# Differentiated Learning in Science


## SUMMARY

Using graphic organizers and literacy strategies, two middle-level science teachers demonstrate their methods for helping students develop literacy skills - from organizing their thoughts for written expression to improving their reading comprehension.


*The challenge for* middle-level students is to continuously improve their reading comprehension, to increase concept understanding, to increase the process of reflection, and to increase analysis, synthesis, and evaluation skills. The challenge for content teachers is to provide effective literacy modalities through which our students can be more successful in mastery of both content and process skills.

*Science for All Americans*, published by The American Association for the Advancement of Science in 1989, was the first presentation of a unified vision of science literacy. It has served as a basis for discussions of the skills and knowledge that our nation's students should have. When the National Science Standards were released by the National Academy of Science in 1996, the overview stressed that teachers need to use many different strategies in order to develop the understandings and abilities necessary for their students to achieve the degree of literacy described both in the Science Standards and in the earlier *Science for All Americans*. Recent journal articles have emphasized that well-planned activities which relate directly to the science concepts being taught increase students' understanding and mastery. The strategies described here are but some of the many possibilities available.

The purpose of this article is to suggest strategies that classroom teachers of middle-level students have found to


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enhance student learning. In the Report of the National Reading Panel in 2000, graphic organizers were among the effective strategies cited to enhance comprehension.

Graphic organizers help students to represent abstract information in more concrete form, to depict relationships among facts and concepts, to relate new information to prior knowledge, and often to organize thoughts for written expression. Graphic organizers exist in a variety of forms. This article focuses on three types of graphic organizers and five literacy strategies that have been used within the authors' classrooms.

The graphic organizers are: (1) Frayer diagrams (2) Concept maps, and (3) Venn diagrams. The literacy strategies include: (1) inference charts; (2) the strategy of who, what, where, when and why; (3) the vocabulary development/getting information from text or the Student VOCABULARY Strategy; (4) the KWL strategy; and (5) the Literacy Strategy of Semantic Feature Analysis.

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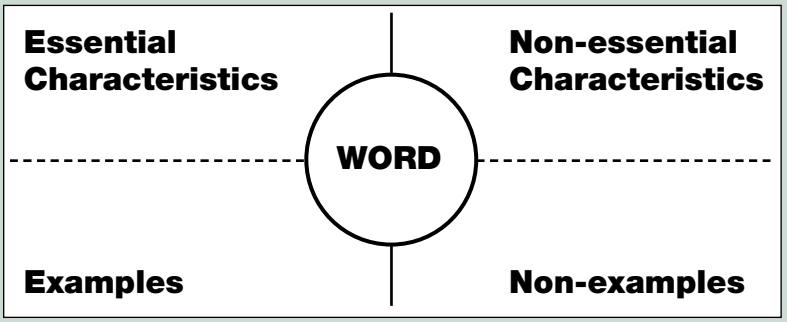
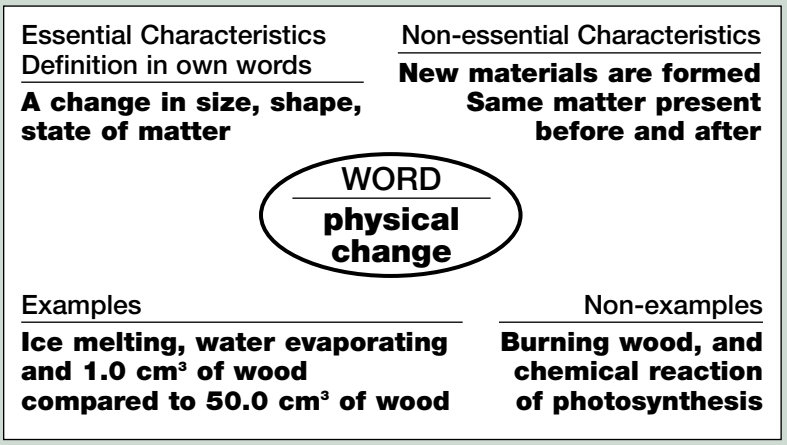
## METHODOLOGY

### Figure 1: The Frayer Model




The Frayer model is easy to modify for both teacher and students. It presents material in a rational manner, is useful in comparing relevant and non-relevant information surrounding a science topic, helps to emphasize concept details and examples, and provides a format to point out science misconceptions. Below is an example.

### Figure 2: The Frayer Model




We have found this format helpful to students in learning important concepts. It helps organize conceptual vocabulary, and it is a good anticipatory activity. It can be used as a summary to help students connect instructional activities or real-world events. Furthermore it allows students to reflect on both their thinking and learning.

