

Spring 2001



ITEM SAMPLER

AN ANALYSIS OF MIDDLE SCHOOL DSTP SCIENCE ITEMS



Delaware Department of Education

The purpose of this handout is to help Delaware teachers prepare their students for the science portion of the Delaware Student Testing Program (DSTP). Included in the handout are the middle level science items that were field tested in classrooms throughout Delaware or were part of the Spring 2000 “live test.” Items included in this handout will not be part of the 2001 DSTP.

Each student taking the test received both a total science score and a set of four sub-scores, broken out in the areas of Inquiry, Life Earth, and Physical Science. Although multiple forms of the assessment were administered across the State, the maximum number of points that could be earned was 68. The Targeted Item Distribution for DSTP Science Test included below shows the number of assessment items for each reporting category and the total number of points that could be earned per category.

Targeted Item Distribution for DSTP Science Test

K-3

Reporting Category	Multiple Choice	Short Answer	Percentage of Entire Test	MC Total Points	SA Total Points
Inquiry	10	6	30	10	12
Life Science	10	6	30	10	12
Earth Science	6	3	20	6	6
Physical Science	6	3	20	6	6
Totals	32	18	100	32	36
Total Point per Test = 68					

4-5

Reporting Category	Multiple Choice	Short Answer	Percentage of Entire Test	MC Total Points	SA Total Points
Inquiry	8	5	25	8	10
Life Science	8	5	25	8	10
Earth Science	8	4	25	8	8
Physical Science	8	4	25	8	8
Totals	32	18	100	32	36
Total Point per Test = 68					

6-8

Reporting Category	Multiple Choice	Short Answer	Percentage of Entire Test	MC Total Points	SA Total Points
Inquiry	5	3	15	5	6
Life Science	10	6	30	10	12
Earth Science	8	4	25	8	8
Physical Science	9	5	30	9	10
Totals	32	18	100	32	36
Total Point per Test = 68					

