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# Literacy Strategies in Middle School Science Classrooms.

Stefanie A. E. Gallina  
*St. John Fisher College*

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This study examined four different scientific literacy strategies and their effectiveness in increasing scientific literacy. These four different strategies include The Learning Cycle Approach, The Venn diagram strategy, the Definition Map, and Science in the News Framework. This study took place with two different eighth grade science classes in the two units of properties of matter and periodic table. The students completed different laboratory activities and ticket out the doors that were assessed to measure the effectiveness of increasing the scientific literacy. The study found that of the four literacy strategies three increased scientific literacy and one did not. The three that supported scientific literacy were The Learning Cycle Approach, The Venn diagram, the Definition Map. The Science in the News Framework did not increase scientific literacy.

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MS in Mathematics, Science, and Technology Education

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### Literacy Strategies in Middle School Science Classrooms

Science literacy is not just important in the science classroom setting but also extends to outside of school. According to the literature scientific literate students create global citizens that are aware of the world around them. Currently there is an increased responsibility and expectation of all teachers to teach literacy skills and help students develop these literacy skills. This paper will examine reasons why scientific literacy is important in the science education of students not just in the classroom but in their future. This paper will investigate multiple literacy strategies and select four different strategies to investigate and rate their effectiveness in increasing scientific literacy of eighth grade science students. The multiple literacy strategies have been selected as strategies used previously in science classrooms selected from the literature. Since there is no one strategy that is guaranteed to work in each skill area multiple strategies were gathered and evaluated. The skills associated with science literacy include reading, writing, analyzing, and vocabulary development. This study will examine the effectiveness of four of these strategies, one in each skill area, in regards to developing science literacy in the science classroom and applying these skills to other academic areas beyond science.

These four strategies include the learning cycle approach for writing skills, definition map strategy for vocabulary, science in the news to increase reading skills, and venn diagram to increase analyzing skills. These four strategies will be used with a Properties of Matter Unit and Periodic Table Unit in two eighth grade science classrooms. The students' scientific literacy skills will be evaluated using classroom observations, laboratory activities, and classroom activities. Through these evaluation

techniques the effectiveness of different science literacy strategies will be investigated in each skill area.

### Literature Review

The literature review will describe what science literacy is and why it is important not just in the classroom but in the real world. Science literacy is necessary to create global citizens that are aware of the world around them. The literature will show different strategies and how these strategies are used to increase science literacy since no one strategy is effective in all skill areas in all topics of science. These strategies include strategies for reading, vocabulary development, writing, and analyzing. The literature will also show the importance of the use of inquiry and integration of different academic core subjects into science to promote science literacy and increase reading, writing, and analyzing skills in science and other content areas.

#### *What is Science Literacy?*

Science literacy is a word that is used when discussing students and their abilities and expected outcomes in science. Science literacy can have many different meanings to different people. Science literacy can have an academic function and it can also have a citizenship function to create global citizens. The definition of science literacy given by McEneaney (2003) “reflects the learning outcomes that are present in the educational system in science. Students need to be able to explain natural phenomena and develop the necessary skills to explain natural phenomena” (p. 218). These standards of science literacy are found in the national science standards so all students develop science literacy in the classroom. Meichtry (1992) also agreed with the science literacy definition provided by McEneaney (2003). Meichtry (1992) described science literacy as “The dimensions of scientific literacy is considered necessary to function in an increasingly scientific and technological world have been broadly defined as the

acquisition of fundamental science concepts, process and problem solving skills, and informed attitudes about science” (p. 437). Science literacy involves learning and understanding the necessary skills and concepts. Students need these skills not just to function and succeed in the school setting but also in the real world. According to McEneaney (2003) all students are capable of achieving scientific literacy “scientific literacy involves at least some science. That is some of the knowledge and skills that such an approach seeks to impart pertain to rationalized interpretation of phenomena in the natural world. Second, there is an assumption that everyone can apprehend this science knowledge, given appropriate pedagogy” (p. 218).

The objectives of science literacy are summarized by Carrier (2005); science literacy skills are skills that all students need to effectively participate in science learning. Some of these skills include: seeking information, reporting and describing information, comparing information, classifying information, analyzing information and identifying patterns, hypothesizing outcomes, causes, effects, etc and describing solutions to problems. These thoughts and skills are a change in the pedagogy of teaching science in the past because students are now being asked to actively participate in their own learning as well as develop their own knowledge. “Historically, education has focused heavily on memorization and recitation which, in the science class, has led to a heavier emphasis on memorizing science terms than on learning science concepts and direct experience” (Groves, 1995, p. 233). In the past students were not active in their learning but passive because they were asked to memorize concepts and terms given to them instead of observing these concepts in action. This created an incomplete view of different science concepts. The changes in science pedagogy since the 1960’s have also changed in terms

of what is important and what is taught. The focus in the 1960's was the historical context of science and how this relates to sciences role in society. The focus in the 1970's was how science is done by scientists including the processes, skills, and concepts. The focus in the 1980's was inquiry skills and how this develops the necessary science skills and concepts along with the interaction of science and its role in society. The history of science teaching can be found in the Figure I below. The figure described characteristics of science teaching techniques in the 1960's, 1970's, and 1980's.

Figure I: Some characteristics of scientific literacy. (Bybee, 1995 p. 30)

<b>The 1960's</b> "Goals Related to the Social Aspects of Science"	<b>The 1970's</b> What Is Unified Science Education?	<b>The 1980's</b> Science-Technology- Society: Science Education for the 1980's
Paul Hurd and James Gallagher (1966)	Victor Showalter (1974)	National Science Teachers Association (1982)
(1) Appreciate the socio/historical development of science.	(1) Nature of Science	(1) Scientific and technological process and inquiry skills.
(2) Aware of the ethos of modern science	(2) Concepts in science	(2) Scientific and technological knowledge
(3) Understand and appreciate the social and cultural relationship of science	(3) Processes of science	(3) Skills and knowledge of science and technology in personal and social decisions.
(4) Recognize the social responsibility of science	(4) Values of science	(4) Attitudes, values, and appreciation of science and technology.
	(5) Science and society	(5) Interactions among science-technology-society via context of science- related societal issues
	(6) Interest in science	
	(7) Skills associated with science	



Since there are various ways of teaching students science there is one basic goal of teaching science, so that new scientific concepts can be applied to a new situation. According to Pasley, Weiss, Shimkus, and Smith (2004) "There is not always agreement about the best instructional strategies, there does appear to be consensus that the goal of science instruction is teaching for understanding, not only understanding of science disciplinary content, but also the centrality of inquiry in science (p. 2)." Although there has been a change in pedagogy since the 1960's the goal has remained the same to increase scientific literacy of concepts and natural phenomena.

#### *The Importance of Science Literacy*

There are two main reasons why science literacy is important for students to understand. One reason is these students will grow up and become productive members of society. Another reason is academically students need to be able to contribute to and participate in a science classroom in description of natural phenomena and science concepts. In order for students to become science literate, productive members of society the quest begins in the science classroom.

Murcia (2005) described a science literate person as one who has a general, broad and practical understanding of science that contributes to their competence, interest and disposition to use science to meet the personal and social demands of their life at home, at work and in the community. An example that Murcia gives is a newspaper article that describes a new piece of science news. A science literate person would be able to review the article, understand the terms used, make links from the article to other aspects of science, and understand the research process necessary to make this possible. However a

scientific illiterate person would possibly misinterpret the article and potentially harm themselves as a result.

