The Effect of PCK on Solving Selected Chemistry Problems

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Abstract

This study examines the immediate and long term effect of using PCK approach of instruction that integrate macroscopic, symbolic and molecular representation of chemical phenomena on solving selected chemistry problems. Three groups of teachers' students had been examined in problem solving chemistry tests. The study shows that there is a significant difference between the groups who get PCK methodology course and those who do not; the results of the study also show that there are a long term effects of using such approach of instruction, there is no significant difference between the answers of group who just completed PCK methodology course, and those who get it the year before.

Key words: PKC, solving problems, long term effect, symbolic, molecular representation

1- Introduction

Important Objectives of elementary science education are to develop students' abilities to reason logically and to become competent problem solvers, consequently school teachers should posses the abilities to solve problems to foster such ability in their students, Ginns, & Watters, (1995). Clements, Krajcik,& Borko considered theory and modeling as important training elements to effective teacher programs, and that science teachers pedagogical content knowledge can be enhanced through such programs. Loughran et al., 2001 defines PCK as the knowledge that a teacher uses to provide teaching situations that help learners make sense of particular science content. Radford, (1998) show that PCK has been successful in improving the science content knowledge of 90 teachers during the 3 years in their graduate study. Understanding the PCK approach needs an understanding for the pedagogy theory, the nature of content to be represented, and the way to be represented.

1-1 Conceptual Change pedagogy

Stofflett, & Stoddart, (1994) states that conceptual change pedagogy proved to be important to get red from previous misunderstanding for learning experience. Students in a science methods course received content instruction about conceptual change pedagogy. After instruction students in the conceptual change group gave qualitatively stronger response. Yager (1991), stated that teacher education must involve conceptual change on the part of teachers, thus making the role of the teacher, as a facilitator of problem solving in science more crucial.
Gabel, Sherwood, & Enochs (1984) examine the problem –solving skills of high school students and concluded that one way of helping students overcome the algorithmic mode is to make certain that students understand the chemical concepts qualitatively before they are represented quantitatively.

The discussion above leads to the second dimension of the problem that is the type of content that is crucial to problem solving in chemistry, in which its misunderstanding would hinder such ability.

1-2 Crucial Chemistry Content:

Staver (1989) found that students harbor misconceptions about the mole that hinder problem solving, science textbooks fail to link the mole concept with the concept of standard number of particles, students believe that such concept is just associated with gram-molecule. Lawrenz (1986), assess the existing state of knowledge in science in-service training program, more than 50% of teachers responded correctly to question about atomic structure but fewer than 50% teachers responded correctly about mass relates to air , motion, and collision.

Gabel, Samuel, and Hunn (1987) stated that because the microscopic level of matter is depicted in science texts, teachers need to be familiar with the particulate nature of matter, their study shows that teachers have difficulties in understanding the properties of conservation of particles and the orderliness of particles in over 50% of the questions in the group that had not received chemistry instruction. Gable, 1993 indicates that an emphasis on the particulate nature of matter led to an increase in the overall achievement scores. Johnson (1998), states that particulate ideas form part of a progression toward a scientifically acceptable particle model. Shumba, &Glass (1994) study the pedagogical content knowledge of preservice chemistry teachers, they show the importance of focusing on an important topic as particle models to understand the relationship between phenomena. Bryan, & Abell, (1999) focuses on presentation of gas properties in terms of the qualitative-quantitative mode. They show that current pedagogic practice involves minimal use of qualitative relationships of the gas laws. Gable, Sherwood and Enchos (1984) found that a majority of students utilize algorithms to solve problems and do not understand the concepts central to the problem themselves. They consider that conceptual understanding in chemistry includes the ability to represent and translate chemical problems using macroscopic (observable), molecular (particulate) and symbolic forms of representation. Students are required to think at the molecular level and explain changes at macroscopic levels in terms of interactions between individual atoms and molecules, however, researches shows that students frequently use symbols without understanding them. This leads to discuss the third dimension of the problem that is the way to represent such crucial content knowledge that hinders conceptualization of subject matter.

1-3 Representation of Content Knowledge

Ginns, & Watters, 1995, points out the results of cognitive research which show that large percentage of adult individuals still function at the concrete operational level; this fact would explain why many teachers may have misunderstanding of some scientific concepts. Lawson, Wollman, 2003, show that only 50% of the subject in most adolescent and adult of their sample were able to make affect transition to formal cognitive functioning. They examined the effect of instructional procedures that incorporate ideas designed and employed to successfully affect transition from concrete to formal cognitive functioning. The results of the study show that such approach encourage orientation towards problem solving, this fact is the outmost importance for educators. Lawson et al., (1989), point that reasoning by analogy, plays a central role in the formation of theoretical concept, the concrete operational level of thought for students would be activated in this way; students gained most when they were taught by teachers who were classified as concrete operational as opposed to formal operational. Staver &Lumpe (1993) state that instruction should place greater emphasis on molecular representations and relate these representations to the macroscopic and symbolic level. Johnstone (1993) states that sub microchemistry involves particulate ideas, micro representational (symbolic), and mathematical manipulation, instruction must link the three basic representation of chemistry so that students work with a combination of the macroscopic, molecular, and symbolic representational modes.