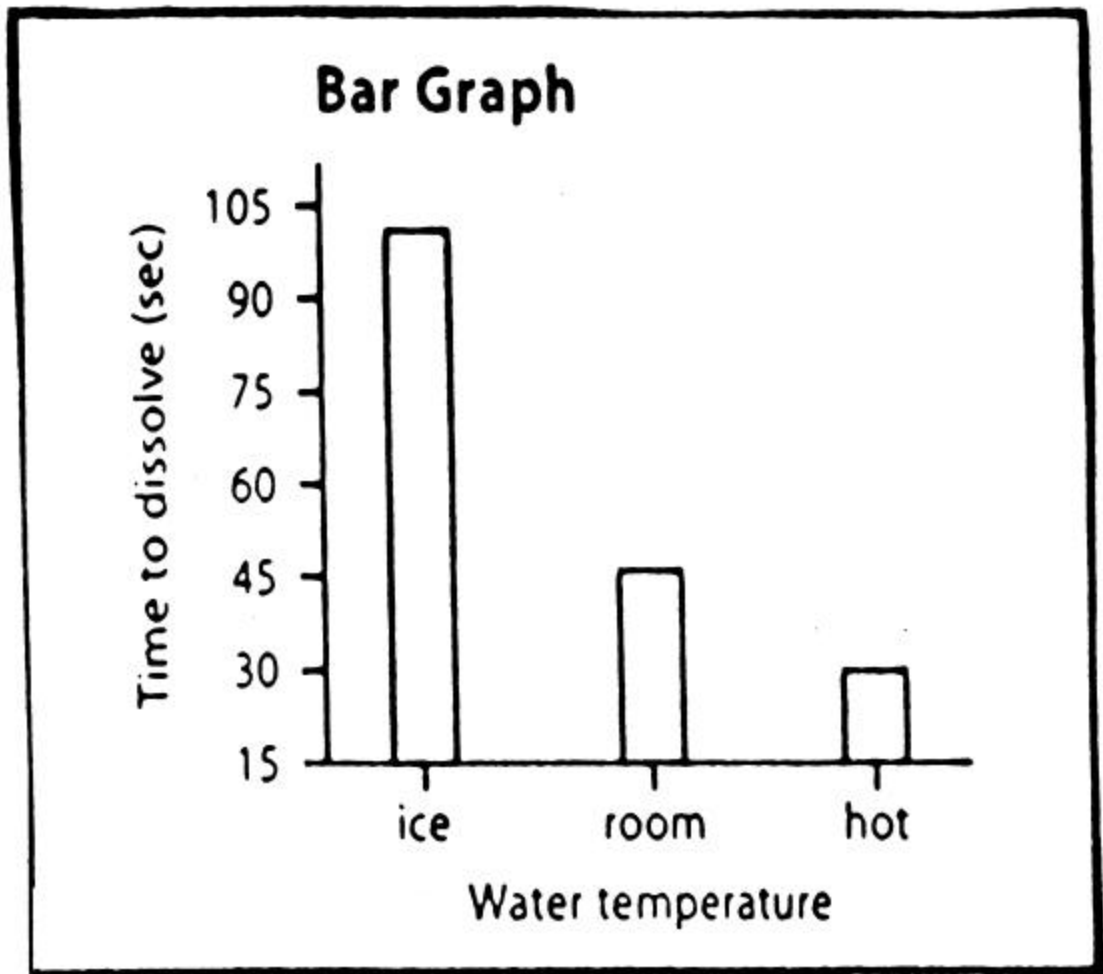
11th

Reporting Category	Multiple Choice	Short Answer	Percentage of Entire Test	MC Total Points	SA Total Points
Inquiry	5	3	15	5	6
Life Science	10	6	30	10	12
Earth Science	8	4	25	8	8
Physical Science	9	5	30	9	10
Totals	32	18	100	32	36
Total Point per Test = 68					

Statewide Patterns and Trends

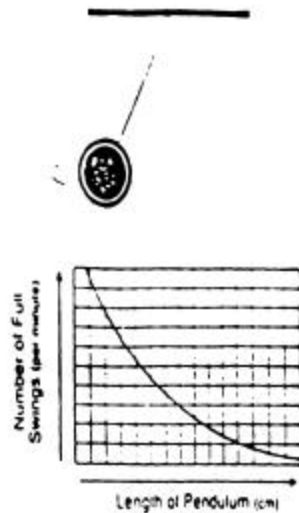
I. Inquiry

Although students did far better analyzing data from a bar graph than they did analyzing data from a line graph, they still need practice constructing and analyzing a variety of bar graphs. For example, students score well on bar graph questions when the longest or highest vertical bar is the correct answer. However, if students were asked to determine the effect of water temperature on the dissolving time of an effervescent tablet, the vast majority would select ice instead of hot because they are relying on past experience and a restricted set of “rules” that govern the interpretation of a graph.



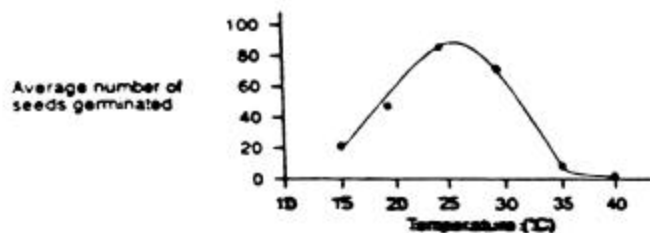
Another indication that Delaware students seem to operate from a restricted set of rules occurs when they are asked to construct or interpret a phase change graph. As long as students are asked to analyze a phase change that goes from ice to water vapor, students can perform well because that is the typical way they are taught to graph this relationship. However, should the phase change be depicted showing water vapor turning to liquid and then to ice, the students do not interpret the graph correctly.