The call for science literate students has not just occurred in the United States but in other countries around the world. Leaders have encouraged scientific literacy as a key educational goal as a result more authors have directed research towards scientific literacy. As pointed out by McEneaney (2003) there has been an increase in the amount of articles published in regards to science literacy from two percent of the total articles in 1988 to ten percent of the total articles in 1999. Of these articles published in 1999 twelve different countries were referenced including Brazil, Finland, and Uganda. McEneaney (2003) also pointed out that a global economy was the main drive behind science literacy. With an increase in the workforce of people that are scientific literate would require less training of workers because they already possessed the necessary technical skills to complete necessary tasks.

One reason science literacy was being stressed around the world was to improve the workforce for that given country. “A scientifically literate workforce is understood to be a more productive and efficient workforce, one that can absorb technological innovation appropriately” (McEneaney, 2003, p. 220). If students are kept up to date with different innovations and are able to understand the different terms and concepts so they will be better able to use the new technology available. A workforce that is well-trained in science and technology can also increase the capital development for a country. The goal of teachers in the science classroom was to help students achieve science literacy. According to Byhee (1995) “The idea of scientific literacy has been around for some time, and most science educators agree that the purpose of school science is to help

students achieve higher levels of scientific literacy” (p. 28). Through the achievement of the science literacy goals students will leave the classroom as science literate citizens that are capable of becoming highly trained workers in the global economy.

*Science Literacy: Integration of other academic areas*

According to Montgomery (2005) “A climate where educators view themselves as literacy teachers within their discipline is essential to the success of any school wide literacy movement” (p. 29). In order to improve literacy in science classroom with an increase in the understanding of science concepts and vocabulary students need to be familiar and proficient with basic literacy skills. These skills include writing, reading, and oral discussions. These skills can be practiced in other content areas and tailored to each content area however the teachers in these content areas need to incorporate the same literacy skills so that the students are practicing and becoming familiar with these necessary skills.

When science and literacy are connected in the classroom many positives are seen as a result of this not just academically in science but also in literacy skills. According to Lundstrom (2005) Test scores go up when science and literacy are matched. A controlled study of 25 Maryland classes, for example found that in just four months, third-grade children who were taught a science-literacy connected curriculum advanced one and a half grades in reading comprehension. The science and literacy connection allows students to practice different literacy strategies in science class. These strategies include writing observations, reading directions, and speaking to their peers in terms of science vocabulary. Douville, Pugalee, and Wallace (2003) claimed that

...science is connected to content literacy through students’ needs to read,

interpret, and create charts, graphs, diagrams, and tables. Science is also related to information literacy through the construct strategies for locating information, accessing information, organizing and applying information and evaluating information gathering process... (p. 389)

The connection between science and literacy allowed students to practice skills such as reading, writing, and analyzing.

The connection between science and literacy was also supported by Carrier (2005) with a case study of English Language Learners these students struggled in the science classroom despite being able to carry on everyday conversations with their peers. "The reason for this puzzling decline in classroom literacy abilities is that the kind of language used in science and other content areas is different from conversational language" (Carrier, 2005, p. 6). As a result of this literacy gap different techniques were used to help increase the science literacy of these specific students. Students were given the opportunity to preview, practice, read, write, and talk about science using strategies from class including sentence frames with key vocabulary. This allowed students to become more comfortable with different science concepts and vocabulary and increased their science literacy as a result. This practice with reading, writing, and talking is necessary to develop science literacy. According to Douville, et. al.(2003) "The integration of literacy into the science curriculum provides teachers with a meaningful, and invaluable, opportunity to teach students how to use the type of specific text strategies that scaffold students in an active construction of meaning with expository science text" (p. 394). The integration of science and other content areas specifically language arts demonstrated that different academic areas are not just isolated but are

integrated and related, similar to how students could use the different knowledge areas of knowledge in the real world acquired in different academic areas. For example students may use this when the need to formulate an oral presentation for their job that includes a proposal of a company budget but before these presentation research and analysis must be completed.

### *Science Literacy through Inquiry*

Another way to connect science and literacy is through the use of inquiry. According to Schmidt, Gillen, Zollo, and Stone (2002) “at the heart of inquiry learning is questioning, but student ability to ask questions about content is often based on prior knowledge. The teacher must set up as the facilitator who sets broad objectives, plans experiences, to help students establish basic knowledge, gathers materials and resources, models questioning behaviors, and guides discovery process” (p. 535). Through these different experiences students were not only exposed to science concepts and themes but they are able to develop their understanding and have the ability to practice and refine different literacy strategies. This was reiterated by Worth, Moriarty, and Winokur (2004) “at the root of deep understanding of science concepts and scientific processes is the ability to use language to form ideas, theorize, research, share and debate with others, and ultimately, communicate clearly to different audience” (p. 36). Students used different literacy strategies and applied this to science concepts in the science classroom.

A study completed by Schmidt et al. (2002) also supports the thought that integrating science inquiry with literacy skills because students not only learned the scientific concepts that were the objectives of this unit but the students also had many opportunities to practice the language arts skills for literacy development. The literacy

skills practiced in this unit included exploration of literature, recorded observations, shared in pairs, small groups, and whole-class discussions, listened to guests, watched videos, and reported orally and in writing as a result of inquiry. Through inquiry students had to identify the information they possessed and devise a plan in order to identify the information and understanding they still needed to meet the objectives of this unit. All of the necessary literacy skills were practiced through the inquiry unit in science along with the understanding of the necessary science concepts.

Worth et al. (2004) also support this idea that the connection between science and inquiry not only improves science learning but also literacy skills.

In addition to engaging in direct investigation of scientific phenomena, students make meaning by writing science, talking science, and reading science. At the root of deep understanding of science concepts and scientific processes is the ability to use language to form ideas, theorize, research, share and debate with others, and ultimately, communicate clearly to different audiences (p. 36).

As students are able to develop their own understanding of the science concepts that are the objectives of the unit, these students are also able to practice the necessary literacy skills to develop the necessary science understanding. Students are actively reading for understanding by researching, making observations, and communicating these understandings of the new science concepts to their classmates and ultimately to their teacher for an assessment.

#### *Strategies to Incorporate Science Literacy*

There are many different strategies that help increase the science literacy into a science classroom. According to Metz (2006) "For scientists and also for our science

students, the ability to communicate through writing and reading is a crucial skill at the heart of developing scientific literacy” (p. 8). The strategies that are examined in this section are vocabulary strategies, reading strategies, writing strategies, and analyzing strategies with the desired outcome of students achieving scientific literacy. These strategies include Science in the News activity, RAFTs, laboratory reports and abstracts, The Learning Cycle Approach, Venn Diagrams, and Primary literature.

### *Vocabulary Strategies*

According to Bybee (1995) “One dimension of scientific literacy includes vocabulary – the technical words of science and technology...functional scientific literacy. Learners demonstrating functional scientific literacy use scientific words appropriately and adequately” (p. 29). In order to understand and describe different scientific phenomena students need to have a comprehension of the necessary vocabulary terms that relate to these phenomena. This is reiterated by Young (2005) “Students level of understanding concerning their science vocabulary is an excellent predictor of their ability to understand science text” (p. 12). Science is a vocabulary heavy subject in regards to amount of vocabulary found in the textbook in order for students to understand the scientific concept they are reading about students need to understand the vocabulary and not be inundated with a large amount of vocabulary. Groves (1995) completed a study that examined the amount of vocabulary in different science text books that are widely used in the United States. The results of this study completed by Groves (1995, p. 232) can be found in Figure II below.

