are needed to fill the puzzle will give self check chance for student. Students know clearly that all of the answer they got from the concept problem has to be played on their puzzle, so when they find that one or more of their answer cannot be played, they have to re-check their answer. It will strengthen the anchor between chemistry concept and chemdoku or chemkuro. See Appendix for this sample.

Comparing Chemkuro and Chemdoku

Chemkuro and chemdoku has differences viewed from the nature of the game, developing easiness, implementation handling, concept range, and student acceptance. Chemkuro is more complex than chemdoku, because chemkuro has complex rule and viewed as more mathematics. The complexity of chemkuro lies on the rule that all the number filled on the box have to be added and equal to the number on the end of column or row. This rule does not appear on chemdoku. For this reason, chemkuro that had been developed is concluding numbers only.

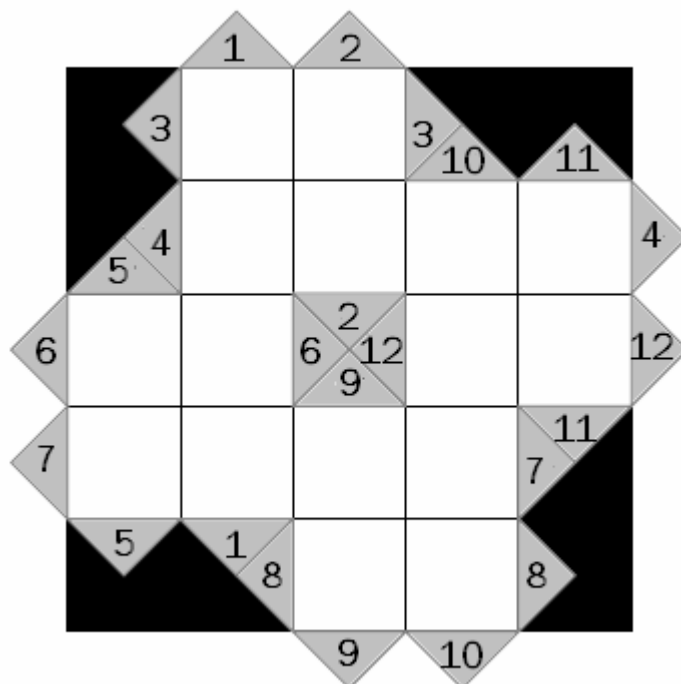
Crute dan Myers (2007) used the complexity to increase student attention to the concept they learned. But, with this complexity, chemkuro becomes more complicated to develop. Teacher or puzzle developer has to choose any number that fit to the chemistry problems. This is not a simple process because they have to check back and forth the puzzle.

The implementation of the two puzzles is not the puzzle problem. A study conducted by Sukisman Purtadi and Rr. Lis Permana Saril (2009) shown that it depends on their introduction and familiarity. Sudoku has well known long before kakuro. So when it is transferred into chemistry learning, student does not get confusion any longer. The rule of chemdoku is similar to sudoku except the numbers or symbols to be filled not always the same or number from 1 until 9. Kakuro has not been as popular as sudoku yet. So, teacher must introduce the kakuro until it is clear.

Chemdoku can play numbers, words, name, chemical structure, and even picture so reach a wide range of concept. It is different from chemkuro that is limited on number problem. Some research showed that students seem to feel that chemkuro is more challenging because it gives self check chance.

Conclusion

Chemdoku has some advantages viewed from the nature of the game, developing easiness, implementation handling, concept range, and student acceptance. Yet, teacher creativity can develop chemkuro more interesting and challenging because this puzzle has not been wide developed yet



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Appendix

Chemdoku

1. Petunjuk

Isi kotak kosong dengan jawaban dari soal yang telah tersedia dengan ketentuan sebagai berikut :

- Jawaban tidak boleh terjadi pengulangan pada satu baris
- Jawaban tidak boleh terjadi pengulangan satu kolom
- Jawaban tidak boleh terjadi pengulangan satu subgrid

