VIEWS ON TEACHING OF PARTICULATE NATURE OF MATTER AT MACROSCOPIC, SYMBOLIC AND MICROSCOPIC LEVELS

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Abstract: Establishing conceptual relationships among macroscopic, symbolic, and microscopic levels is important in chemistry teaching and learning. The aim of this study was to investigate how pre-service chemistry teachers use macroscopic, symbolic, and microscopic levels and how they integrate teaching strategies with these three levels while teaching particulate nature of matter. Also, their opinions on the importance of using these levels in their instructions were examined. Eight pre-service chemistry teachers participated in this study. Three open-ended questions were administered to all participants at the beginning of practice teaching course. Then, three participants were interviewed to deeply analyze their responses. Written responses of question-2 were analyzed by researchers independently, then they came together to reach a consensus. Results indicated that pre-service chemistry teachers mostly preferred to use lecturing method at each level of chemistry in their instructions. Moreover, most of them had difficulties in using all levels and integrating these levels into teaching methods/strategies while teaching particulate nature of matter. However, they thought that using these three levels while teaching chemistry concepts is important in order to enhance student meaningful learning. Thus, teacher education programs should emphasize macroscopic, symbolic and microscopic levels, interactions among them, and how to use these levels in chemistry teaching.

Keywords: particulate nature of matter, macroscopic, symbolic, microscopic, pre-service chemistry teachers

BACKGROUND, FRAMEWORK, RATIONALE, AND PURPOSE

Establishing conceptual relationships among levels, which are macroscopic, symbolic, and microscopic, is important in order for students to meaningfully understand chemistry (Hinton & Nakhleh, 1999; Johnstone, 1993). The macroscopic level of chemistry is related to the observable phenomena such as burning a candle and color change. The symbolic level is represented using pictorial, algebraic, physical, and computational shapes. At the microscopic level, burning candle becomes a chemical process and carbon atoms of the wax react with oxygen molecules in the air, thus carbon dioxide molecules are produced (Hinton & Nakhleh, 1999; Wu, 2003).

Research studies revealed that students could not correctly explain chemical concepts using these three levels (Hinton & Nakhleh, 1999; Pozo, 2001). Especially, they have difficulties in

understanding chemistry topics at the symbolic and microscopic levels (Tsai, 1999; Wu, 2003). Reasons of these difficulties might be their poor understanding of nature of particles (Ben-Zvi, Eylon, & Silberstein, 1986; Williamson & Abraham, 1995), their incomplete or inappropriate mental models (Harrison & Treagust, 1996), and their poor connections between school science and real life experiences (Osborne & Freyberg, 1985 as cited in Wu, 2003).

Recent studies on pre-service teachers' use of three levels have shown that pre-service teachers explain chemistry concepts using the macroscopic level, but they cannot use the symbolic and microscopic levels during instruction. Moreover, they cannot create connection among these levels (Lee, 1999; Pozo, 2001). The purpose of this study was to investigate how pre-service chemistry teachers (PCTs) use the macroscopic, symbolic and microscopic levels, and how they integrate teaching strategies into these three levels while instructing particulate nature of matter (PNM). In addition, their opinions on the importance of using these three levels in their instructions were examined. Research questions of this study were as follows:

1. How do PCTs use the macroscopic, symbolic and microscopic levels while instructing PNM?
2. How do PCTs integrate teaching strategies into the macroscopic, symbolic and microscopic levels while instructing PNM?
3. What are the pre-service teachers' opinions on the importance of using the macroscopic, symbolic, and microscopic levels in their instructions?

METHODS

Eight PCTs, 3 males and 5 females, enrolled in practice teaching course in a state university in Turkey participated in the study. Three open-ended questions were administered to all participants at the beginning of the semester. Suggestions of six experts in chemistry education were taken into consideration about the open-ended questions. After the first teaching practice of participants in the high school and university, three of them were voluntarily interviewed to deeply analyze their responses to questions. Interviews were tape-recorded and lasted approximately 45 minutes. As this study investigated pre-service teachers' understanding on PNM at all levels, researchers examined only question-2 which is presented below:

"You are supposed to teach PNM to your students by integrating the macroscopic, symbolic and microscopic levels into your instruction.

a) What kind of teaching method(s)/strategies would you use? How would you design your instruction? Why?
b) How would you teach PNM concepts at each level?
c) Do you think that this kind of instruction affects your students' understanding of PNM? Why?"

