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Formation of Chemistry Teachers: Contributions of Historical-Critical Pedagogy for Instrumentalization of Chemical Solutions Teaching

José Vieira do Nascimento Junior[1], PhD; Edilson Fortuna de Moradillo[2], PhD; & Hélio Oliveira Pimentel[2], PhD.

Abstract

All discussions regarding development of scientific concepts are in evidence in research field of sciences teaching, due to difficulty secondary students find to learn it. The purpose of this work is to report the results of a research conducted in two parts, at two secondary education schools from municipal public school system of Salvador city (Bahia State, Brazil) in the years of 2011 and 2014. The idea was collecting students' concepts about chemical solutions before and after didactic mediation. The students' responses demonstrated that current pedagogic models do not cover social relations, that is: student-teacher-knowledge relationship is not being considered in a social-historical perspective which could provide a significant contribution in elevation of students 'learning level. Based on these results we propose a new way of didactic mediation, taking Historical-Critical Pedagogy (HCP from now on) as basis, in order to deal with science contents, conciliate scientific knowledge with social practice; and specially contribute for improving chemistry teaching in secondary education system.

Key Words: Chemical solutions; Teachers' formation; Historical-Critical Pedagogy (HCP)

1. Introduction

Appropriation of scientific knowledge from socio historical perspective plays an important role in developing across vision of social being (Moradillo, 2010, p. 145).From this point of view the PCN (National Curriculum Parameters)explicates the Brazilian education system's needs to promote formation of individuals with critical thought in society (Brazil, 2006, p. 7).

This critical view capability must be introduced in classrooms, especially in classrooms of Brazilian public schools where nontechnical and/or new school pedagogic practices have been predominating for a long time, and have not been succeeding in achievement of purposes cosmovision. Such practices do not enable students to develop certain cognitive skills, like being capable to articulate the logic and history of social reality and helping them to build critical analysis capacity. While application of technical pedagogy the student is merely an information receiver, the new school pedagogy is centered at student only. As result, both have in common the exclusion of those actors from concrete social practice of producing knowledge which occurs in social praxis, that is: the human being permanently transforming her/himself and surroundings through work –in order to handle his/her existence. Adoption of these two pedagogic models leads, as result, the actors (students) having difficulty to act in social field (Saviani, 2011, p.382).

[1]Department of Exact Sciences of State University of Feira de Santana, Transnordestina Avenue, Novo Horizonte, postal code: 44036-900 - Feira de Santana, Bahia, Brazil. electronic address: *jvnjunior@hotmail.com (researcher's phone number: +5571991227631).*
[2]Chemistry Institute of Federal University of Bahia, Salvador, Bahia, Brazil. *edilson@ufba.br* and *helpim@ufba.br*

Current way of teaching science contents can be indicative of gaps left by those pedagogic approaches. Both privilege a descriptive-operational way of teaching, generally leading student to simply memorize the concepts (becoming more of definitions rather than concepts), depriving them of their multiple determinations and causal and social nexus. Every concept is the resultant of its multiple determinations; the concept existence is constituted of its own relation-conceptual web.

To break traditional pedagogic practices (long-held assumptions) and advance from macroscopic-phenomenon to a microscopic- abstract level in sciences teaching, chemistry in particular, is necessary to overcome the barrier that separates real and descriptive view of phenomena, including representational level, towards the characterization of a system by its molecular-atomic nature. Explanation of such phenomena is based on abstract concepts as atoms, molecules, ions, electrons, etc., allowing system's description in a microscopic dimension.

Thus, building of scientific discourse taking the students' spontaneous concepts (Vygostky, 2010, p. 242) as point of departure would allow them to have a better understanding that science is in constant process of evolution and the concepts worked in classroom will also evolve in the course of pedagogic process.

In this regard, the systemized knowledge of chemistry would go beyond classroom boundaries recovering, partially, the relations of science with society's historical process and philosophy. According to Gamboa (2012):

[...]A reflection is needed allowing to bring back the critical thought of theoretical knowledge, the capacity of self-reflection in science learning as well as reintroduce full socio- interaction (p. 57).

In order to achieve such purposes is necessary to face the challenges and change those pedagogic paradigms deeply rooted in Brazilian education system. One of these challenges is related to poor attainment levels of students in Natural Sciences and Mathematics. In terms of comparable teaching and learning quality-level indicators the latest results of Brazilian students 'performance are too far from indicators presented by education systems of the Programmed for International Student Assessment - PISA of the Organization for Economic Cooperation and Development –(OCDE from now on), where the Brazil is an effective member (OCDE, 2016, p. 31).