Soal

1. Unsur $^{137}_{56}\text{Ba}$ mempunyai jumlah elektron sebanyak ...
2. Nomor massa dari nuklida $^{39}_{19}\text{K}$ adalah ...
3. Nuklida $^{222}_{86}\text{Rn}$ mempunyai jumlah neutron sebanyak ...
4. Ion $^{127}_{53}\text{I}^{-}$ mempunyai jumlah elektron sebanyak ...
5. Elektron valensi dari $^{79}_{34}\text{Sn}$ adalah ...
6. $^{27}_{13}\text{Al}$ termasuk dalam periode ...
7. Elektron valensi dari $^{35}_{35}\text{Br}$ adalah ...
8. Jumlah elektron dari $^{110}_{50}\text{Sn}^{2+}$ adalah ...
9. Nomor atom dari atom yang mempunyai jumlah neutron 42 dan nomor massanya 75 adalah ...
10. Nomor atom dari unsur yang memiliki neutron sebanyak 123 dan nomor massanya 204 adalah ...
11. Atom $^{89}_{39}\text{Y}$ mempunyai jumlah proton sebanyak ...
12. Nomor atom dari atom yang mempunyai konfigurasi elektron 2 8 18 18 8 adalah ...
13. Nomor massa dari atom yang memiliki neutron sebanyak 47 dan proton sebanyak 34 adalah ...
14. Jumlah elektron yang dimiliki oleh atom yang bermassa 89 dan jumlah neutronnya 50 adalah ...
15. Jumlah elektron pada kulit terluar dari atom $^{16}_8\text{O}$ adalah ...
16. Nomor massa dari atom yang memiliki neutron sebanyak 48 dan elektron 33 adalah ...
17. Nomor atom dari atom yang memiliki konfigurasi elektron 2 8 18 32 18 3 adalah ...
18. Atom K ($z = 39$) memiliki massa sebesar ...
19. Nomor atom dari atom yang termasuk dalam golongan VIIIA (18), periode 5 adalah ...
20. Nomor massa dari atom yang memiliki proton sebanyak 56 dan neutronnya 80 adalah ...
21. Jumlah elektron dari $^{131}_{54}\text{Xe}$ adalah ...



22. Atom yang termasuk dalam golongan VIA (16) mempunyai elektron valensi sebanyak ...
23. Jumlah neutron suatu atom 78 dan nomor massanya 132, maka jumlah protonnya adalah ...
24. Jumlah elektron dari $^{16}_8\text{O}^{2+}$ adalah ...
25. Nomor atom dari atom yang menempati golongan VA (15) periode 2 adalah ...
26. Jumlah elektron dari ^7_3Li adalah ...
27. Jumlah elektron dari atom yang memiliki nomor massa 76 dan jumlah neutron sebanyak 43 adalah ...
28. Nomor atom dari atom yang menempati golongan VA (15) periode 4 adalah ...
29. Nomor massa dari atom yang memiliki neutron 26 dan proton 22 adalah ...
30. Dari keempat unsur berikut : ^7_3Li , $^{40}_{20}\text{Ca}$, $^{75}_{33}\text{As}$, dan $^{19}_9\text{F}$, unsur yang termasuk dalam golongan metaloid adalah unsur yang memiliki nomor atom

	28	11	4	136	6	10	7	8
7		19		13	24		136	6
1	136	6	9	29		22		2
136	2		5		8	4	1	30
12	5	1	136	14	27	3		
	26	9		4	1	18	5	20
9		136	3	15	4		2	17
2	21	8	1		3	25	6	
6	16		8	7		136	9	23

Kunci Jawaban :

6	33	39	54	136	3	81	7	48
7	48	54	39	81	6	33	136	3
81	136	3	33	48	7	6	54	39
136	39	7	6	3	48	54	81	33
54	6	81	136	39	33	3	48	7
48	3	33	7	54	81	39	6	136
33	7	136	3	6	54	48	39	81
39	54	48	81	33	136	7	3	6
3	81	6	48	7	39	136	33	54