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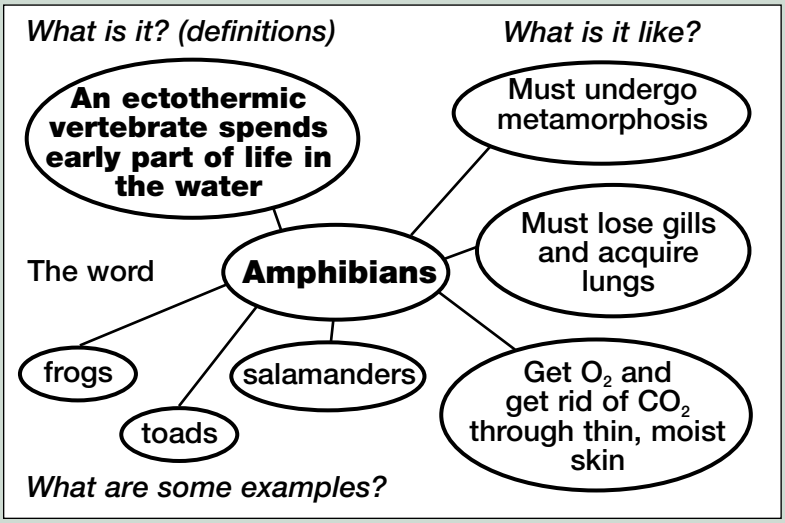
### Figure 3: A Concept Map




Above is an example used in a life science class.

### Figure 4: A Student-Made Concept Map

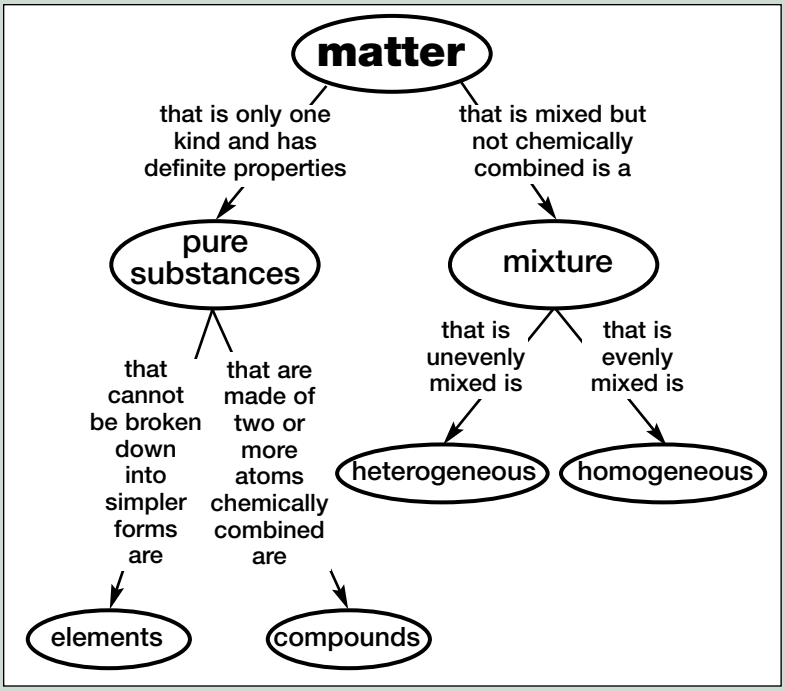



Figure 4 shows another student-made concept map. Here the connecting terms are the key to understanding student thinking.

**Graphic organizers**

1. **The Frayer model** is a word categorization activity that helps learners develop their understanding of concepts. (Frayer et al, 1969) It gives students an opportunity to briefly show their understanding and to elaborate by providing examples from their prior knowledge and own lives.

Figure 1 shows the general pattern for the Frayer model.

2. **A concept map** is a specific type of graphic organizer that helps students visualize various connections between words or phrases and a main idea. Joseph D. Novak of Cornell University developed the idea of concept maps in the 1960s. His work was based on the theories of David Ausubel (see the Novak citation at end) and the importance of prior knowledge as the key to learning new concepts.

Most forms of a concept map are composed of words or phrases surrounded by a circle or square that connect to one another and ultimately back to the main idea through graphic lines. These lines help students to "negotiate meaning" as described in the 1996 work of Hyerle titled *Visual Tools for Constructing Knowledge*. Concept maps have been shown to support struggling readers (Lovitt & Horton, 1994) by building off of students' prior knowledge and by asking them

to reflect on their understanding while reading. Figures 3 and 4 show examples of student-made concept maps. Either type can be used as whole-class activities, individual tests or homework.

3. **Venn Diagrams** are a simple but powerful way to compare and contrast. The English logician John Venn (1834-1923) created the first schema to visually represent complex logical propositions and algebraic statements. Such diagrams describe and compare attributes and characteristics of things, people, places, events, ideas, etc. Figure 5 is an example of a Venn diagram wherein the unifying characteristic is shown in the overlapping area.

