SYSTEMIC APPROACH TO TEACHING AND LEARNING CHEMISTRY (SATLC) AS INTEGRATED APPROACH TOWARDS TEACHING PHYSICAL CHEMISTRY

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ABSTRACT

Enthusiasm is crucially needed in teaching and learning of chemistry at educational institutes. Issues and problems in achieving that end needs to be addressed on top priority. In this scenario the role of the instructor is of vital significance. A teacher can minimize the difficulties in concept building by providing better perspective related to the basics of the subject. This can be accomplished through novel efforts involving personal input. The recently emerged concept based teaching methodology, systemic approach to teaching and learning chemistry (SATLC), is a fascinating route to meet this noble endeavor. This new teaching method has been discovered to play a pivotal role, towards the efforts for promoting better understanding of chemical concepts. In addition to that, the results reported from the evaluation of SATL technique have been very promising as far as the improvements in students' academic achievements are concerned. In this presentation we discuss some examples that highlight the efficacy of SATLC based teaching method for providing clear understandings of some salient concepts in physical chemistry. [*AJCE, 1(2), July 2011]*

INTRODUCTION

There are several strategies, through which teaching and learning of scientific subjects in general, and chemistry in particular may be made much easier to understand. Various teaching options continue to be reported in literature to illustrate the basics of chemistry in order to enhance its teaching and learning (1-8). In the past decade an innovative way of teaching and learning through systemic approach (SATL) has been introduced (9-12) for this end.

The basic goal of this approach is the achievement of meaningful (deep) learning by students. Meaningful (deep) learning was described by Amusable (13) as the formulation of non-arbitrary relationships between ideas in the learners' mind. According to Novack (14) meaningful learning, means that learners deal with a learning task by attempting to form relationships between newly and previously learned concepts. Michael (15) stated that meaningful learning occurs when the learner interprets, relates, and incorporates new information with existing knowledge and applies the new information to solve novel problems.

SATL is a new way of teaching and learning, based on the present day idea that anything is related to everything globally. The method emphasizes that students should not learn isolated facts (memorization), but connects concepts and facts in a logical context. The SATL model proposes an arrangement of concepts through closed, interacting conceptual systems ("concept clusters"), in which all interrelationships are made clear, up front to the teachers and learners using a concept map-like representation. These goals are met through developing diagrams through which such a closed conceptual system is amicably represented and that such diagram is called a "systemic diagram"

The usual approach to teaching a subject involves arranging the associated concepts in a linear manner. The choice of the specific linear approach is often highly subjective and it may obscure relationships that students can easily understand otherwise. The SATL technique, however, involves organizing the concepts associated with a subject in such order that it describes the interrelationships among these very concepts.

METHODOLOGY

Chemistry courses not only incorporate some basic general disciplines of mathematics, physics and chemistry but they further advance to involve the following specialized chemistry disciplines: Physical chemistry, Organic chemistry, Inorganic chemistry, Analytical chemistry

Traditional method of teaching the above branches of chemistry is wherein a teacher presents the knowledge in front of students as close compartments with occasional bridges and links. To have clear concepts, a deep understanding of each branch of chemistry is important. Use of SATLC methodology provides a tremendous potential to meet such goals.

In the forthcoming narrative some examples comprising of SATL modules for teaching Physical chemistry to students of grade 9 are being presented. Those students, having no cleared perceptive of the basic concepts of Physical chemistry, were selected through assessment. These may open new avenues for making students realize the importance of some basic Physical chemistry principles and encourage them for acquiring deep rooted learning. The concepts were initially explained to the students through systemic diagrams and then their ability to develop such diagrams was analyzed.

Lecture 1:

Lecture 1 includes the explanation of some of the basic laws of Physical Chemistry. This branch of Chemistry is based on some fundamentals few of which are given in the form of following basic laws:

Boyle's Law: $P\ V = constant$

Charles's Law: $V = constant\ T$

Avogadro's Law: $V = constant\ n$

Ideal Gas Law: $P\ V = n\ R\ T$

These laws, when taught in a linear and thus isolated way, seem to demonstrate no interdependence in between themselves or some other very significant physical properties like density, viscosity, entropy etc. In fact this is not the case. The physical parameters are never isolated. These are highly interlinked as demonstrated through the following systemic diagram (SD0) Figure 1.

The systemic relationships between parameters of the general gas equation are shown in figure 1. It provides a picture that depicts question marks towards nature of linkages among these vital state functions and thus seeks to clarify their correlations.