Figure II: Amount of new vocabulary found in four different high school science textbooks.

Text	Projected Total Terms
PSSC Physics	1, 538
BSCS "Green"	1,899
Modern Chemistry	2,950
Earth Science	992



The amount of vocabulary found in these science textbooks reflects the number of new terms found in a textbook. The vocabulary words were counted the first time they appeared and not recounted each additional time they appeared. In order for students to be successful in understanding science concepts and reading science textbooks students need to have a working understanding of these new words. However if students are more focused on memorizing the new vocabulary words their understanding of science will be a simplistic one or incorrect (Groves, 1995).

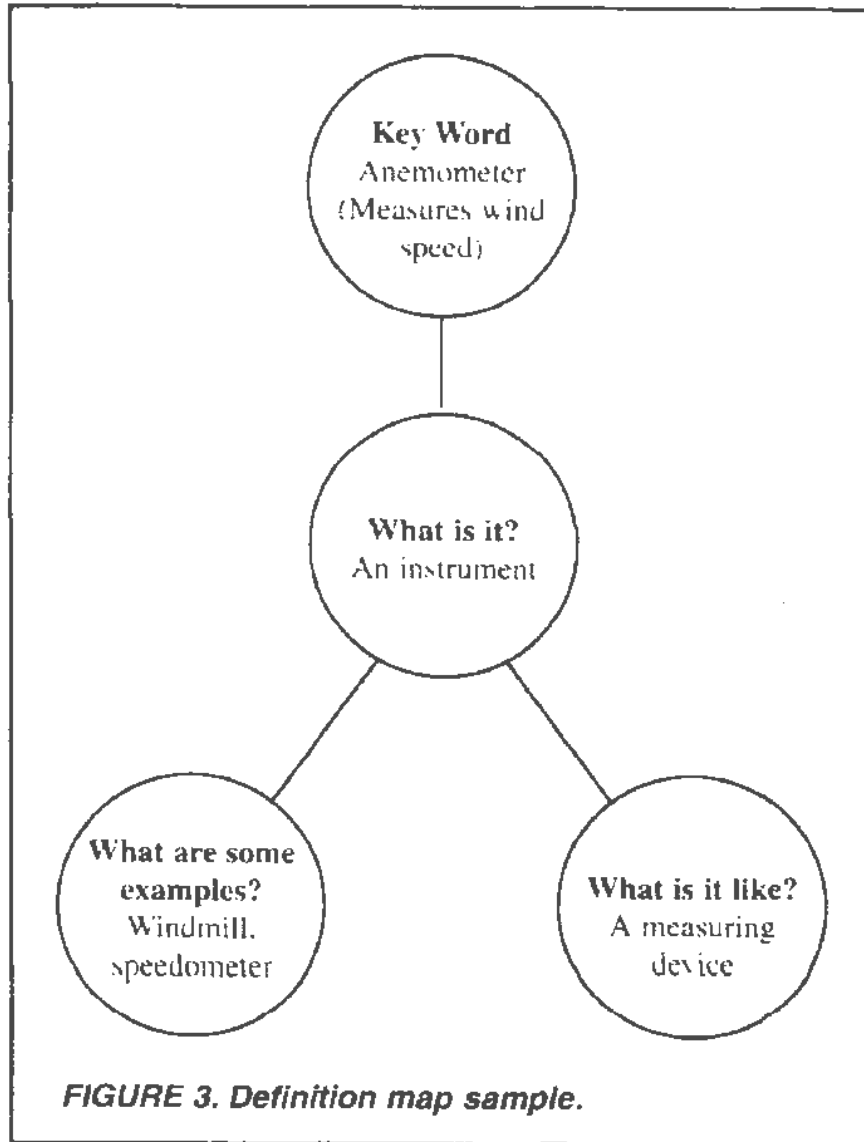
Science vocabulary is compared to foreign language vocabulary in a study completed by Valette and Valette (1985) according to this study it was found that a high school French textbook contained 1,475 new terms. Groves suggest that: (1995) “Foreign language courses also focus on vocabulary development, so they can provide a model for comparison with science vocabulary development. The vocabulary found in the Earth Science textbook is the only science textbook in Groves’s study that has less new terms than the foreign language textbook. However the PSSC Physics textbook, BSCS “Green” (High School Biology textbook), and Modern Chemistry textbook all contain more new terms than the foreign language textbook. The increase in amount of vocabulary presents science teachers with some challenges of incorporating vocabulary development along with understanding the necessary science concepts for each area of science. Some strategies of promoting vocabulary understanding are discussed next.

One strategy suggested to increase students understanding of vocabulary is through the use of word walls. “A word wall is a display of vocabulary words on large cards attached to a dedicated surface of the classroom” (Vallejo, 2006, p. 58). Students are involved in the creation of a word wall in a class period. Students are placed into

groups and given a vocabulary word. Once students have the vocabulary word they will then write it large enough on piece of cardstock along with an illustration and a definition on the back of the card.

A word wall can be used in a variety of ways to increase student use and understanding of vocabulary once it is created. One way Vallejo (2006) suggested using a word wall is asking students to construct sentences using the vocabulary terms that suggest the students understand their relationships and understanding of each word. Another use suggested by Vallejo (2006) is called a definition map students created a card that contains the main idea in the center of the board or on the students' paper. Students then create branches around the main word by relating it to other vocabulary words on the word wall. Young (2005) was in agreement with this idea by allowing students to relate key vocabulary words together and make connections to prior knowledge however her method is slightly different. Students create a chart for each vocabulary term, the chart called a definition map, found in Figure III. Around the vocabulary term, three questions are asked and answered in a circle with lines connecting to the main word. These questions are: 1. What is it? 2. What is it like? 3. What are some examples?

Figure III: Definition map sample (Young, 2005, p. 15)



The use of these vocabulary organizers allow students to make connections and create an organized way of looking at the different relationships that make sense to the students. According to Jensen (2005)


Presenting knowledge in a well-organized form is useful, but its also inadequate. It's far more important – and a requirement for good teaching – to ensure that the knowledge in the students' brain is well organized. Students are pretty good at understanding a simple example, but without support, they may not form an effective mental model. (p. 48)

In order for students to be successful in understanding and creating links with key vocabulary words and concepts students need to have the opportunity to work with the words and organize these words in a way that makes sense to them so that other connections may be made to prior knowledge and real world examples.

Young (2005) suggested using words within their real world meaning, establishing relationships between words, and provides students with multiple exposures to these words. One strategy presented by Young (2005) is vocabulary TV visualization found in Figure IV. Vocabulary TV visualization helps students internalize vocabulary words by creating a mental image of the vocabulary word through an illustration along with a definition of the word, three synonyms, three antonyms, and a sentence describing what you like about your word. Another strategy suggested by Young (2005) is called Rate your words found in Figure V. This is a pre-reading activity that helps students assess their level of understanding of featured vocabulary words. Students are given five to six different vocabulary words and then are asked to rewrite each word in the chart under one of four category headings (1: Words I know and can use correctly, 2: Words

you almost know, 3: Words you think you have seen or heard of before, 4: Words you do not know at all). Students are able to communicate their understanding of the related vocabulary words.