### Literacy strategies

1. **Inference chart modeling** is a literacy strategy that helps middle-level students distinguish inference from an observation made in reading materials such as textbooks, newspapers, and periodicals. This can also be a fun way to look at claims made in advertising of consumer products. Most science educators would agree that inferring is a basic science process skill that connects the students' observations with their hypotheses.

Figure 6 is an example of the inference chart model.

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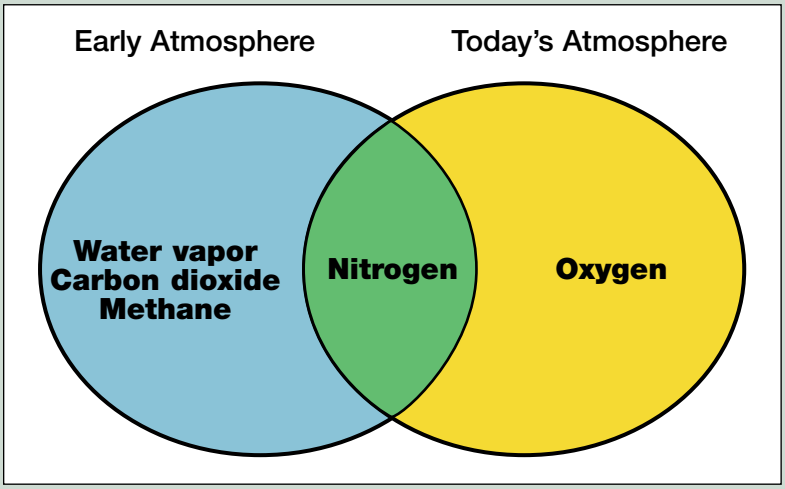
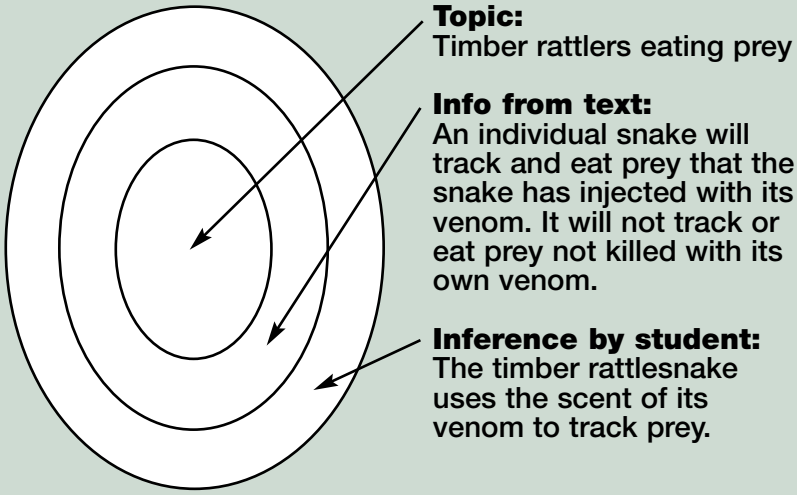
**Figure 5: Venn Diagram**
**used for comparing and contrasting**




The comparison of early and today's atmosphere shown in the diagram above simply but eloquently answers two critical questions. The first question asks what items you want to compare and what characteristics the items have in common. The intersecting portion shows the common element of nitrogen being present. The second question is how the items are the same (the intersecting) and how are they different (non-intersecting portions)? The class discussion could spring from this potent diagram, or a student might use such a diagram to answer an assessment item.

**Figure 6: Inference Chart**



2. **The Literacy strategy of who? what? where? when? why? how?** helps students to be scientifically literate. Students should be able to read and analyze any writing to make responsible critical judgments. Based on the age-old newswriting concept, it is a useful strategy when studying current events, newspaper articles, and science magazines. Students should be guided to ask the following questions in order to complete such a form *(see Figure 7)*: **Who** are the important figures associated with and affected by this event, discussion, discovery, etc.? **What** are the important developments, issues, events, discoveries, etc? **Where** did this event, discussion, discovery, etc. take place? **When** did this event, discussion, discovery, etc. happen? **Why** is this event, discussion, discovery, etc. important? **How** did/will/might the event, discussion, discovery, etc. affect later events, discussions, discoveries, etc.? As students read an article on science or other topics, they fill in the organizer with key words and elaborations, then compare and discuss their findings with classmates in small groups. If several different articles are being read by the class, each group could present a summary of their article using the format.