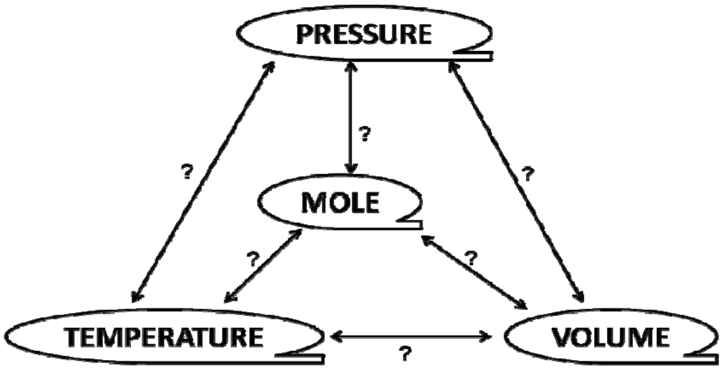

Figure 1. A diagram that seeks to enquire the Systemic relationships of parameters of general gas equations (SD0)

In this diagram (figure 1), individual concepts have been connected to the others, but the nature of connectivity which leads to comprehension is totally absent. We can improve our understanding by filling in blanks of this connecting diagram, through explaining known gas laws which are Boyle's and Charles's laws, as shown in (SD1) figure 2. As Boyle's law states there is an inverse relationship between pressure and volume, whereas Charles's law postulates the direct relation between temperature and volume, therefore it can be predicted that pressure and temperature are inversely related to each other (figure 2).

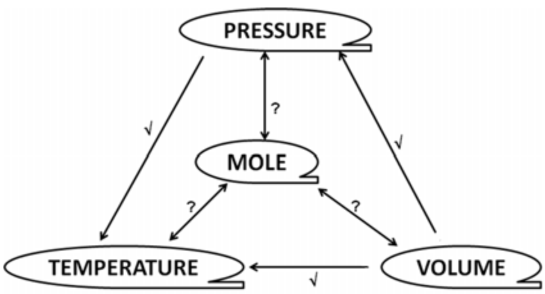

Figure 2. Systemic relationships of parameters of general gas equations (SD1) in which tick marks figure out gas laws just discussed by the teacher

Here some relationships are known and some are unknown, and are still left with question marks. As the teacher now brings in discussion the concepts underlying mole, .

a new diagram SD2 (figure 3) gets developed and equation of state $PV = n\ RT$ becomes a logical outcome. Greater the number of moles in a system greater will be the pressure and with the constant pressure the increasing number of moles increases the volume, while, the temperature is the average kinetic energy of molecules of the system

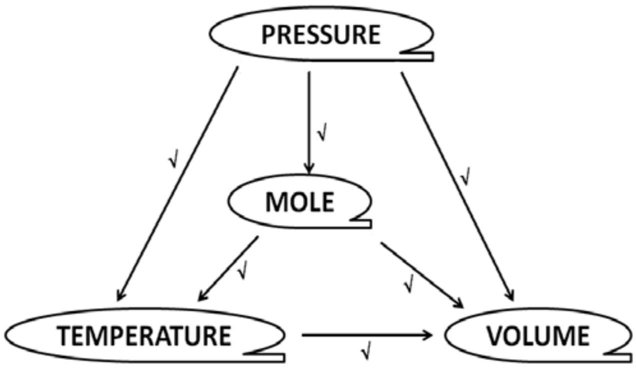

Figure 3. Systemic relationships of parameters of general gas equations (SD2)

Now the teacher delves into further information and discusses diffusion phenomenon in gases. According to Graham's law, rate of diffusion of gases is inversely proportional to the square root of their densities. Number of moles per liter of various gases at given temperature and pressure is constant, so density of a gas is directly proportional to their molar mass or molecular weight. Therefore rate of diffusion of gases is also inversely proportional to molecular weight of gases. These valuable ideas could be made to appear on our systemic diagram (SD3) (figure 4).

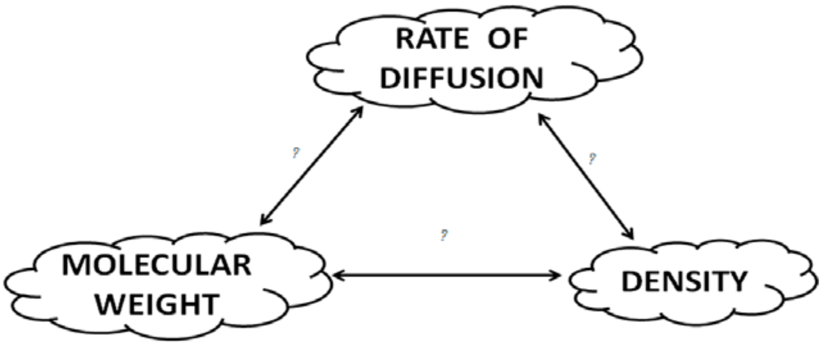

Figure 4. Systemic representation of Graham's Law of diffusion (SD3)