Figure IV: Vocabulary TV visualization (Young, 2005 p. 13)



1. Draw a visual image of a television screen. Next, draw the visual image in the TV screen that comes to your mind related to the key vocabulary word. For example, what visual image do you have for the word "bouyancy"?
2. Use simpler words to describe the vocabulary word or phrase.
3. Write three synonyms for your word.
4. Write three antonyms for your word.
5. Write one sentence discussing what you like about your word.

Figure V: Rate your words (Young, 2005 p. 16)

Words	1	2	3	4
Psychrometer				Psychrometer
Atmosphere	Atmosphere			
Troposphere				Troposphere
Acid Rain		Acid Rain		
Water Cycle			Water Cycle	
Precipitation		Precipitation		

Note. Rating scale: 1. Words you know and can use correctly. 2. Words you almost know, but the meanings are foggy (partial knowledge; meaning may contain misconceptions or a guess). 3. Words you think you have seen or heard before ("pick up" words that are slightly familiar and were experienced in a variety of places, such as television, radio, conversations, magazines, and other subject areas). 4. Words you do not know at all (no prior knowledge).

*Reading Strategies*

Not only is vocabulary important for students to understand different science concepts but if students are learning just the vocabulary and not the concepts related to and surrounding the key overarching concepts of science because of this it is necessary to help students develop strategies to help them read for understanding and write to communicate to others. Bybee (1995) suggested “Learners should relate information and experiences to conceptual ideas that unify the disciplines and fields of science” (p. 29). This thought is reiterated by Tovani. According to Tovani (2000) “The ‘E’ generation needs to comprehend more than ever before. Readers of tomorrow must do more than memorize words. They must be prepared to analyze, validate, and ask the next logical question. They have to know how to think” (p. 110). Students need to be able to read for understanding, analyze what they are reading and be able to apply this to all the different academic areas not just science or english language arts.

Science literacy through reading can be developed using a variety of different methods that relate science concepts to the real world for application. One such way is suggested by Murcia (2005) used newspaper articles and an activity called Science in the News the framework for Science in the News can be found in Figure VI. The framework is meant to enable students to organize and assess the information being presented in a science-based newspaper article. This framework identifies science ideas and words, science procedures, attitudes and values, and effect on our lives and how we live. According to Murcia (2005) “It prompted thinking about science ideas and concepts and generated discussion about the values, assumptions and methods underlying science” (p. 41). When articles are found that are aligned with the current science concept in the



classroom students are able to make connections between the science concepts and vocabulary they are learning about in the classroom and the application of these concepts and vocabulary words in the real world.

Figure VI: Science in the News Framework (Murcia, 2005, p. 41)

News report's heading: Dolly scientist to clone humans

What is the researcher's conclusion? They cloned the cells of people who had a medical problem so they could use the cloned cells to experiment and cure the disease

<i>Science in the News</i>	List information from the article	What questions need to be asked	Finding answers
Science Ideas and Words	<u>embryo</u> <u>cure</u> <u>cells</u> <u>clone</u> <u>motor neurone disease</u>	<u>How does motor neurone disease start?</u> <u>are there other ways of curing the disease?</u> <u>How does cloning work?</u> <u>What is an embryo?</u>	<u>Search the internet, find a book on neurone disease, contact scientists who know a lot about it.</u>
Science procedures	<u>experimenting using the stem cells from embryos for cloning</u>	<u>Do other cells have the disease in it or Just Stem cells?</u>	<u>What experiments did they do?</u>
Attitudes and Values	<u>human cloning remains dangerous, undesirable and unnecessary</u>	<u>I think it's necessary so why does this person say its undesirable?</u>	<u>contact the ethics people and ask them why they say its undesirable.</u>
Effect on our lives and how we live	<u>usefull treatment for diseases like motor neurone disease</u>	<u>How would they tell people? would they put an ad in the news paper or would they go out and find everyone with the disease?</u>	<u>Its up to the scientist so there is no way of knowing.</u>

Creech and Hale (2006) concurred with using Science in the News framework. However there is a slight difference with their activity. This activity is broken into four different parts for each quarter of the school year. In the first quarter students complete a Science in the News activity by completing the framework in Figure VII. This framework allowed students to identify the science concepts in the article, identify the procedures in the article, and student reflection of the article through creating a question they would like to ask the scientists or author. In the second quarter students are required to read a non-fiction science based book and then create a children's book on the same science concept. Once students complete the children's book students are able to understand the specific science concept that they understood and demonstrated they understand the concept through the use of key vocabulary. In the third quarter students read a biography of a famous scientist with the goal of knowledge of scientists and the work they completed. Once all students finish the biography they create a vignette of their scientists and dress as the scientist and presented this to the class. In addition to reading for understanding of the science concepts students are able to practice their communication skills. The last quarter students participate in a book club of four to five students. Students in the book clubs created a reading schedule, and discussed their books. The individual students created a reading journal where connections are made between the science presented in the story and science in the classroom and their lives.

Figure VII: Science in News Report Student Handout (Creech and Hale, 2006, p. 25)

**FIGURE 3****Science in the News report student handout.**

Name: \_\_\_\_\_  
 Period: \_\_\_\_\_  
 Month: \_\_\_\_\_  
 Topic: \_\_\_\_\_  
 Due date: \_\_\_\_\_  
 Internet use (circle one):  
                                   No           Yes (any reputable source)           Yes (Newsbank only)

**Directions:**

1. Find an article about scientific research/observations that was published in a newspaper, magazine or journal during the month listed above. The article must be at least 200 words long.
2. Read the article and write down what the scientists were trying to find out (what question were they trying to answer)?
3. Underline, in two different colors, the following information (color in the boxes to make a key)
  - The methods the scientists were using (procedure) and the type of data collected.
  - What the scientists found out (results and conclusion).
4. Answer the questions below.
5. Staple the article, or a copy of it, to the back of this page.
6. Turn in this assignment on or before the due date listed above.

**Questions:**

1. a) Title of the article \_\_\_\_\_  
    b) Topic of the article \_\_\_\_\_  
    c) Author(s) \_\_\_\_\_  
    d) Source of article (name of newspaper, magazine, address/URL and name of internet site) \_\_\_\_\_
2. a) Write the full name and title (if given) of a person quoted in the article. (If no one is quoted, choose a different article.)  
    b) Why was this person quoted? What is his/her expertise?
3. How did scientists obtain the evidence on which this article is based? What steps did they follow, what types of tools did they use, and what type of data did they collect?
4. Draw a diagram of the important information explained in this article. Label your drawing with words/descriptions.
5. Write a summary of this article. Your summary must be at least four complete sentences in your own words. Do not use direct quotes from the article.
6. Do some more thinking about this article. Write at least one "on my own" question that you would like to ask the author or the scientists involved.

The use of primary literature is a common way for students to develop an enthusiasm for science. This is seen in the first two strategies of Science in the News. Metz (2006) described using primary literature such as the *Nature* paper by James Watson and Francis Crick (1953). “The short length – after all, the authors were in a rush to be the first published – gives students an easy entry into the scientific primary literature, while allowing them to appreciate the human side of one of the greatest discoveries of all time” (p. 8). Primary literature allows students to look at important scientific concepts and become enthused about reading science.

