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Helping Students Understand the Particulate Nature of Matter

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Whenever I taught about the particulate nature of matter in solids, liquids and gases, I often had difficulty explaining this abstract concept to my students. The students, in turn, had much difficulty conceptualizing the structure and behaviour of the particles, which ultimately led to difficulties in understanding the complex configuration of particles in matter at various levels.

This article focuses on studies that reveal students' alternative frameworks for the particulate nature of matter in solids, liquids and gases. Also, I suggest factors that contribute to these alternative frameworks, incorporating my own experiences in developing an understanding of this concept. Finally, in light of these alternative conceptions and difficulties, I consider strategies for effectively teaching this abstract concept.

Rationale

During my teaching experiences, students often asked me thought-provoking questions like "How small is an atom, and what does it look like?" In responding to these questions, I was often compelled to use textbook explanations. I explained concepts to my students in the same way they had been explained to me in school. I would tell them, "Atoms are very small and cannot be seen with the naked eye." During the Primary Science Module and the Lower Secondary Science Module at the Aga Khan University Institute for Educational Development (AKU-IED) in Karachi, Pakistan, I realized that my explanations did not facilitate my students' conceptual understanding of the particulate nature of matter.

This realization provoked my interest, and I decided to review the research literature on students' and teachers' alternative frameworks for the particulate nature of matter and the factors that contribute to these alternative frameworks. Most of the research links alternative frameworks to the following factors:

- The teacher's inadequate explanation of the concept
- The textbook's vague explanation and representation of particulate theory
- The atom as an abstract concept
- The use of fewer hands-on activities in teaching the concept

After my research, I planned to explore teaching strategies that could improve students' conceptual understanding of the particulate nature of matter.

Students' Understanding of the Particulate Nature of Matter

The particulate theory of matter is fundamental in science. Scientists use it to explain the behaviour of matter and the complex configuration of the materials that make up objects. The arrangement and behaviour of the particles in materials are abstract concepts because of their invisibility at the macro level. The abstract nature of matter is thus beyond the understanding of primary and secondary students, as well as many teachers.

The problem begins in the elementary science curriculum, where children are not given opportunities to classify the various types of materials they encounter in their daily lives. Peacock and Smith (1992) found that elementary students had great difficulty distinguishing between objects and the materials that make up the objects. Moreover, textbooks rarely address this satisfactorily. These difficulties remain with students until they are introduced to particulate theory in secondary school.

Research shows that understanding what *particle* means is crucial to understanding the particulate nature of matter. Students often think of a particle as matter like a grain of sugar or sand because in everyday language the word *particle* is used to refer to bits of matter in a solid. This tendency was evident in the students I worked with during the modules. The students associated the properties of the particle with those of a grain of sand. Driver et al. (1994) found that children attribute to an atom properties such as hardness, hotness, coldness and colour—the physical macroproperties of solid bits. This conception of particles often creates difficulties for students in understanding the intrinsic movement of particles and the spaces between particles in the three states of matter. I, too, used to think of atoms as bits of solid, like sugar grains; from that perspective, the particles in a solid would be motionless and have no spaces between them. This conception is contrary to the scientific view of particles of matter. Particles of matter represent atoms and molecules.

I will now discuss students' ideas about the three states of matter in light of research and my experiences. Dow (cited in Driver et al. 1994) explored secondary students' ideas about atoms and their arrangement in a solid and found that, although the students could explain particles in a solid, they could not rationalize the attraction between the particles or their rigidity. Students often do not believe that there are spaces between the particles of a solid and that these particles are in constant motion; the idea is at odds with their existing conception of solid matter. For students, this raises the question, If the particles in a solid object are moving, then why is the object itself static?