Density is not only related to molar mass but also to a range of other parameters. We can progress further to bring density into focus. As it is known that density depends on mass and volume but mass and volume are further related to concentration. Both density and concentration are affected directly by mass but, volume inversely affects them. Therefore density and concentration can be linked to each other. The density can be enhanced by concentrating the solutions. Thus we came upon the Systemic diagram (SD4) Fig.5

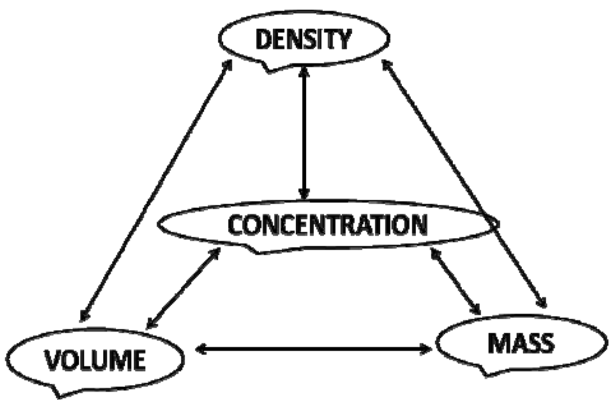

Figure 5. Systemic relationship of concentration and other physical parameters (SD4)

By the combination of figure 3 and figure 5 a new systemic diagram (SD5) (figure 6) can be obtained, which can make the concepts clearer as all the relationships were explained earlier, and one gets deeper into delicate issues underlying physical chemistry.

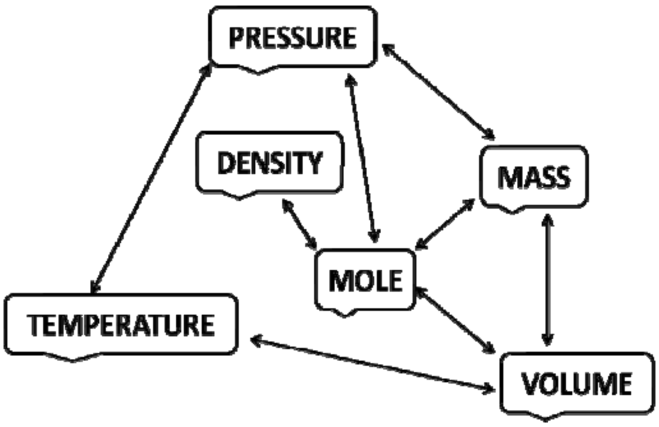

Figure 6. Systemic relationships of parameters of general gas equations (SD5)

Lecture 2:

In this lecture few more of the physical properties of matter are discussed and correlated with parameters demonstrated in lecture 1 and also with some other factors. Surface tension is one of the important properties of any liquid. It can be correlated systemically with some other parameters (SD6) (figure 7) and one of them is intermolecular force. Surface tension is caused by cohesive forces among the liquid molecules. There is a driving force to diminish the surface area; hence, the surface area of the liquid shrinks until it has the lowest surface area possible. That is the reason for the spherical shape of water droplets.

Intermolecular forces are not independent but linked systemically with other factors like viscosity and temperature (SD7) (figure 8). Viscosity measures the fluidity of a liquid. Stronger attractive forces between the molecules of a liquid resist the flow. Increasing temperature minimizes the intermolecular forces and consequently affects the viscosity.

Considering the temperature of a system, another systemic diagram (SD8) (figure 9) can be constructed. This systemic diagram also brings into focus and explains the interconnections of molecular properties to another significant issue that is entropy of a system. Entropy, a thermodynamic property, can be utilized to determine the energy available to do useful work in a thermodynamic process.

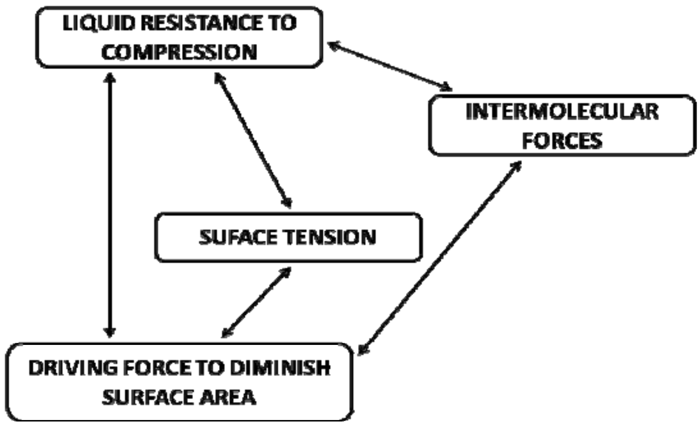

Figure 7 Systemic approaches for understanding surface tension (SD6).