In addition to the incorporation of primary literature into the classroom the use of other resources can spark enthusiasm for reading science and exploring different science concepts. Schlichting (2002) suggested getting parents involved to get them involved in learning, thinking, and processing of information through: using high-quality trade books, sketch to stretch, and think aloud. According to Schlichting “These three important strategies support and encourage children’s learning, and provide parents with the opportunity to be engaged in the learning process along with their children through social and interactive learning situations” (p. 46). The first example was a trade book which contains more exact information and specialized information that gives the reader more understanding. Most of these books are up to date with colorful diagrams, photographs, and gripping stories that will draw students in. The second example was sketch to stretch which students draw a visual representation of what a story means to them. “Throughout this process students are integrating what they remember from the story, how they felt, interesting details, or events, new content information they heard or read, or how the story may connect with their own lives” (Schlichting, 2002, p. 47). Students practiced

critical thinking skills and relate the story to prior knowledge they possessed. With the story students are able to build upon the prior knowledge and add to this with the new science concepts in a way that they are better able to understand for themselves. The last example was think aloud, “this occurs when two or more individuals engage in a focused and intentional conversation about a specific topic, issue or theme with the desired outcome being enhanced knowledge, understanding, and comprehension of the information presented, and a greater connection to, and interest in, the topic” (Schlichting, 2002, p. 50). This strategy can be used by parents to model active thinking while reading. This strategy can help students create a deeper understanding of the topic for themselves through conversations with another person. Students also are given a chance to practice literacy strategies specifically reading for understanding and communicating with peers in regards to the selected science topic.

Tovani suggested three different access tools in *I Read It, But I Don't Get It*. These three access tools are double entry diaries, comprehension constructors, and coding sheets. Double entry diaries (example in Figure VIII) are used to promote student thinking about what they are reading. Students are required to write down a quote with page number and link the quote to prior knowledge they already possess. Double entry diaries can be adjusted to the desired outcomes and such as instead of linking to prior knowledge students can draw a picture to visualize, summarize what they are learning, and decoding what the author is trying to say. The second method was comprehension constructors found in Figure IX. Comprehension constructors enable students to make connections from the reading to prior knowledge. Students are also prompted to make inferences regarding the reading. When students create inferences they are drawing from

prior knowledge and make connections to new knowledge they are developing. The last method was coding sheets with examples found in Figure X. Coding sheets prompted students to identify prior knowledge, summarize what they have read, and record questions they have as they read the text. Students are able to stop and think about the information they are reading and in effect process this new knowledge and relate it to their prior knowledge.

Figure VIII: Double Entry Diaries (Tovani, 2000, p. 115).

Direct quote and page number	This reminds me of...
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.



Figure IX: Comprehension Constructors (Tovani, 2000, p. 121).

<b>What's Your Thinking?</b>
What are you wondering?
_____
_____
_____
What do you think might be a possible answer to your question?
_____
_____
_____
What connections can you make?
_____
_____
_____

Figure X: Coding Sheets (Tovani, 2000, p. 135).

**“Who is Dean in the White House?”**

- Before you begin to read, write down everything you know about Abraham Lincoln on the page next to the beginning of the piece.
- Highlight confusing parts. Next to each highlighted section, list at least one fix-up strategy you used to construct meaning.
- List Five important facts
  - 1.
  - 2.
  - 3.
  - 4.
  - 5.
- Write three important questions.
  - 1.
  - 2.
  - 3.
- Write a complete and thoughtful response.  
(Write your response on the last page of the piece.)

*Writing Strategies*

El-Hindi suggested students write about science in order to improve their literacy skills through dialogue journals and writing eco-mysteries. El-Hindi (2003) recommends these two activities that "...encourage students' talking, reading, and writing about science in a way that supports both inquiry-based science instruction and a student-centered approach to literacy" (p. 536). Dialogue journals allow students to write about the science activity that they just completed. In the dialogue journals students are asked to write their observations, and then reflect upon these observations. By students encouraged to write reflections on their observations students are able to create a meaningful understanding of science activity. This supports literacy because students are able to show their thinking and development of understanding through the use of vocabulary and science concepts they observed.

Another suggestion from El-Hindi was eco-mysteries. Eco-mysteries was a student written story about a ecological problem. A student is given the topic and then asked to complete research regarding this problem. Once the research is complete students are to create a story about the scientific phenomenon. This activity can be extended to reading and acting out these eco-mysteries. Through this activity students investigate real world problems and identify the scientific phenomenon behind the mystery. By integrating the scientific literacy through the writing of stories based upon research regarding a real world concept, students are able to develop and practice the literacy concepts of reading, writing, and communicating with the use of necessary science vocabulary and concepts.

Loranger (1999) supported El-Hindi's ideas of using writing about science to increase student understanding and higher level thinking skills. While writing a RAFT students assume the role of a living or nonliving thing and write a story from the perspective of this thing. RAFT stands for Role, Audience, Format, and Topic, these help the students organize their ideas and create a story. Role is what role will the students have such as a tree, piece of quartz, Audience is to whom is this written such as a mouse, a drop of water, Format is the format such as a letter, comic strip, or diary entry, Topic is the topic of discussion such as a letter to a predator asking why it needs to prey on you or a journal entry describing a day in the life of an element. The topic can be tailored to what the specific outcomes of scientific concepts and vocabulary. Loranger (1999) suggested students experience higher level thinking when they take on the role of another object and write from its perspective (p. 241).

Another formal aspect of writing in science is the creation of lab reports as the result of a laboratory activity in science. One way to help guide students in regards to this is discussed by Worth et al. (2004) "...the facilitators made explicit the literacy strategies that support formal report writing, such as identifying audience and purpose, establishing voice, using appropriate content-specific language, writing concisely, and creating an appropriate organization and structure" (p. 38). This allows students to discuss in their own thoughts and explanations of the science phenomena they witnessed. This allows students to demonstrate their understanding and thought process of science concepts. Writing a formal lab report is similar to creating a RAFT because the role, audience, format and topic all need to be identified by the student or done by the teacher in order for students to complete the assignment.

Another twist on writing formal lab reports was suggested by Montgomery. According to Montgomery “The format of an abstract demands that students concisely describe each aspect of a laboratory investigation. Research has shown that summarizing is an effective strategy for increasing student achievement” (p. 29). Through writing abstracts students are able to create a piece that shows how the scientific principle relates to real world applications. Students are able to summarize the actual topic and key concepts that were observed and demonstrated in the laboratory activity. The use of vocabulary related to the concept shows student understanding of the concept.

Meichtry described The Learning Cycle Approach for laboratory instruction. “The Learning Cycle is an approach to laboratory instruction that sequences learning from concrete to abstract and provides opportunities for students to be actively involved in inquiry-based activities which emphasize the use of thinking skills, small group learning, and communication skills” (Meichtry, 1992, p. 437). During laboratory activities students are presented with concrete activities that allow students to visualize and carryout scientific experiments this in part leads to the formation of an understanding of that topic. The Learning Cycle Approach has three phases. Phase one is called concept exploration where students are involved in activities where they learn from these activities. Phase two is called concept introduction where students discuss the activities they completed and the teacher guides the students towards the concept or pattern that was observed. Phase three is called concept application where students apply this new concept to a new situation to extend their understanding of this concept. The five types of labs which are skill labs, confirmatory lab, solution lab, procedure lab, and problem lab are used during The Learning Cycle Approach. The outcome of each of these labs is

different such as critical thinking and problem-solving abilities. According to Meichtry (1992) “Science processes such as observing, hypothesizing, measuring, collecting and analyzing data, and drawing conclusions which are practiced throughout each of the three approaches...promote problem-solving and critical thinking skills to be applied within the science classroom and within other learning, personal, and everyday life situations as well” (p. 441). Students are able to practice such skills as critical thinking with a science concept so that this skill can be applied to another academic area.