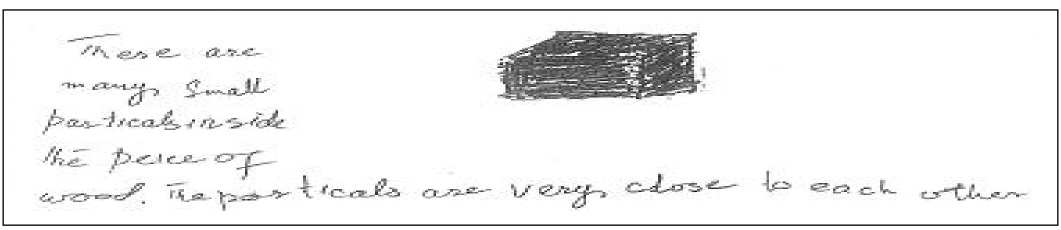
In our exploration of students' understanding of the particulate nature of matter during the Primary Science Module, we asked the students to draw the arrangement of particles in a liquid, a solid and a gas. The students' drawings did not indicate an understanding of a liquid and a solid as being composed of particles (see Figures 1 and 2). Yet their descriptions (based on their learning from the textbook) did. Furthermore, the students did not accept that these particles are constantly moving.

It is obvious from the drawings that the students see the world as concrete. Thus, a liquid is to them a continuous substance; in fact, the students' explanation of particles was that they are small droplets of a liquid, which they often associated with a molecule. The problem with the students' models of the particles of a liquid is that they do not explain evaporation and similar natural phenomena.

In the case of a gaseous state, the students had great difficulty understanding the particles of a gas and their free movement (see Figure 3).

When I taught this concept in my classroom, my students believed that they could see the movement of particles in a sunbeam falling in a dark room. They had confused dust particles with particles of a gas present in the air. My conception was similar to that of my students. This is due to the association of the visual particles of a solid substance with the abstract

Figure 1
A Student's Drawing of the Particles in a Solid



particles of a gas. Similarly, Driver, Guesne and Tiberghien (1985, 106) found children explaining, "Air is something which exists but cannot be seen or touched, something which circulates, gets in and out of places where matter is unable to go." This conception isolates air from matter, which ultimately leads to difficulties in believing that gases are present in the air and that the particles of gases are constantly moving.

When the scientific concept of particles is introduced, students find it difficult to understand because it does not match with their prior conceptions. This mismatch results in what Driver et al. (1994) call a "concept-confliction." Does school science, including textbooks and additional resources, address students' existing difficulties? Do current teaching approaches challenge students' prior conceptions? No. In fact, current resources and approaches tend to create further confusion. For example, many junior and intermediate science textbooks in Pakistan provide two-dimensional examples of the atom's structure that contradict the scientific image of the atom.

Some illustrations in textbooks in Pakistan show large spaces between the particles of a liquid. I used to think that these spaces represented some kind of continuous material holding the particles together. I had no conception of attractive forces. My alternative framework interfered with my understanding of the scientific view of particles of matter and their arrangement. The same is true with students.

Language also affects the explanation and interpretation of a concept. Sometimes students' alternative frameworks are the result of lexical limitation or the use of words with different meanings in everyday language and scientific terminology. This can create difficulties for students in comprehending the scientific conception. For example, in everyday life, the word *particle* is commonly used to refer to solid bits and *air* is used to describe the gases in the atmosphere. Also, students have difficulty applying scientific concepts to the real world when scientific language is used to clarify the phenomena.

These alternative frameworks can hinder students' understanding of the scientific conception of particles of matter. This then leads to difficulties in understanding and explaining many scientific phenomena. During my M.Ed. teaching, I noticed that students often had difficulty understanding physical and chemical phenomena such as evaporation, sublimation, decomposition, condensation and diffusion in terms of the particulate nature of matter. Even science teachers face this difficulty. For example, I experienced difficulty comprehending phenomena during the Lower Secondary Science Module. To me, a burning candle was an example only of a physical change. I was surprised to find that it is also an example of a chemical change. Until then, I had read in my textbooks and heard from my teachers only about physical change.

How can teachers make teaching and learning more effective for students?

