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Pre-service Primary Science Teachers' Ideas about Particle Model of Water

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Introduction

In recent literature, much attention has been paid to the ideas students have about particles (Pereira & Pestana, 1991; Longden, Black & Solomon, 1991; Maskell, Cachapuz & Koulaidis, 1997; Johnson, 1998a, 1998b; Kokkotas & Vlachos, 1998). Studies show that many students have difficulty in conceptual understanding of chemical concepts such as chemical reactions, states of matter, change of state, and dissolving at both the primary and secondary levels in schools. In addition, many students find it difficult to explain such concepts in terms of particles. On the other hand, some studies have emphatically shown that the ideas of particles provide the means for the students to understand the chemical concepts better.

The literature has shown that many primary school children's ideas about solids, liquids and gases are greatly influenced by 'everyday' usage of things or words (Russell, Longden & McGuigan, 1991; McGuigan, Qualter & schilling, 1993; Maskill, Cachapuz & Koulaidis, 1997). For instance, they consider solids as hard and rigid, and have difficulty classifying soft, malleable and granular solids. They think liquids are 'runny'; so that viscous liquids cause conceptual difficulty to them. Many tend to associate gases to gas flame, the air we breathe, aerosol cans that contain gas, heating, cooking, etc. A few studies (e.g. Russell, Longden & McGuigan, 1991; Johnson, 1998a) found that gases are the least well understood by primary school children. When children are given the opportunity to draw and label the three states of matter, they tend to be able to give far more examples of solids than liquids, and more of liquids than gases. While they do succeed in naming at least some solids and liquids, they falter badly when asked to name gases. They are not able to relate matter, such as smoke, flour, and ice to particles (Adams, Doig and Rosier, 1991; Maskill, Cachapuz & Koulaidis, 1997). They see matter as continuous representations that are directly observed and do not realize that matter is made up of particles. They would draw a block for solids, a partially filled container for a liquid, and wavy lines to represent a gas.

Literature also suggests that children find it hard to understand some change processes, e.g. melting, condensation and evaporation, at the macroscopic level (Adams, Doig & Rosier, 1991). Several researchers have recommended that chemistry be taught at three levels: macroscopic, microscopic and symbolic (Gabel, Samuel & Hunn, 1987; Johnstone, 1991). However, Skamp (1998) suggests that for primary science, the macroscopic and microscopic levels may be sufficient for teaching some fundamental chemical concepts (e.g. boiling). This would probably help students to appreciate the behaviour of matter better. The symbolic representation of chemicals is not necessary for the instruction of primary science because chemistry content covered in primary science syllabus is very limited (Skamp, 1998).

Recent research has shown that particle ideas can enhance students' understanding of some chemical concepts. Johnson (1998a, 1998b) investigated students' views of boiling, evaporation and condensation of water and the effect of the teaching of particle ideas on students' understanding as part of a three-year longitudinal study. Thirty-three students (ages 11 to 14) were interviewed, using objects and events as stimulus for question-

ing. The interviews were conducted at the different stages of the teaching schedule throughout the three years. The results suggest that the teaching of particle ideas enhances the students' understanding.

Purpose of the study

In view of the literature reported above, it is useful for upper primary school students to know the structure of matter in terms of particles such as atoms and molecules. This will enhance their conceptual understanding of some chemical phenomena. However, this does not necessarily mean that the particulate nature of matter should be formally introduced to primary school students; rather, the particulate nature of matter can be the underlying schema in a teacher's mind as he or she interacts with learners on this topic. Depending upon the specific content and context and the age of the students, some teachers may find it appropriate to help their students think of the world in terms of particles. But are the science teachers adequate in their knowledge about the particulate nature of matter? The purpose of this study was to find out how much teachers knew about the particulate nature of matter and whether they were adequate to teach particle ideas when opportunities arose. The topic of water was chosen for this study because it is one of the few chemistry topics to be taught in Singapore primary schools.

This study investigated the ideas the pre-service primary science teachers had about the different representations of models of water based on the particulate nature of matter. The teachers' views about the arrangement of particles in ice, water and water vapour; and also about how and why the particles move about from one state to another, were explored. The implications of the study for the science teacher education and the teaching and learning of primary and secondary science will be discussed.

Methodology

Sample

The sample comprised a cohort of 92 pre-service primary science teachers who were enrolled in the one-year Postgraduate-diploma-in-Education (PGDE) programme from the National Institute of Education (NIE). Among them, 73 (79%) were female and 19 (21%) were male teachers. Their age ranged from 21 to 39 and the average age was 24.3 years old. Some of them had working experience before joining NIE. Forty student teachers (43%) had some short-term teaching experience (ranging from 1 month to 6 months), such as being involved in the NIE Contract Untrained Teacher Scheme or relief teaching. For their highest qualification, 3 held Master's degrees, 19 Bachelor's degrees with Honours, and 70 Bachelor's degrees without Honours. The disciplines of these degrees include Science, humanity and commerce subjects.

For their highest science background (science refers to the school science subjects including Biology, Chemistry, Physics and Science), 40 student teachers (43%) read one or two sciences up to the university level (Honours, 3rd Year, 2nd Year or 1st Year). Among them, 2 (2%) studied science up to Honours year, 23 (25%) up to 3rd Year, 5 (5%) up to 2nd Year, and 10 (11%) up to 1st Year. Forty-four student teachers (48%) read one, two or three sciences up to A-level. Eight student teachers (9%) read one or two sciences up to O-level. These three groups of student teachers, each with a different science background, will be referred to in this paper as 'University', 'A-level' and 'O-level'. Almost 99% of the sample had been taught the Particulate Nature of Matter about solids, liquids and gases at the Secondary 3 Chemistry classes. The Particulate Nature of Matter is part of the O-level chemistry (pure Chemistry or Chemistry in Science) Syllabus.