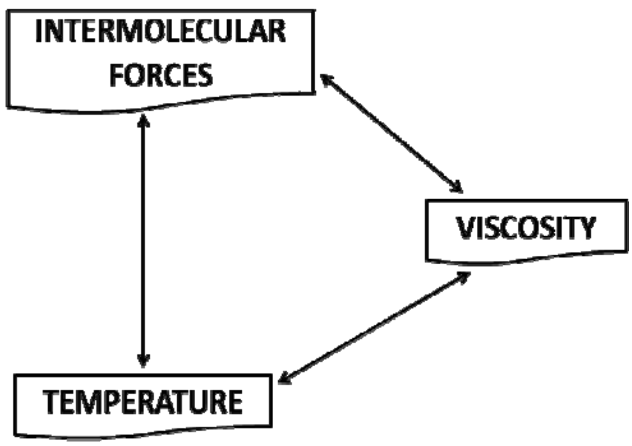

Figure 8. Systemic relation between viscosity, temperature and intermolecular forces (SD7)

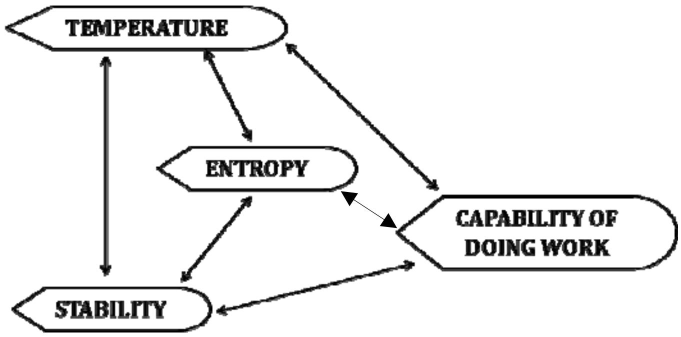

Figure 9. Systemic relationship between entropy and other parameters (SD8)

Lecture 3:

In Lecture 3 the summary of previous lectures is provided and all the parameters discussed are summed up in one systemic diagram (SD9). Moreover the students' comments are also collected and their ability to develop systemic diagram is also examined (see students' comments in the forthcoming narrative).

Understanding of the above sub-systemic diagrams (SD0-SD8) facilitates students to find the connections between the various physical parameters given in the Systemic diagram (SD9). This leads to deep learning (meaningful understanding) of a scientific knowledge domain and the learner is able to come into terms with an important educational goal (9-12).

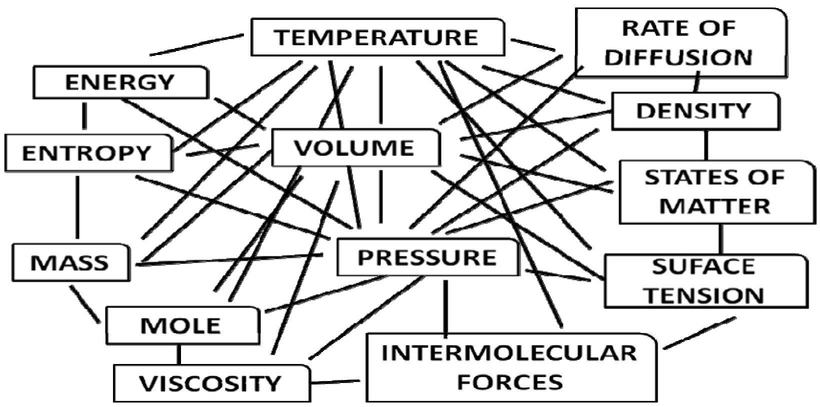

Figure 11. Systemic relations between physical parameters (SD9)

It will be miserable to decipher all of these interrelationships when taught via linear approach that is practiced in our classrooms. We can only solve this complexity if we are provided with the sub-systemic diagrams (SD0-SD89) in building the systemic paradigm (SD9) and thus the interconnections of parameters of general gas laws with the other physical properties can be presented in an effective way.

In this diagram (SD9) that appears at the end of our systemic presentation (Final systemic Diagram, SDF) we have brought major physical chemistry related concepts on board in full view. As we develop comprehension we can fill in the blanks to find a bird's eye view of the issues in one go.