As part of the solution it is recommended to provide students with appropriate methodological instruments so that bring into classroom an outside perspective (social practice with its concreteness and history), and extend transposition of knowledge from cognitive point of view towards historical and logical contents' point of view. It is necessary to mediate knowledge taking into account the learner's social reality where the pedagogic process actors can understand and apprehend how knowledge was developed during its history process.

The chemistry contents could be taken as a starting point to demonstrate how knowledge arises from materiality of social reproduction, relation between man and nature. For this is recommendable adoption of HCPas it goes beyond the established relationship teacher-student-knowledge in the classroom, unlike of neotechnicist and new-school pedagogic trends (Saviani, 2011, p. 381).

By HCP methodology approach Saviani considers a dialectic perspective between theory and practice through implementation of pedagogic practice in five steps: social practice, problematization, instrumentalization, catharsis, social practice return. These pedagogic moments/steps are theoretical categories that can be implemented in classroom but not limited to (Martins, 2013, p. 277).

The HCP approach starts from a non-structured social practice in order to interacting with science knowledge. Then, this knowledge returns to social practice less spontaneously and more scientific and systemized. Thus, a dynamic dialectic is established between theory and practice (Saviani, 2013, p. 122).For teachers training programs, the subject "chemical solutions" could be included as a knowledge element to be mediated and promote introduction of concepts like solute, solvent, mixtures, dilution, ions, charges, etc.

2. Objectives

Contributions of subject (chemical solutions) in teaching-learning process can be as it follows:

- Push students onto a higher level of critical thinking by using materials and tools of their everyday life.
- Develop appropriate skills, values and attitudes regarding social issues by associating chemistry and society.

- During instrumentalization step, introduce the HCP approach as contribution in chemical knowledge mediation process by selecting contents, books, and other resources.
- Provide students with appropriate instruments/tools to enable them to learn and describe dilution process, calculate concentrations, convert measure units, interpret experiments, and describe dilution processes.
- Observe safety aspects related to chemical solutions handling, by providing all material safety data sheets (hazards and benefits) of materials and substances involved.

3. Methodology

The research /survey took place at two secondary education schools (School A and B) that belong to the municipal public school system of Salvador city (Bahia State, Brazil). Following methods were applied in two moments:

(I) **Year 2011** - Collect spontaneous concepts about chemical solutions from School A's students. The group N1 was composed of251 students from six classrooms, 42students/class average. In the course of investigation was possible to understand how more complex notions of matter's microscopic structures are built. Every class of N1 group was subdivided into groups of 3 or 4 students to facilitate materials handling during experiment process, as well as get their effective participation and collecting their prompt responses. Moreover, the dynamic of classes was to establish dialectics between theory and practice by emphasizing student's contexts (Moradillo, 2010, p. 17) with support of didactic books (Mol, 2005, p. 666). Finally, it was carried out didactic mediation and re-evaluation of concepts involved.

(II) **Year 2014** - Second step of investigation occurred in School B with group N2 composed of 31 students, with purpose of verifying progress of concepts taught in the course of a period of 3 years. Operational and representational aspects related to concepts were mediated too (numerical, graphical, nomenclature, representation models of molecules).In this step, contents weren't mediated via experimental class.

3.1 Investigation method in detail

After conducting four theoretical and two experimental classes, 50 minutes each, following questions was asked to Group N1:

(a) What means solution?
(b) According to chemical solutions concepts, explain behavior of electrolytic cell lamp regarding dilution of initial NaCl solution.
(c) Why does lamp/bulb light up when solute is NaCl and does not light up when solute is sugar?
(d)

The experiment was adapted from experiment described in Gerson and Mol(2005) didactic book, for producing dilutions with two solutions: one of saline solution with 0,3% NaCl concentration, and other with sucrose, indeterminate concentration, separately placed in an electrolytic recipient connected to a light bulb (lamp) (p. 666). In both solutions the variations of lamp's glow during consecutive dilutions, from 100 ml to 500 ml volumes, were monitored. In another test, charged electrodes put in portion of NaCl and graphite, both solids, for checking existence of electric current conductivity. While experiments were progressing dialectic between teacher and students occurred in the process. Theoretical aspects of NaCl dilution, salvation, ionic dissociations, etc.; and talks about how solid and liquid materials work as electricity conductors; and use of terms as mixture, substance, matter, chemical bonds, chemical interactions were included(Echeverria, 1996, p. 15).