Inverse relationships like the kind depicted on the graph below are also problematic for students. For example, the relationship between pendulum string length and number of full swings is an inverse relationship, meaning that as one variable increases, the other decreases. The following item from the spring DSTP illustrates this point with a P value of .38 (38% of the students answering correctly).



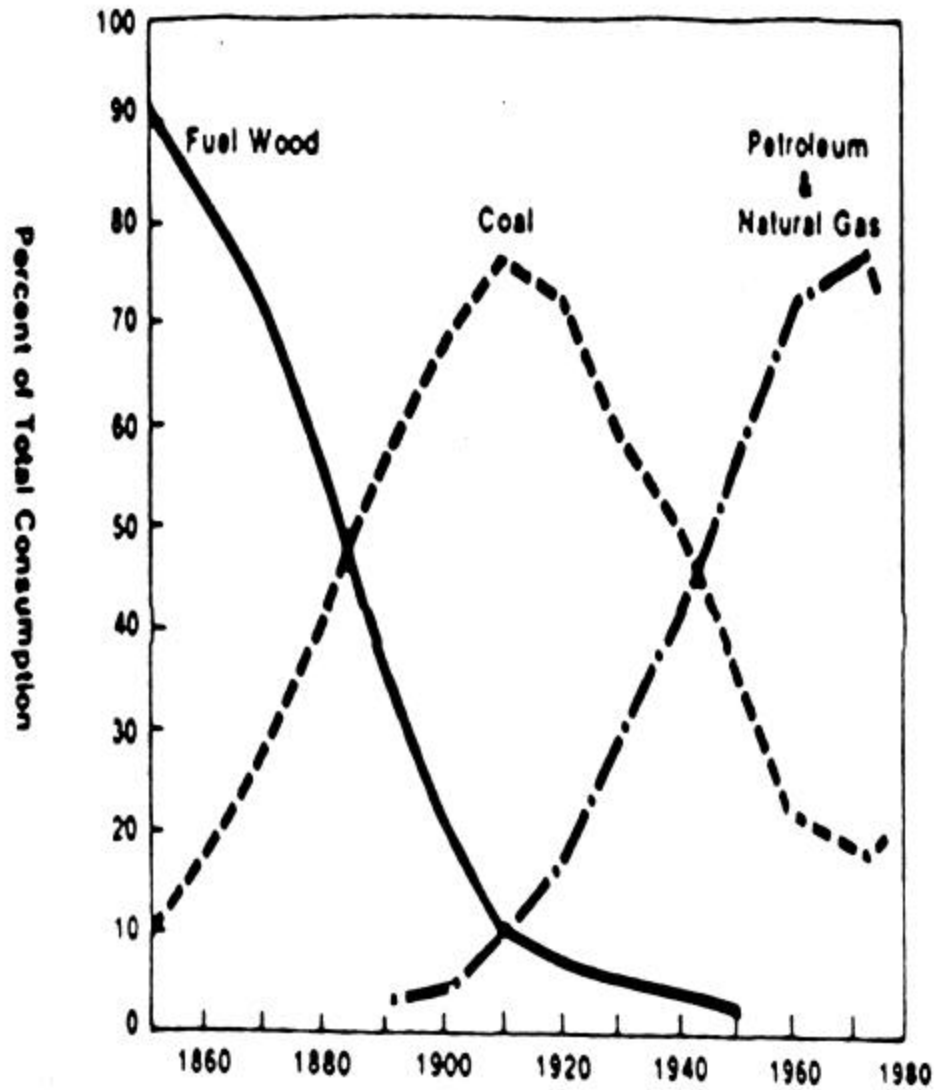
Students also need practice interpreting the overall trend in graphs. Often times they will analyze the predominant trend, but ignore portions of the graph or data they assume are insignificant. For example, students correctly interpret the overall trend in the graph of the effect of temperature on seed germination but they seem to ignore data that levels out over a shorter period of time. In the case of the graph below, students ignore data points from 35 to 45° C.