### *Analyzing Strategies*

The purpose of analyzing strategies is to promote higher level thinking skills. These skills are necessary to promote student ability to use science vocabulary and make connections to science concepts. Some strategies used to increase students ability to analyze and promote science literacy are described below.

Compare and contrasting is a way to promote higher level thinking skills. According to Loranger (1999) “...using a Venn diagram, students compared and contrasted two classroom pets...familiar objects and then moved to more difficult concepts, such as chemical and physical changes that occur” (p. 241). Students are able to compare and contrast specific science concepts in order to create a deeper understanding of the concepts with higher level thinking skills related to science vocabulary and concepts.

Cause and effect is a way to describe how one event might affect another event. Lorranger (1999) suggests “To encourage the students to think critically, they could be presented with written ‘effects’ and asked students to come up with the causes...”(p. 241). Students are able to analyze different situations and allow them to use higher level

thinking skills to predict the next event in a given situation. The example given by Lorranger was predicting what will occur to a food web in different situations. Cause and effect is also visible when students create a hypothesis prior to completing a laboratory activity. This hypothesis is then re-examined after the laboratory so that the students prior knowledge can be confirmed or connected to.

### *Summary*

The literature reviewed has shown that there are many different types of strategies that can be used to increase students' scientific literacy. These strategies were separated into reading, writing, analyzing, and vocabulary strategies. The incorporation of these strategies leads to increased science literacy as demonstrated by the literature from above. Through the increased emphasis on scientific literacy not only students attitudes and achievement in science increase but also in other academic areas.

### Methodology

This study consisted of four different strategies intended to increase scientific literacy. The four strategies included in this study were the learning cycle approach for writing skills; definition map strategy for vocabulary, science in the news to increase reading skills, and venn diagram to increase analyzing skills. The study took place with two different eighth grade science classrooms in the Greece Central School District in Rochester, New York. Class A consisted of twenty-five students fourteen of which were male and eleven were female. Class B consisted of twenty-eight students sixteen of which were male and twelve were female. In addition to the twenty-eight students in class B there was a teaching assistant that was assigned to work with an autistic student. This teaching assistant was there to keep the autistic student focused and on task as a one-on-one monitor.

The study took place during two different units during November and December of 2006. During this time the units being studied were Properties of Matter and Periodic Table. Through these units four different science literacy strategies were used to evaluate their effectiveness in increasing scientific literacy. These four different strategies were incorporated into instruction through the use of laboratory activities, tickets out the door, warm ups, and classroom room activities these activities. The learning cycle approach was used to investigate density and buoyancy. Definition map strategy was used to evaluate students understanding of different vocabulary words regarding states of matter. The venn diagram strategy was an analysis activity used to compare and contrast chemical and physical changes. The science in the news strategy was a reading strategy used to read and examine a science article regarding elements and compounds.



*Writing Strategy: Learning Cycle Approach*

The learning cycle approach examined the science concepts of density and buoyancy. Students took part in a two day laboratory activity called density and buoyancy found in Appendix A. Students were placed into groups of two randomly using popsicle sticks. On day one students completed phase one of the learning cycle approach called concept exploration. Students obtained three different objects from the classroom and predicted if they were buoyant or not. Students calculated the density of each of the objects and were introduced to phase two, concept introduction. During this time there was a classroom discussion of the different objects and their different densities. The teacher then posed the question “What did we see?” Students volunteered answers that they saw in the laboratory activity. Students described the density and if the object was buoyant or not. The teacher then asked if there was a pattern present? Students replied with yes and described the relationship between density and buoyancy which is the concept introduction. After the class discussion students completed a CEI conclusion to answer the question “How does density relate to buoyancy?”

On day two students completed phase three of the learning cycle approach, concept application. Students were given four different liquids and told to calculate the density of each liquid. Students were then asked to take an object from the previous day and predict if it was buoyant in each of the four different liquids. Once the predictions were made students placed their object in each liquid and recorded their results. Students were then asked to complete a CEI conclusion to answer the question “How can you determine if an object will float in a given liquid?” Through answering this question

students were able to demonstrate their ability to apply the relationship of density and buoyancy to different liquids and one object.

The ticket out the door was a method to assess each individual student's knowledge of density and buoyancy found in Appendix B. The first question was "How is density related to buoyancy?" The second question was students predicting where different objects will go when placed in water based upon their different densities.

In order to evaluate the effectiveness of the learning cycle approach the two CEI's completed in the laboratory activity were evaluated using the rubric found in appendix C. This rubric evaluated the student's ability to identify the relationship between density and buoyancy using evidence from the laboratory activity. The ticket out the door was also evaluated on a six point scale. If students were able to describe the relationship between density and buoyancy they received one point and for each object they correctly placed in the water they received one point. Classroom observations were also made by another teacher present in the classroom. The observing teacher described the use of different vocabulary by the students when they described what they saw and student engagement.

#### *Vocabulary Strategy: Definition Map*

The definition map strategy was used to examine the vocabulary words associated with the states of matter. After students completed a phase change lab they were introduced to the four phase changes that included melting, evaporation, freezing, and condensation. Students completed a definition map for each word found in appendix D.

During the phase change lab students were randomly assigned into groups of three by picking popsicle sticks with student's names on each. The purpose of the phase change lab was to have students watch and visualize the melting of the solid ice cups into

a liquid and then the evaporation of the liquid into a gas. On day one students were divided into groups of three and took data for 25 minutes from the heating of ice to a gas. In the groups of three students were given a job to complete during the lab. One student was in charge of timing each minute, another student was in charge of finding the temperature at each minute, and the third student was in charge of recording the data every minute. Once students completed the data collection they turned in their data tables so that the class average could be calculated and given out in day two. On day two students wrote down the class average data from the overhead and completed a graph with the class data. Students then completed the lab where they identified the different states of matter in the graph along with the periods of time when a phase change occurred. The last part of the lab was analysis questions and a CEI conclusion that asks "How does adding heat affect a substance?" Once students completed the laboratory and turned it in students were given a definition map for each vocabulary term regarding the phase changes which were melting, freezing, condensation, and evaporation.

In the definition map the students recorded the word in the center each circle around the main word had the following questions: What is it?, What is it like?, What are some examples? The definition maps were collected and evaluated using the rubric found in appendix E. As a ticket out the door students were asked to create a paragraph with the four words to demonstrate the relationship and that they understood the meaning of each word. This was rated on a four point scale. Students that were able to demonstrate their knowledge of all four words received a four. Students that were able to demonstrate their knowledge of three words received a three. Students that were able to demonstrate their knowledge of two words received a two. Students that were able to

demonstrate their knowledge of one word received a one and if a student did not demonstrate their knowledge of any words received a zero.

*Analysis Strategy: Venn Diagram*

The venn diagram strategy was used to assess students ability to analyze two different concepts which are chemical and physical changes. This strategy was used after a lesson which introduced the two different concepts by creating a brochure and a lesson that contained stations. At each station students were asked to identify whether the station represented a chemical or a physical change and why. Once students completed these two lessons a ticket out the door was given to the students found in appendix F.

Day one students were shown different examples of changes and asked to develop a class set of characteristics of a chemical change and characteristics of a physical change. Students were prompted by the teacher and given three demonstrations of a chemical change and three demonstrations of a physical change. With the set of class characteristics students then completed a brochure or a poster to demonstrate the characteristics of chemical and physical changes. The students worked in randomly picked groups of two by popsicle sticks. The poster or brochure needed to contain a definition of chemical and physical changes, examples of each, and characteristics of both chemical and physical changes.

