Chapter 76
Developing Scientific Literacy:
Introducing Primary-Aged Children to Atomic-Molecular Theory

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ABSTRACT

This chapter challenges existing school science curricula modes for teaching atomic-molecular structure and describes a current research project designed to provide supporting evidence for reviewing school science curricula. Using evidence from this project and other research studies, the chapter argues for the introduction of atomic-molecular structure in the curriculum at Year 3 or 4 and proposes that consideration be given to devising a spiral curriculum in which the macroscopic and microscopic properties of matter are taught concurrently rather than sequentially.

ORGANIZATION BACKGROUND

Three years ago, a former high school teacher responded to questions about matter and atoms from his young son. His son's interest and apparent capacity to grasp the concepts led to the teacher offering to teach the rest of his son's primary class. The apparent success of this early venture led to further development of the teaching and learning program and the backyard development of innovative hands-on models to better facilitate the learning. We are two science teachers, now University educators of preservice primary teachers, who became interested in this program. Our study seeks to verify whether the teacher's claims of success can be supported by research. Consequently, the research participants in this case are a diverse class of Year 4 children in a school new to the specialist science teacher. Our research examines the development in these children's understanding of atomic-molecular theory from their learning experiences with the specialist science teacher following 10 hours of instruction on atoms, molecules, and elements (1 hour per week over a 10-week period).

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SETTING THE STAGE

Commonly, the teaching of atomic-molecular structure begins in high school. For example, in the new Australian Curriculum: Science (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2013) the first mention of 'atoms' is in Year 9, when most students are 14 years old. The new K-12 Next Generation Science Standards from USA (National Research Council [NRC], 2013) are based on disciplinary core ideas from their earlier framework (NRC, 2012). This K-12 Framework introduces particles at Grade 5, and then elaborates these as atoms at middle school level, Grade 6. By the end of Grade 8 students should know there are approximately 100 different types of atoms, but even in this bold new curriculum which aims to introduce core ideas in science, technology and engineering from students' earliest schooldays, the details of atomic-molecular structure and the Periodic Table are still not tackled until Grade 9. However, at least this progression attempts a spiral curriculum (pioneered by Bruner, 1960) by introducing the scientific language of atoms earlier and building upon this baseline. The new national science curriculum to be introduced in the United Kingdom from September 2014 appears at first glance to be conservative, but introduces the particle model and atoms from Key Stage 3, i.e. Year 7 and onwards (Department of Education, 2013). However, this is classed as high school and part of the secondary science curriculum; there is no mention of atoms in the primary science curriculum.

Yet an Australian researcher (Jakab, 2013) found that most of her participants aged 8 years or older could state some everyday knowledge of molecules when first asked, and some 11 year olds had sophisticated knowledge, one expressing the aspiration to become a particle physicist. This chapter will report on an independent innovative attempt to teach children of equivalent age about atoms, atomic-molecular theory and the Periodic Table.

This practice of leaving atomic-molecular structure to high school seems to be the consequence of the developmental stage theory of Piaget and others (Inhelder & Piaget, 1958). Interestingly, in the Australian context, this approach also seems to coincide with broad student resistance to, and lack of enthusiasm for, the learning of science. This is evidenced by measureable decline in the number of Australian secondary students who continue with the study of science, particularly the physical sciences, into the final years of high school and university (Goodrum, Druhan, & Abbs, 2011). Yet research reported by Tytler and Osborne (2012) has shown that students are highly interested in science at 10 years of age, and form their career aspirations by age 13 or 14. The importance of engaging students early in science education is supported by other studies: grade 8 students who expected to have a career in science are more likely to graduate with a science degree (Maltese & Tai, 2010; Tai, Lui, Maltese, & Fan, 2006) and 65% of a sample of scientists and graduate students had developed their interest in science before middle school (Maltese & Tai, 2010). Leaving the 'Big Ideas' of science until high school may be too late.

The Problem with Piaget

The Piagetian model of developmental stages (Inhelder & Piaget, 1958) holds that children pass through four defined stages of cognitive development. Infants to age 2 years are in the sensorimotor stage, and from ages 2 to 7, children are in the pre-operational stage, during which they cannot conserve quantity nor think logically. Children aged 7 to 11 years are in the concrete operational stage in which they begin to think logically but only with practical aids, and from ages 11 to 16 years and onwards, children transition to the formal operational stage with the development of abstract thinking. It is on this basis that abstract concepts such as atoms are delayed in curricula

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