Students Comments:

After the end of this unit, students were asked to answer the Questionnaire below. Most of them responded positively to this particular SATL method. The summary of their response is shown in table 1.

Table (1):

Question	Response		
	High	Moderate	Low
To what extent did you benefit from this methodology?	100%	-	-
To what extent were these lectures useful to you?	100%	-	-
Did this lecture add something new to your knowledge about SATLC?	87.5%	12.5%	-
Did this lecture give you the chance to participate in discussion?	50%	50%	-

Students were also able to develop the systemic diagrams (SD) on their own accord, which is an indication of their understanding of the topic. Few of the connectivity diagrams prepared by them are given below.

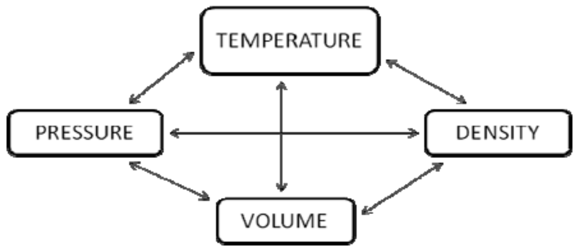

Figure 12. Systemic Diagram of some physical parameters

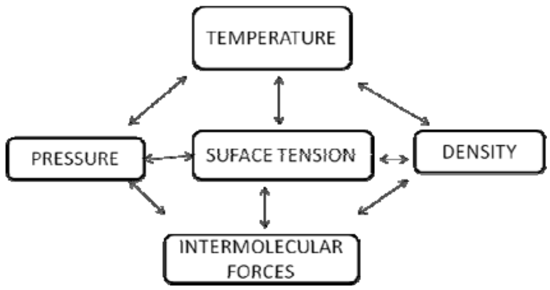

Figure 13 .Systemic Diagram of Surface tension.

Some students also gave their comments, which are as follows:

- This has benefited me a lot. Several concepts of mine are cleared. I got many ideas to go through the basics of chemistry at a glance.
- This is the best lecture I have ever attended.
- Basic concepts of chemistry are presented in an excellent way. It really provides me an opportunity to learn chemistry, and correlate it to collective issues.
- This lecture is very meaningful to me. Now I understand that through systemic approach it's very easy to have the clear concepts of chemistry.

CONCLUSIONS:

SATL based teaching lessons are magnificent means to: (9-12)

1. Enhance the learning process in a classroom.
2. Making maximum connections between chemistry concepts and the real world around us.

REFERENCES:

1. Rayl, A. J. S. *The Scientist* 2001, 15, 16.
2. Williams, K. R.; Myers, G. H. *J. Chem. Educ*. 1999, 76, 19.
3. Lorenz, B. Sizzling Organic Chemistry Dramas, http:// www.heptune. Com/chemtale.html (accessed Jul 2007).
4. Waddell, T. G.; Rybolt, T. R. *J. Chem. Educ*. 1991, 68, 1023.
5. Bopegedera, A. M. R. P. *J. Chem. Educ*. 2005, 82, 55.
6. Gammon, S. D. *J. Chem. Educ*. 1994, 71, 1077.
7. Furlan, P. Y. *Chemical Educator* 2000, 6, 351.
8. Bergmeier, B. D.; Saunders, S. R. *J. Chem. Educ.* 1982, 59, 529.
9. Fahmy A. F M. and Lagowski J. *J(2001) Chemical Education International* 3 (1).
10. Fahmy, A. F. M., Lagowski, J. J.(2003). Systemic Reform in Chemical Education An International Perspective, J. Chem. Edu. 80 (9), 1078.
11. Fahmy, A. F. M., Lagowski, J. J.(2011) The systemic approach to teaching and learning (SATL): A 10-year review, AJCE, 1(1), 29-47
12. Fahmy, A. F. M., Lagowski, J. J. (2011). The systemic approach to teaching and learning (SATL): Operational steps for building teaching units, AJCE, 1(1), 62-80
13. Ausubel, D. P. (1963) The Psychology of Meaningful Verbal Learning;
14. Grune and Stratton: New York.
15. Novak, J. D. (2002) Sci. Educ. 86, 548–571.
16. Michael, J. (2001). Adv. Physiol. Educ. 25, 145–158.

ACKNOWLEDGEMENT

The authors would like to offer their thanks for Prof. Fahmy A.F.M., Professor of organic chemistry at Faculty of Science, Ain Shams University, Cairo, Egypt, for his kind advice and help in writing of this manuscript.