Effect of Temperature on the Number of Seeds that Germinate



Finally, some questions may require that students compare two graphs or present more than one variable on the same graph, as seen in the item below. Students need repeated practice in determining how the variables depicted on a graph relate to one another.

The graph below gives a very concise energy history of the United States.



II. Physical Science/Earth Science

Data from the questions on density suggest that students find this a difficult concept for several reasons. In order to understand density students must recognize the relationship between mass and volume for a given material. This requires that they have ample opportunities to measure a variety of materials (both solid and liquid) to better understand this relationship. Secondly, students have been learning about properties of materials in the elementary grades but have not had to distinguish between characteristic and general properties of materials. They need to measure a variety of objects and to understand that even though the objects size and shape may change their densities will not. In addition, they are going to need experiences to observe how changes in temperature affect the volume of materials and consequently their density.

Gases present a particular challenge since many students do not realize that gases have mass because they have very limited experience with this state of matter prior to middle school. Consequently, in their view, if gases do not have mass, there is no reason to assume they have density.

Understanding density in all states of matter and across contexts rests on a deeper model of the particle nature of matter. Some students will have some success with density when restricted to solids and liquids, but no student will be successful with all three states without a particle model from which to reason. Without a particle model of matter students will never understand phase change, conservation of matter, recycling of matter, and how density drives many of Earth's processes. The research has shown that middle school students who cannot conserve matter across all three states are unlikely to understand chemical reactions in high school.

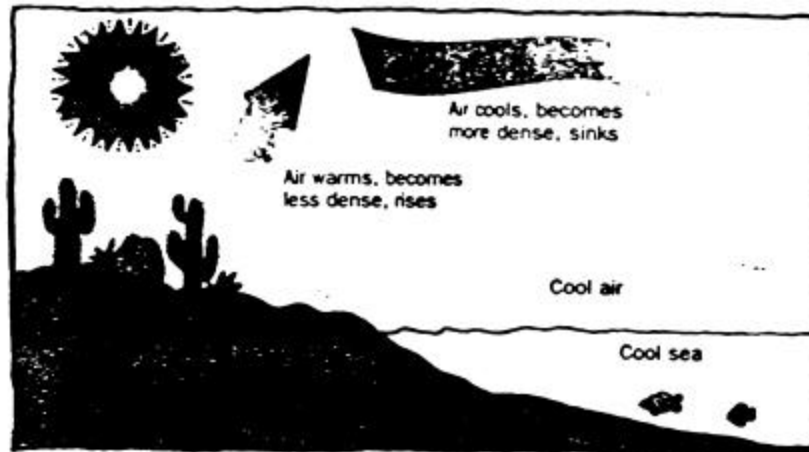
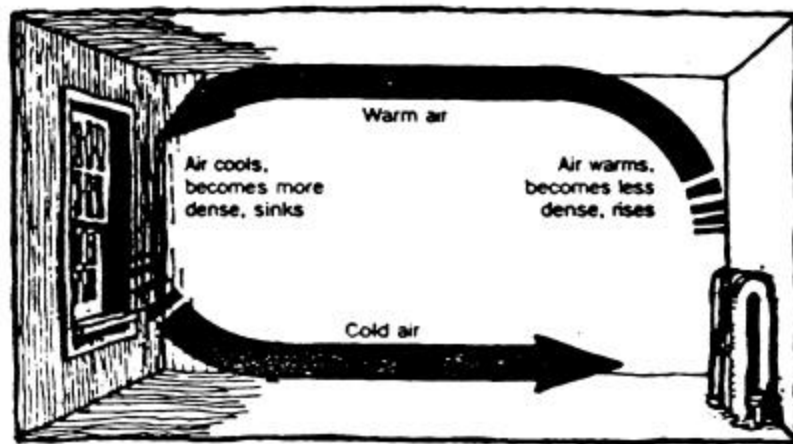
One of the questions from the DSTP asks students the following question:

Which of the following air masses would have the highest barometric pressure?