2- The Problem

Literature review show that teachers should have a sound conceptual knowledge base in order to implement effective problem-solving strategies, teacher educators must identify effective strategies for science instruction in teacher education courses that will enable all students to construct accurate concept, that take into consideration students' misunderstanding of abstract chemistry concepts, the ability of making transition from the concrete level to formal level, and making connections between the macroscopic, molecular and symbolic level in order to solve chemistry problem, this leads to the problem of the study;

2-1 The Study Questions

The study questions are:

1- Is there a significant difference in the answers of students who get pedagogic content knowledge in problem solving in chemistry and those who do not?
2- Is there a long term effects of using such approach of instruction that integrate macroscopic, symbolic and molecular representation of chemical phenomena in solving selected chemistry problems?

2-2 Sample

Investigation of succeeding in solving chemistry' problems was implemented on 115 students' teachers enrolled in the second, third, and fourth year program in teacher education in one of Jordanian universities. Teacher education program consists of four years of comprehensive education in methods and discipline courses that are required to pursue Bachelor of teaching degree.

Students study general chemistry courses beside labs in their second year of study. They study methodology course in their third year. Students had been tested at the end of second semester of the academic year.

2-3 Procedure & Instrument.

Instruction in methodology course implies discussing misunderstanding of physical science concepts, one of the cure concepts that is discussed is mole concept, such concept, is not only a fundamental unit of measurement, but it is also an important foundation for more complex chemical concepts such as stiochemistry, concentration of solutions, and the pH. If students are to construct accurate frameworks of complex chemical concepts and successfully solve quantitative problems, they must have a clearly defined conceptualization of the mole concept; failing to do so, it is likely that their chemical problem –solving ability will be severely limited

The experimentally determined value of the mole $(6.2 * 10)^{23}$ is too large to be comprehended in a concrete manner, comprehension requires a level far beyond memorizing formal procedures, the mole represent a way for moving between macroscopic and particulate level, but this media is difficult to understand. The instruction depends on using analogy as a central role in formation correct scientific concept about mole. There is a misunderstanding that mole represents a mass property, not a number of particles. Diagrams were presented to students to show how an equal number of substance A, have to reacts with equal number of substance B, or multi number of it, whatever the mass of each particle is; the concept of dozen was introduced, 12 boys need a dozen, or 2 dozens or three dozens of shirts. To illustrate the even distribution of particles in gas phase, that the same number of particles gets the same space regardless of their atomic mass, using analogy students would see that 300 passengers, of children or adults for example should get the same distribution of seats regardless of their body mass. The study used Symbolic Application Particulate chemistry test (SAP), that Dorothy Gable, 1994, had designed to define the conceptual level of high school chemistry teachers in U.S.A. This instrument consists of 30 questions of problem solving for 10 chemical concepts; density, mixture, conservation of matter, kind of reactions, mole, chemical reaction, solution, equilibrium, and pH, on three levels; Symbolic, Particulate and Application.

The reliability coefficient for the test had been calculated using
Kuder –Richardson Formula Number 20, KR20
$Rc = N/N-1\{1- £CW/S^2\}$
Rc stands for reliability coefficient
N stands for number of questions
£CW stands for summation of the proportion of correct answers multiplied by the summation of proportion of wrong answers
$Rc= 30/29\{1-6.37/15.6\}=.61$

3- The Result

3-1 Answering the first question of the study.

Is there a significant difference in the answers of students who get pedagogic content knowledge in problem solving in chemistry and those who do not?

The standard deviation for students in the fourth and the second year had been obtained, S_{x1-x3} =.86, t= 16.3-13.55/.86= 3.19

The critical value for t at $\alpha_{.05}$= 1.99, which means that there is a significant difference between the group that get methodology science course emphasizing pedagogic content knowledge that could to allow better capabilities to solve chemical problems.

3-2 Answering the second question of the study

Is there a long term effects of using such approach of instruction that integrate the macroscopic, symbolic and molecular representation of chemical phenomena on solving selected chemistry problems?
The standard deviation for answers of students in the fourth year who get the methodology course the year before, and those in the third year who had been just completed the class had been obtained: S_{x2-x3} = .89, t= 16.86-16.3/.89= .61

The critical value for t at $\alpha_{.05}$ =1.994, which means that there is no significant difference in the answers of students who had recently get instruction about problem solving and those who get such instruction in the year before, and that that the null hypothesis is tenable.

4- Conclusion.

The result of the study shows that instruction focusing in getting red of students' misunderstanding of abstract chemistry concepts such as mole by making transition from the concrete level to formal level using analogy while encouraging students to make connections between the macroscopic, molecular and symbolic level would enhance students' capabilities to solve chemistry problem.

The study also shows that such approach have an immediate and long-term effect in solving chemistry problems, there were no significant difference between the group that had just completed methodology course and the ones that had it the year before..

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Table (1)

Students' group	Students' Number	Students' Average	Percentile	Standard deviation
Second year	45	13.55	13.55/30=45%	3.75
third year	35	16.86	16.86/30=56%	3.62
Fourth year	35	16.3	16.3/30=54%	3.8