Day two students traveled around the room to six different stations at each station students were directed to complete a change. Once students completed this change they identified if the change was a chemical or a physical change with an explanation of why, including what characteristic the change demonstrated. The ticket out the door for this day was the venn diagram found in appendix F. Students worked independently on the

venn diagrams so that individual student achievement was measured. One side of the venn diagram was chemical changes and the other side was physical changes. On the right and left side students wrote four characteristics specific to chemical and physical changes. In the center area students wrote two similarities between chemical and physical changes. The venn diagram was assessed on a point system out of ten points. Students were given one point for each accurate characteristic that was specific to chemical or physical changes up to eight points. Students were also given a point for each similarity between chemical and physical up to two points.

*Reading Strategy: Science in the News*

Science in the News was used as the reading strategy. A newspaper article was used with the periodic table unit. An article was taken from a news station in Calloway, Kentucky about mercury and harming students found in appendix G. Students were given the Science in the News framework from Murcia (2005) to go along with this article found in appendix H. The students were given the article once they had completed a lesson on elements and compounds so that they had background information to relate meaning to.

Day one students completed a reading about elements and compounds to demonstrate how each are related. Students used this information to create different compounds with gummi drops. Each gummi drop represented a different element and when placed together with toothpicks they created compounds. This demonstrated to students how elements make up compounds. Day two students used their background knowledge of elements and compounds to complete a science in the news framework from Murcia (2005). Students were randomly assigned partners using popsicle sticks.

Students completed the reading as a pair reading. One student read a paragraph and then the next student read the next paragraph. Once students completed the reading they completed the science in the news framework and answered questions related to the elements and compounds as found in the appendix G with their partners. Students were assessed based on their completion of the science in the news framework. The report heading was worth one point, the researcher's conclusion was worth two points, and each square in the chart was worth one point. In addition to the assessment of the science in the news framework classroom observations were made by another teacher. This teacher examined the conversations between partners regarding the article and the relationship this has to the elements and compounds being discussed in class.

## Results

The data collected varied between laboratory activities for the Learning Cycle Approach strategy, Ticket out the door comparing and contrasting chemical and physical changes for the Venn diagram strategy, the states of matter vocabulary development through a definition map, and an in class article about mercury for the Science in the News strategy. The results of each strategy demonstrated the effectiveness of each strategy to increase scientific literacy. Each different strategy was assessed based upon the criteria set forth in the methods section of this paper. The different results show the student achievement through a variety of assessments including ticket out the doors, classroom activities, and conclusions from laboratory activities, and observations made by another teacher present in the room.

### *The Learning Cycle Approach Strategy*

The Learning Cycle Approach strategy was assessed using two different types of assignments the first was the Density and Buoyancy Laboratory Activity Conclusions the second was the Density and Buoyancy ticket out the door. The learning cycle approach was administered to the two different classes of eighth grade students. Adjustments were made in between administering to two different classes. The first adjustment was changing the directions in part two of the laboratory activity. The directions were not clear the first time causing students to loose track of the activity they needed to complete. This caused students to not understand how to complete a specific data table in part two because the directions were at the top of the page while the data table was at the bottom of the page. The second adjustment made in between classes was the clarification of the conclusion in part two. The conclusion needed to be more specific so that the teacher

could identify if the students were able to make the connection between density of an object and liquid in relation to the objects buoyancy in that specific liquid. Without this clarification students did not identify the relationship between density and buoyancy because they did not understand what the conclusion question was asking them to describe.

With these two adjustments that took place students greatly benefited and were able to meet the objectives of the laboratory activity. This was evident in the results from the ticket out the door and the analysis of the conclusions from part one and part two. Table I: Density and Buoyancy Laboratory Activity Results show the students score from each conclusion in the laboratory activity after it was assessed using the rubric in Appendix C. As a result of the modifications in the laboratory activity a higher percentage of students received a three or four as a rubric grade in Class B. In Class B sixty-seven percent of the students received a three or four and in Class A sixty percent of students received a three or four on the Part I conclusion. In Class B seventy-five percent of the students received a three or four and in Class A forty-five percent of students received a three or four on the Part II conclusion.



Table I: Density and Buoyancy Laboratory Activity Results

## Part I results for Class A and Class B

Score for Part I	4	3	2	1
Class A Number of Students	9	3	4	4
Class B Number of Students	6	2	3	1

## Part II results for Class A and Class B

Score for Part II	4	3	2	1
Class A Number of Students	4	5	5	6
Class B Number of Students	8	1	1	2

The ticket out the door found in Appendix B was also used as a tool to measure student success of identifying the relationship between density and buoyancy and the applying this to unknown objects. The results for the ticket out the door are found in Table II: Density and Buoyancy Ticket out the Door Results. As a result of completing the learning cycle approach seventy-nine percent of the students were able to correctly identify the relationship between density and buoyancy by receiving a four or above on the Density and Buoyancy Ticket out the Door. Only four of the forty-seven students were unable to place different objects into the liquid based upon their density because they received a two or lower on the Density and Buoyancy Ticket out the Door. These three students were unable to transfer the new skill of the relationship between density and buoyancy that was just learned into a new situation and needed more practice with this.

Table II: Density and Buoyancy Ticket out the Door Results

Score	6	5	4	3	2	1	0
Number of Students	16	14	8	5	3	0	1

As the observer walked around the room the students were constantly using the new vocabulary words that were introduced during this activity: Density and Buoyancy. Throughout the Learning Cycle Approach students were in amazement to see and actually predict the buoyancy of an object accurately based upon the density they calculated themselves. Most students showed a sense of pride and accomplishment as they moved on throughout the laboratory activity. Students also enjoyed working in only groups of two because they were able to complete the tasks themselves and not be spectators throughout the laboratory activity.

#### *Definition Map Strategy*

The Definition Map Strategy was assessed giving students a zero through four based upon their understanding of four different vocabulary words from phase changes. Students completed a laboratory activity where they observed the four different phase changes. The ticket out the door was the definition map containing these four vocabulary words. The words were freezing, melting, evaporation, and condensation. Students needed to demonstrate their understanding by writing a definition, an example, and something it is like. Students that were able to do this for each word were given four points. Table III: Definition Map States of Matter Results demonstrate the students' understanding of each of the four words.

Table III: Definition Map States of Matter Results

Score	4	3	2	1	0
Number of Students	34	9	6	2	0

Students that received a four were able to identify the differences between each of the four vocabulary words and give an accurate example and definition of each.

However students that received less than a four demonstrated difficulty in identifying a definition of each word. Students did not have a problem when it was necessary to provide an example of each word. This is the result of the laboratory activity that was completed prior to this ticket out the door. Students were able to visualize and see the four different phase changes and then able to recall each individual phase change from the laboratory activity previously completed.

This activity was a tool used by the students to organize the four vocabulary words and give them a reference sheet they could use as a study guide. This strategy was self-explanatory and did not need any adjustments between classes. The students enjoyed completing this and felt that it was helpful because it was a technique for them to organize these four different vocabulary words but yet can be very similar because they all deal with phase changes.

#### *Venn Diagram Strategy*

The Venn diagram strategy was assessed giving students one point for each correct response. Students were able to receive up to four points in the chemical change portion of the Venn diagram, up to four points in the physical change portion of the Venn diagram and up to two points in the similarities between chemical and physical changes portion of the Venn diagram. The Venn diagram was therefore assessed on a ten point scale. Since the Venn diagram was also administered in two different classes there were not any adjustments that needed to be made between classes. Students completed the same activities prior to receiving the Venn diagram as a ticket out the door without any

adjustments. The activities included classroom demonstrations, chemical versus physical change laboratory activity, and a PowerPoint presentation highlighting the differences between chemical and physical changes.