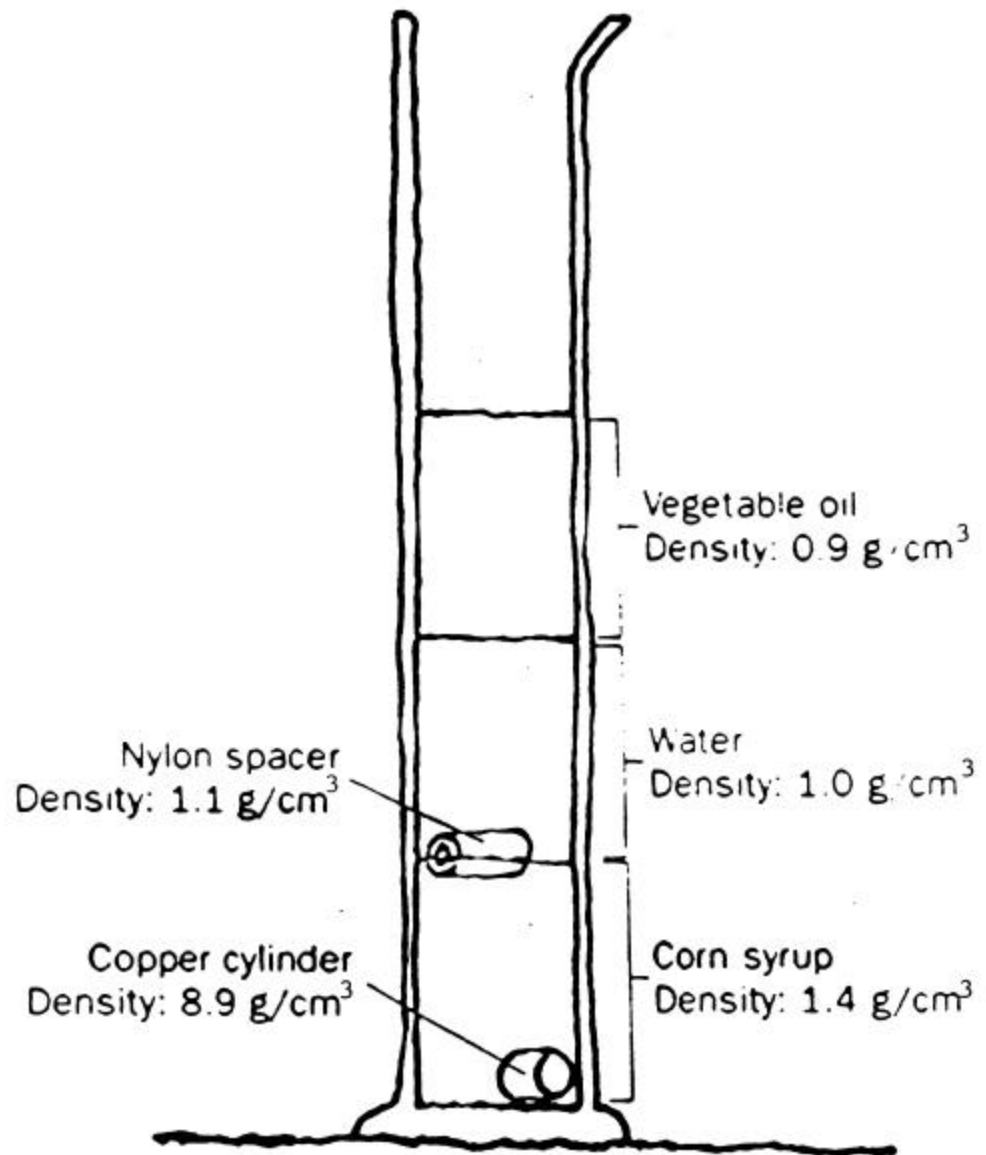
- | | | | |
|-----|-----------------|-----|-----------------|
| (F) | Cold, dry air | (H) | Warm, dry air |
| (G) | Cold, moist air | (I) | Warm, moist air |