My Understanding as a Teacher

Based on these findings, I have concluded that children (and adults) have their own understanding of the world. They develop their particulate schema of matter through a series of experiences. Teachers usually ignore these prior experiences in the science classroom. Therefore, students encounter conflicting conceptions. Gega (1990, 39) writes, "Children do not simply receive or absorb incoming information like a sponge; instead they actively

Figure 2
A Student's Drawing of the Particles in a Liquid

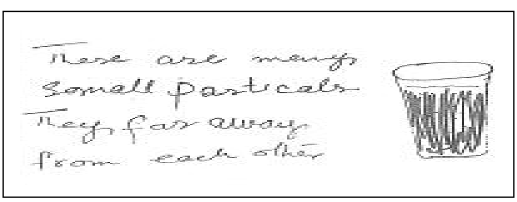


Figure 3
A Student's Drawing of the Particles in a Gas

construct meaning by referring to related information already stored in their long-range memories from previous experiences." In other words, students do not enter the science classroom with blank minds; rather, they bring with them their own experiences and interpretations of the world.

The findings on students' ideas about the particulate nature of matter have implications for science teachers and the science curriculum. Teachers must develop effective instructional strategies and provide more comprehensive explanations. The concept of the particulate nature of matter in the three states is best introduced after the students have successfully identified the physical properties of selected materials. Teachers often introduce this concept very late and rush through it without making sure that the students understand the physical properties of materials at the macro level. The concept should be brought from primary science into secondary science in a way that helps develop students' understanding of the concept from the macroscopic level to the microscopic level.

In the case of the gaseous state, students must understand the concept of particles for different gases present in the atmosphere. Several practical activities can help children to understand that air, as an example of a gas, contains many tiny particles that are far apart. For example, students can do experiments that involve compressing air in a syringe. A simple experiment such as spraying perfume in the air followed by discussion will also illustrate that particles in the atmosphere are in constant motion, travelling from place to place.

In the case of a liquid, most of the empirical evidence reveals that under ordinary conditions students perceive liquid as a continuous substance. This was true with my students (see Figure 2). A simple experiment such as dissolving salt or copper sulphate in water will help make the concept of particles in liquid comprehensible to students. It will also establish that there are spaces between the particles and that the particles of a liquid move.

Finally, teachers' explanations greatly affect students' understanding of the particulate theory. In teaching this abstract concept, teachers must be confident enough in their content knowledge to clarify the concept for the students. Effective teachers carefully explain the concepts and expose the students to everyday situations that illustrate the concept, which consolidates understanding of science. This approach also links school science with real-life phenomena, such as the evaporation of water from clothes and the condensation of water droplets on the outside of a glass full of ice.

Implications for the Science Teacher and the Teacher Educator

These findings have significant implications for the professional development of a science teacher.

To teach this concept, teachers must provide clear explanations and representations of the particulate model at the macro level. Where the macrorepresentation of particles is not sufficient to give students a visual image of the microperspective of particles, teachers must demonstrate the hybrid model of the macroperspective and the microperspective. The research also shows that the particulate theory of matter is an abstract concept. The teacher's own content knowledge and knowledge of resources play important roles in the students' understanding; in my context, these are the most crucial issues. Helping students understand the concept is possible only when the teacher clarifies his or her own conception of the particulate nature of matter and develops appropriate resources. The teacher must have sufficient content knowledge and pedagogical content knowledge at the secondary level to teach concepts comprehensively.

References

Driver, R., E. Guesne and A. Tiberghien, eds. *Children's Ideas in Science.* Milton Keynes, U.K.: Open University Press, 1985.

Driver, R., A. Squires, P. Rushworth and V. Robinson. *Making Sense of Secondary Science: Research into Children's Ideas*. London: Routledge, 1994.

Gega, P. C. *Science in Elementary Education.* 6th ed. New York: Macmillan, 1990.

Peacock, G., and R. Smith. *Teaching and Understanding Science*. London: Hodder & Stoughton, 1992.

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