4. Findings

Step I

Year 2011 - Before attending experimental classes, most of N1 group's students, about 52, 2%, used to associate solution concept to an act of mixing up solute and solvent by 'fitting' one into another, where the solvent just serves as a dispersing agent mean to solute. On the other hand, 67% of students expressed some notions about the act of mixing: Solution is composed of a solute (diluting) and solvent (dissolving); solution is the result of a mixture containing the solute inside the solvent; solution is a mixture of two liquid substances; solution is a mixture of chemical compounds. These statements show students expressing their spontaneous concepts. However, concepts of system's phases and homogeneity weren't mentioned.

Besides, they used to assume that chemical solutions are exclusively liquid, and substance and compound are the same thing .It demonstrates that students 'explanations were in macroscopic level as also influenced by their everyday life observation and experiences.

This mistaken view about chemical solutions discloses their lack of knowledge about mixture of substances, systems whose properties depend on component characteristics, etc. The role of solute and solvent should be reviewed under a microscopic dimension of matter structure (Souza, 2008, p. 3).

Step II

After attending theoretical classes (didactic intervention) the questions (b) and (c) were asked to Group N_1: Group N_1's responses were condensed as it follows:

The higher is the volume the lower is the lamp's lightening. As solution volume increases the concentration decreases. Where electricity passes the lamp lights up, and where there isn't electrical circuit the lamp doesn't light up.

Most part of students could observe correctly the relation between solution volume and intensity of lamp's glow, taking into account the definitions of volume and concentration taught in class, but dilution concept wasn't mentioned. Besides, their explanations didn't include the species involved in dilution, the nature of bonds and interactions and conductivity process with liquid and solid conductors. It demonstrates that theoretical aspects related to atomic-molecular nature and abstract models related to interactions between solvent molecules and solute species need to be better mediated (Vygotsky, 2010, p. 242).

As Group N_2 was assisted by other teacher the N_2 classes weren't submitted to same didactic mediation done to N_1. Because of it, only question (C) was asked to Group N_2 in 2014.

In group N2, when analysing questions related to conduction of liquid solutions, 42% of students answered NaCl becomes a conductor when is dissolved in water. However, when they tried to justify absence of conductivity in saccharaised solution they couldn't interrelate knowledge's phenomenological, theoretical and representational levels: As Na is not present in saccha rose solution electricity is not conducted, acting as an isolator. In this case, an atomic-molecular dimension approach would be needed to justify role of species in solutions (Mortimer, 2000, p. 276).

Based on results described above a new teaching methodological approach is recommendable, having HCP steps as basis. To go beyond current outcomes is important to bring mediations back to classrooms, by including historical and philosophical aspects of science, economics and politics, taken from XV century until development of capitalist society (social and scientific revolutions triggered by the new world conception), and its techno-scientific-political consolidation at the end of XVIII century and beginning of XIX century. From scientific perspective is also needed to include information of the important contribution of Lavoisier to chemistry, the new conception of substance, distinguishing between substance and mixture, molecule notion, etc., (Netto; Braz, 2006 p. 136).

Development of a new pedagogical philosophy is necessary to be appropriated by students, and bring a new vision of contents and social practice, changing from transmission to transformative (Anunciação, 2014, p. 130).

5. Conclusion

This investigation is the result of an experiment carried out in two secondary education institutions, in 2011 and 2014, by interviewing 282 students and some chemistry teachers. It reflects what students think of contents regarding chemical solutions and their difficulty to handle the concepts (operationalization and formalization). They were unable to articulate interrelation between their own concepts and systemized chemical knowledge. This situation hasn't been improved much since then. Student's responses demonstrated they are not capable to establish a consistent understanding of mixtures and substances in a microscopic dimension of matter's structure. It shows that the descriptive-operational teaching of chemical solutions currently practiced in schools pushes students to memorize the concepts instead of thinking about them.

Such low performance results in chemistry learning requires address certain inadequate school conditions as the elevated classes size, for example, where we can find 42 students in a classroom; as well as adopt pedagogic practices that privileges and takes into account the context within which students do science.

The challenge is to change the pedagogic paradigms in effect in public schools, and introduce a different approach. The HCP could be this pedagogic proposal by applying formats that would meet the needs reported above, by valuing school spaces, performing a didactic mediation with a dialectic dynamics between theory and practice, and establishing logical and historical relations of contents involved.

Doing so, both teacher and student would develop a new vision of science teaching and learning, acquiring a larger awareness of social, historical dimensions in which knowledge was produced, and also realizing that the following elements: man, knowledge, history, society are inseparable.

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Attachments

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