At first blush, this question is often interpreted as a “barometer” question when actually it is a density question. It is worth thinking about why the majority of Delaware students incorrectly selected warm, moist air instead of cold, dry air. In order to replace students’ naïve notion that warm, moist air is heavy, they must again work from a particle model of matter. It is important for them to understand what happens to particles when they heat up or cool down. In order to answer this question, students would need to understand that particles of matter move closer or farther apart when the temperature changes. For instance, in a given parcel of air, as the air cools, the particles move closer together becoming more dense and consequently sink; as the air is heated, the particles move farther apart becoming less dense and rise. During cooling, the particles move closer together and the mass increases relative to the volume of the parcel of air. This particle model of matter is what is needed to understand the “barometer” question.

The following diagrams illustrate this concept of density.



Finally, when presented with a density column question, students' number sense is critical to answering the question. In the example below, students would need to understand that if a nylon spacer has a density of 1.1 g/cm^3 its density is more than water (1.0 g/cm^3), but less than corn syrup (1.4 g/cm^3), the spacer will become "suspended" between the water and corn syrup.



III. Life Science

Delaware students, based on the DSTP, have a very good grasp of the macro-adaptations of animals. For the most part, they can correctly select the appropriate beak of a meat eating bird or the foot for an aquatic animal. When it comes to plants, however, it seems as though students have had fewer opportunities to observe and infer how the structures of different plants help them survive in their habitats. Below is a typical example of a structure/function item on plants from the DSTP. The majority of students explained that photosynthesis does not occur in the desert. So students appear to associate photosynthesis with leaf size.

Desert plants have very small leaves or no leaves at all. What is the most likely explanation for this?

- A) Larger leaves dry up and drop off.
- B) Photosynthesis does not occur in the desert.
- C) Small leaves limit water loss.
- D) Small leaves limit heat loss.

Structure/function questions at the micro level pose the greatest challenge for middle school students. Students need experiences with observing different kinds of cells that extends beyond identification to understanding how differences in cellular structure determine their different functions. For example, why does a blood cell look so different from a ciliated epithelial cell? Or, given a particularly salient structure like the cell wall, students should be able to recognize it as an important structure of a plant cell and explain the function of the cell wall.

IV. Constructed Responses (short answer)

All constructed response or short answer questions are graded on a 0-1-2 point rubric. The majority of Delaware students are not earning the full two points for these questions. There are probably a host of reasons for this occurrence. After examining the statistics and sample student work from the constructed responses on the DSTP, it appears that there are a number of strategies that teachers could use to improve performance. Students need to acquire the habit of explaining observations, data, relationships, phenomena, events, etc. This means they need to learn what constitutes a full explanation. Providing a full explanation, in turn, presumes that students understand what has been posed to them in the question initially. Often students will correctly provide part of the response but for some reason, stop short of a full response. This particularly occurs when there are two parts to the item. For example, in the item below, students could correctly describe a procedure for increasing the rate of dissolving but then neglected to explain why the method they described will work. Thus, the students earn only one point when they could have earned two.

Describe a way to increase the rate at which a 10-gram cube of sugar can dissolve in 100 ml of water. Explain why this method will work.

Scoring Tool:

- | | |
|-----------|---|
| 2 points: | Student describes and explains one scientifically accurate method to speed up dissolving, e.g., breaking up (increases surface area or smaller pieces dissolve faster); heat it up (increase solubility); stirring or shaking (increases contact with the water particles). |
| 1 point: | Correct procedure but without reason that explains why method will work, or incorrect reason. |
| 0 points: | Inappropriate or incorrect response. |

Another related pitfall is the tautological explanation that students often provide where they repeat either part of the question or the procedure as the explanation. In other words, it worked because the procedure I used works that way.