Qualitative content analysis method (Creswell, 2009) was used to analyze the data. Firstly, responses of participants were analyzed independently by each researcher. During the data analysis, the researchers took into consideration whether the participants integrate the macroscopic, symbolic and microscopic levels into their instruction, and which teaching methods/strategies they used while teaching PNM at each level. Moreover, the researchers categorized the participants' opinions on the effects of using levels in their instructions on students' understanding of PNM. Then, all researchers came together and discussed the

answers to reach a consensus on the answers. The names of the participants were coded as from PCT-1 to PCT-8. PCT-1, PCT-2, and PCT-3 were also interviewees in this study.

RESULTS

Results of the study indicated that PCTs mostly prefer to use lecturing method at each level of chemistry in their instructions. To teach PNM at the macroscopic level, PCT-2 and PCT-4 stated that they would use lecturing. For instance, in her written response, PCT-2 claimed that she would give chemical bonding concept at the macroscopic level as; *"I will give firstly the definition of these two concepts (ionic and covalent bonding) and I will give examples from daily life."* In the interview, she also confirmed to use lecturing at this level as; *"At macroscopic level I'll state what ionic compound is. I'll use lecturing and I'll relate sodium chloride with daily life by saying that sodium chloride is table salt."* On the other hand, PCT-1 used demonstration while teaching the void structure of matter at the macroscopic level and stated it as;

"I use demonstration to explain the void structure of matter. For example: ethyl alcohol + water mixture. Before the demonstration; I ask students what they expect to see or at the end of the demonstration I want them make prediction for the aim of experiment."

She also confirmed same ideas in the interview. PCT-6 preferred to use analogy. He stated that *"For the macroscopic level, I would use analogy which will make the understanding of the topic easy for students, for example, I may use solar system analogy for the Bohr's atomic model."* Other four participants did not state any method and also they did not teach PNM at this level.

To teach PNM at the symbolic level, PCT-1, PCT-2 and PCT-4 stated that they would use lecturing. For instance, PCT-4 explained how she would give the instruction on the topic of compounds at the symbolic level as; *"to present the symbolic form of the molecule, I would draw on the board that one oxygen atom is bonded to two hydrogen atoms to form a water molecule."* PCT-2 also wrote that *"I will write examples to the board by using Lewis dot structure and symbols of elements. I will show the occurrence of ionic and covalent bonding with correct arrows."* However, in the interview, she claimed that she would enrich her lecturing using questions related to the formation of compounds from elements to make students more active. Other five participants did not state any method for teaching PNM at this level. Although PCT-3 did not propose any method in her written responses, in the interview, she stated that she would use lecturing while teaching PNM at the symbolic level.

PCT-1, PCT-2 and PCT-4 stated that they would use lecturing to teach PNM at the microscopic level. All of them mentioned that they would use videos and animations to show the structure of matter at the microscopic level during their lecture. For instance, in her written response, PCT-2 explained this situation on the topic of ionic and covalent bonding as; *"I will use an animation or video to show students what happens at the microscopic level while these bonding occur."* Moreover, in the interview, she claimed that she would support lecturing using analogy to teach ionic bonding at the microscopic level. Other five participants did not state any method for teaching PNM at this level. Although PCT-3 did not mention any method in her written responses, in the interview, she claimed that she would use lecturing by supporting animations while teaching at the microscopic level as *"Just saying an element loses or gains electron while forming a compound is not sufficient. We also need to use animations to make them understand the concepts at the microscopic level."*

Finally, in both written responses and interview, most PCTs thought that teaching chemistry topics at three levels is important. They claimed that this kind of instruction has powerful effects on student learning since it provides meaningful learning by making concepts more

concrete. In addition, they thought that it helps students to visualize the concepts; therefore, students do not try to memorize concepts. Moreover, they stated that learning in the microscopic level prevents students having misconceptions on the concepts. One of the participants explained this situation as following: *"When the instruction doesn't include the microscopic level, students could not be able to understand the concepts so these concepts should be made concrete."*

CONCLUSIONS AND IMPLICATIONS

The PCTs participated in the study thought that it was important to use these three levels while teaching chemistry concepts in order to enhance student meaningful learning. However, they had difficulties in using all levels and integrating these levels into teaching methods/ strategies while teaching PNM. Several studies in the literature support the findings of the present study (Bektas, Tuysuz, Ekiz, Uzuntiryaki, 2010; Pozo, 2001). Although all participants had taken teaching method courses, they only preferred lecturing method for all levels in their instructions. It is recommended that teacher education programs should emphasize the practical lessons regarding integration of levels to the different teaching methods in chemistry. Moreover, if representations and explanations at the symbolic, microscopic, and macroscopic levels are emphasized during teacher training programs, pre-service teachers' difficulties in using three levels can be overcome.

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