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**Figure 7: Who? What? Where? When? Why? How?**

| | |
|---|---|
| **Author:**<br>**Topic:**<br>**Title:**<br>**Source:** | |
| **who** → | |
| **what** → | |
| **where** → | |
| **when** → | |
| **why** → | |
| **how** → | |

3. **The Literacy Strategy of Vocabulary Development/Getting Information from Text (Student VOCABULARY Strategy)** is one through which students deal with conceptual vocabulary in the context of a reading passage. The VOCAB strategy is a comprehensive activity — more interactive than guided reading. It helps students make meaning of vocabulary in context based on their individual learning styles. It works well with small groups of students. It works with reading-based learning disabilities in resource room situations. If the VOCAB sheet text itself is too much of a challenge, the strategy can be simplified by drawing a picture and writing a brief explanation to demonstrate understanding of a term. The strategy works best when a teacher shares key vocabulary words with students in advance and asks students to use the VOCAB strategy to learn the meanings of any unfamiliar terms either before or during the reading of the passage. Figure 8 is an example of how the term "rotation" might be explained.

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### Figure 8: Student VOCAB Strategy

Vocabulary Word: **rotation**

1. Write the sentence in which it appears in the text:
   **The spin of an object in space is called its rotation.**

2. Based upon how it is used in the text, predict what the word means:
   **It means the Earth spins around in a circle as it moves.**

3. Consult an "expert" for the actual definition (e.g., a friend, teacher, text resource).
   Expert: Expert's definition: **(glossary)**
   **The spinning motion of a body on its axis.**

4. Show your understanding of the word by using it in a sentence of your own:
   **The Earth's rotation is like the spinning of a basketball on my finger.**

5. Choose one of the following ways to help you remember the word's meaning:
   - Draw a picture of what the word means to you; select and perform a miming action that reminds you of the word
   - Connect the word with something similar that you've heard — in a story, a news report, or a song. Write down an association or connection you have made:
   **Using a top, I would make it spin on a table on its axis.**

6. Explain why you chose this way to represent what the word means to you:
   **It would show the top spinning around in a circle as it moves on its axis. At the same time, it would also be moving in different directions on the table.**

4. **The Literacy Strategy of Getting information from Text**

K-W-L: What I Know; What I Want to Learn; What I Learned, commonly known as K-W-L (and the variation Before-During-After, or B-D-A) is a strategy that can be used to help students predict and connect information with prior knowledge. Individual students, small groups of students, or an entire class can brainstorm prior knowledge and vocabulary related to a topic. In this role, it serves as a way to engage students. Figure 9 shows a blank K-W-L.

A variation with these headings as shown in figure 10 might be preferable in some situations.

Following the activity or reading, completion of the "Learned" column provides an opportunity to explain and to elaborate. Comparisons between "What I Know" and "What I Learned" may also serve to help students check their own misconceptions and to help teachers assess student learning. Students begin the process by filling in the first two sections of the chart, and misconceptions generally show up in the "What I Know" column.

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**Figure 9: K-W-L**

| K<br>What I Know | W<br>What I Want to Know | L<br>What I Learned |
|---|---|---|
| | | |

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**Figure 10: B-D-A**

| B<br>What we know before reading | D<br>Questions and important information during reading | A<br>Conclusions made after reading |
|---|---|---|
| | | |

5. **The Literacy Strategy of Semantic Feature Analysis** helps students ascertain a term's meaning by comparing its features with those of other words that are in the same general category. This strategy provides students with a visual representation to rely upon to discern the similarities and differences between related terms. This strategy is most effective when considering discriminating features. The organizational approach involved helps to develop science process, classification and data recording skills. Misunderstandings and misconceptions can be dealt with as students are asked to reflect on their work and to explain the rationale behind questionable choices. While highly organized, the matrix is flexible in that it can be expanded upon by the addition of both terms and features.

Figure 11 is an example used in a physical science classroom.

Because they have been shown to help students:

represent abstract information in a more concrete form;

demonstrate relationships among facts and concepts;

relate new information to prior knowledge; and

organize thoughts for written expression,

graphic organizers can be among the most effective strategies for teachers of middle-level students to enhance student learning and comprehension.


REFERENCES:

Edwards, A.W.F., Stewart, I., (2004) Cogwheels of the Mind: The Story of Venn Diagrams, JHU Press

Frayer, D., Frederick, W. C., and Klausmeier, H. J. (1969). A Schema for Testing the Level of Cognitive Mastery, Madison, WI: Wisconsin Center for Education Research

Hyerle, D. (1996). Visual tools for constructing knowledge. Alexandria, VA: Association of Supervisors of Curriculum Development.

Just Read Now (n.d.). Frayer Model. Retrieved 2008, Feb. 25, from *www.justreadnow.com/strategies/frayer.htm*

Report of the National Reading Panel, *www.nationalreadingpanel.org*


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**Figure 11: Vocabulary Development: Semantic Feature Analysis Grid**

| **Category:** | **states of matter** | | |
|---|---|---|---|
| **terms** | **features** | **features** | **example** |
| solids | Definite shape | Definite Volume | Ice ($H_2O$) |
| liquids | No definite shape (shape of the container) | Definite Volume | Liquid water ($H_2O$) |
| gases | No definite shape | No Definite volume | Water Vapor ($H_2O$) |