

Final Paper for MSTC 4047  
Physical Curriculum & Methods Laboratory  
May 2003

## **A Lesson on the topic of Density**

Written by Linda Ruiz McCall

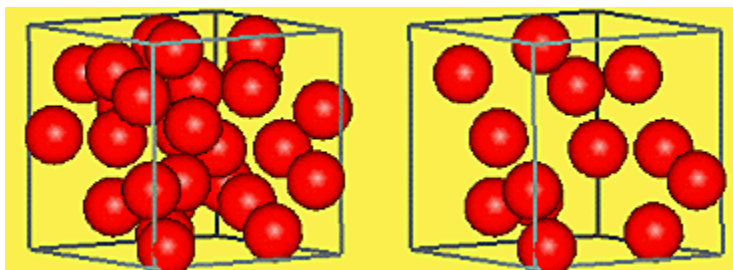
This paper is divided into three sections. The first is a description of the topic and its current scientific understanding. Next, we will look at the research findings on what student's understanding of the topic is thought to be. Finally, a lesson including activities to help student's overcome common misconceptions is described.

### **The Scientific View of Density**

As an earth science teacher, I have chosen a topic that is pervasive in the study of the earth, atmosphere and ocean, namely, density. It is a topic that on its face seems easy to understand, yet commonly presents problems for students. The scientific understanding of density is often presented as shown below.

## **Density**

Take a look at the two boxes below. Each box has the same volume. *If each ball has the same mass, which box would weigh more? Why?*



The box that has more balls has more mass per unit of volume. This property of matter is called density. The density of a material helps to distinguish it from other materials. Since mass is usually expressed in grams and volume in cubic centimeters, density is expressed in grams/cubic centimeter.

We can calculate density using the formula:

$$\text{Density} = \text{Mass} / \text{Volume}$$

Source ([www.nyu.edu/pages/mathmol/textbook/density.html](http://www.nyu.edu/pages/mathmol/textbook/density.html))

In addition to the simple definition of density, it is important to understand the scientist's view of the particulate nature of matter. In our class discussion, we learned the "Tenants of Molecular Kinetic Theory" as being,

- 1) Matter is composed of particles – bits of atoms/molecules
- 2) Between the particles is empty space – void
- 3) The particles are much smaller than the space between them.
- 4) Particles are in constant motion
- 5) Particles frequently collide
- 6) Temperature is a measure of particle speeds
- 7) Groups of particles have average speed – Motion is random
- 8) There are attractive or repulsive forces between particles.

It is my goal to teach density by incorporating the particulate nature of matter in the lessons.

### **Student's View of density**

In my short experience in teaching 8<sup>th</sup> grade students, I found that they have great difficulty understanding the concept of density. Some student's are able to "do the math" and define variables and plug them into the formula, while many have difficulty dealing with two variables at a time. Most students seemed to be confused about the meaning of mass and weight. Others did not grasp volume as being an empty space.

In his research, "Pupils' Conception of Matter and its Transformations (age 12-16), Bjorn Andersson found that students had "*significant difficulty in distinguishing between amount of substance and volume.*" (p.64). Upon interviewing students about a blood-pressure gauge applied to their arms, the students thought that the air was pushing their arm only while it was actively being pumped. Even though the band was still exerting pressure on their arms when the pumping stopped, they thought that the air pressure had stopped and only the armband was compressing their arm. Andersson concluded that, "The idea that air exerts pressure on its surroundings only when it is in macroscopic motion may be regarded as a result of conceiving matter as static....And why should continuous matter, filling every space be compressible?" (p.65) The topic of students misunderstanding of empty space in matter is one that seems to surface in many research findings. We saw that Andersson referred to it as did Joseph Nussbaum in "The Particulate Nature of Mater in the Gaseous Phase". Nussbaum found in his study of 8<sup>th</sup> grade students that "*only about 45% of the pupils explained decisively that there was empty space between particles.*" (p.130). It is my feeling that this is perhaps the biggest stumbling block to students understanding density.

The research also pointed to a finding that I must mention. In the study by Debbie Sheppard and John Renner on "Student Understandings and Misunderstandings of the States of Matter and Density Changes", they stated that "*73% of the students in grade ten and 66% in grade twelve function at the level of concrete operations*" (P.663). The percentages were expected to be even higher for grades seven and eight. Their research indicated that student in the "concrete" level of development need objects to tie to mental activity. Objects, which can be directly manipulated. It will be my attempt to address the afore mentioned student difficulties through the activity described in this paper.

## **Density Investigation**

written by L. R. McCall  
as a project for Columbia Teachers College  
May 2003

### **Aim**

To observe particles and see how their size, shape and “packing” might be used to define the term **density**.

### **Materials**

\* Three spice jars the same size containing bullion cubes, “rainbow jimmies”, and paprika

**Activity One** - Designed to get student’s thinking of matter in terms of particles. Also, to help students by allowing them to manipulate objects while they think about them.. In addition, it is hoped that the concept of volume as separate from quantity of substance will be recognized.

- 1) Keep each jar sealed.
- 2) Carefully observe the contents of each jar and describe the size, shape, color and anything else that you see. Write it down.
- 3) The label on the jar gives the net weight and the mass for each jar. Since we use the metric system in science. Write down the mass for each.
- 4) What do you observe about the size of each jar? Write it down.
- 5) How does the size of each jar relate to the jar’s volume? What if the jar were empty? Would the volume change? Explain.

**Activity Two** - To give student's a visual picture of space existing between particles to help them in constructing this difficult concept. To allow students to combine the concepts of mass and volume in order to begin to understand density.

1) Given your results from activity one, compare and contrast the objects or "particles" in each jar. How do they pack within the jar? Do you see spaces between the particles? Write down your observation?

2) Fill in the table below: (since the jars have the same volume use  $100 \text{ cm}^3$  as the volume for each spice)

Spice name	mass	volume	density

3) Which of the spice jars do you predict will be the most **dense**? Why? Explain by including a description of the particle size, "packing" and other characteristics. Refer to Activity One.

4) **Density = Mass/Volume** Calculate the density of each spice and write it in the table in step#2. Did your prediction about the density of each spice hold? Why or why not? Explain below.

**References:**

Andersson, B. (1990). Pupils' conceptions of matter and its transformation, Studies in Science Education, 18: 53-85.

Nussbaum, J. (1985). The particulate nature of matter in the gaseous state. Children's Ideas in Science. R. Driver, E. Guesne and A. Tibergien. Philadelphia, Open University Press:124-44.

Shepherd, D.L. & Renner, J. (1982) Student understandings and misunderstandings of states matter and density changes, School Science and Mathematics. 82, 650.

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Template: C:\Documents and Settings\Administrator\Application  
Data\Microsoft\Templates\Normal.dot  
Title: Final Paper for MSTC 4047  
Subject:  
Author: Mom  
Keywords:  
Comments:  
Creation Date: 8/17/2005 1:18:00 PM  
Change Number: 2  
Last Saved On: 8/17/2005 1:18:00 PM  
Last Saved By: Michael Passow  
Total Editing Time: 8 Minutes  
Last Printed On: 8/17/2005 1:23:00 PM  
As of Last Complete Printing  
Number of Pages: 5  
Number of Words: 1,241 (approx.)  
Number of Characters: 6,467 (approx.)