The results of the students' achievement in the Venn diagram can be found in Table IV: Chemical vs. Physical Changes Venn Diagram results. These results are broken into Class A and Class B results. In Class A seventy-seven percent of the students received a seven out of ten or greater. In Class B ninety percent of the students received a seven out of ten or greater. The students that scored a five or below did so because they did not have enough time to complete the Venn diagram before having to move onto another class. However those students that were able to write clearly and concisely did finish in the time allotted.

Table IV: Chemical vs. Physical Changes Venn Diagram results

## Class A Results:

Score	10	9	8	7	6	5	4	3	2	1
Number of Students	5	3	7	2	3	1	0	0	1	0

## Class B Results

Score	10	9	8	7	6	5	4	3	2	1
Number of Students	2	13	3	1	0	1	1	0	0	0



While students were completing the Venn diagram they easily filled in the chemical change section and the physical change section of the Venn diagram. Students used accurate definitions of chemical and physical changes in this section along with different examples they have seen in the laboratory activities or class demonstrations. Students also included signs that a chemical or physical change occurred in the appropriate section of the Venn diagram. The students however did struggle with the similarities portion of the Venn diagram. Students were not sure as to what they could place in this part of the Venn diagram and needed clarification of directions for this portion of the Venn diagram.

#### *Science in the News Strategy*

The Science in the News Strategy was used with a News Article about mercury contamination that occurred in a middle school. This was relevant to the students and engaged them into the story. Students completed the article after discussing elements and compounds in class. The Science in the News framework was slightly adjusted from the original produced by Murcia (2005) in order to fit the Mercury article. Students read the article with a partner and then filled in the framework on the reverse side of the article found in Appendices G and H. One adjustment made in between classes was to have the students complete a reading strategy while they read the article. Students were able to choose from annotating or chunking and summarizing while they read the article as another reading strategy. As a result students were better able to analyze and think about the article as they read it instead of just skimming the article for the answer or main idea.

The students became very interested in the article before they even finished reading. The students were asking questions about Mercury, where it is found, and how

this story could have happened. The students seemed to have a basic understanding of what occurred in the article. However when it came time for students to begin filling in the Science in the News framework, they began to struggle with the different parts of the framework. As the observer moved about the room the students quickly filled in the *Information from the article* column with no problem because it was all information from the article and fairly straight forward. The students did struggle with the next two columns: *What questions need to be asked?* and *Finding answers*. These two columns required students to think beyond just the information in the article and analyze what had occurred. As a result students needed prompting in order to fill in these columns of the article. Also students commented on the idea that there was not enough direction for them to fill in each part of the framework from the article because they did not know what went in each box of the framework.

The results from the Science in the News Strategy are found in Table V: Science in the News Mercury Article Results. These results show that students did complete the article and the science in the news framework with some prompts from the teacher. Students that received a five out of five completely filled in the science in the news framework. Students that received a four out of five were missing two or three boxes in the science in the news framework. These two or three boxes were mostly from the “Finding Answers” column. These students did not completely understand what they needed to complete in this section or if they needed to research new information about the article and place it into the framework. Students that scored a two, one, or zero were not focused during the activity. These students were not engaged in the article and therefore lost interest and motivation to fill in the science in the news framework. Instead

of responding to the prompts from the teachers these students chose not to complete this framework.

Table V: Science in the News Mercury Article Results

Score	5	4	3	2	1	0
Number of Students	23	4	0	4	2	1

### Discussion and Conclusion

Three out of the four literacy strategies were shown to increase the scientific literacy of the two eighth grade science classes. The three literacy strategies that were shown to increase the scientific literacy were the Learning Cycle Approach, the Definition Map, and The Venn diagram. The Science in the News Framework did not increase scientific literacy but it did increase student interest and engagement about the mercury article.

The Learning Cycle Approach with the density and buoyancy laboratory activity was effective in increasing the students' literacy regarding these two key vocabulary words. Students worked using hands on activities to observe the actual phenomena happening. Once students observed how the density affects the buoyancy of an object they then investigated why this occurred instead of being told by the teacher the reason. Students were able to take ownership of their learning. By taking ownership of their learning students were then more equipped to describe the phenomena that was occurring and explain this in the conclusion they wrote. Not only did students internalize this new information and the relationship between density and buoyancy but they were able to apply this to a new situation in the ticket out the door. As a result of the student achievement in the ticket out the door students demonstrated they could predict the buoyancy of different objects given their density.

These results for the Learning Cycle Approach agreed with the literature from Meichtry that described The Learning Cycle Approach for laboratory instruction. "The Learning Cycle is an approach to laboratory instruction that sequences learning from concrete to abstract and provides opportunities for students to be actively involved in

inquiry-based activities which emphasize the use of thinking skills, small group learning, and communication skills” (Meichtry, 1992, p. 437). The students in the study were actively engaged in their learning experience and thus better able to transfer this new knowledge into different situations. Due to the fact that the students were manipulating and investigating density and buoyancy themselves they were able to better associate different aspects of density and how it related to buoyancy thus increasing their scientific literacy of density and buoyancy.

The Definition Map strategy was effective in increasing the scientific literacy regarding the four vocabulary words associated with phase changes. This strategy created an organizational tool for the students to organize the four different vocabulary words and their definitions. The definition map allowed students to distinguish the definition for each word, identify examples and what the word is like. This in effect allowed students to separate the four different vocabulary words and examine the differences and similarities between the four different words. After students completed the phase change laboratory activity where they examined the four different phase changes the organization into a definition map allowed students to process the phase changes they observed.

The research supported the idea that students need to organize information they have previously learned in order for them to be successful. According to Jensen (2005) Presenting knowledge in a well-organized form is useful, but its also inadequate. It’s far more important – and a requirement for good teaching – to ensure that the knowledge in the students’ brain is well organized. Students are pretty good at

understanding a simple example, but without support, they may not form an effective mental model. (p. 48)

Since students completed the phase change laboratory activity prior to completing the definition map strategy they were better prepared to understand the four different vocabulary words. These four different vocabulary words in the definition map were then better related to the examples students observed in the phase change laboratory activity.

The Venn diagram strategy with the chemical and physical changes increased the students' scientific literacy regarding analyzing strategies. After observing different chemical and physical changes in classroom demonstrations and chemical and physical change laboratory activity students were able to compare and contrast the similarities and differences between chemical and physical changes. Students used the Venn diagram to organize their knowledge of chemical and physical changes. While filling in the Venn diagram students were able to increase their scientific knowledge of chemical and physical changes because they used examples, definitions and non-examples to demonstrate their understanding of chemical and physical changes.

According to the literature Venn diagrams are effective in increasing scientific literacy through analyzing skills. According to Loranger (1999) "...using a Venn diagram, students compared and contrasted two classroom pets...familiar objects and then moved to more difficult concepts, such as chemical and physical changes that occur" (p. 241). Students are able to compare and contrast specific science concepts in order to create a deeper understanding of the concepts with higher level thinking skills related to science vocabulary and concepts. In essence students were able to create a deeper

understanding of both chemical and physical changes to increase their scientific literacy through analysis skills.

The Science in the News Framework was not an effective strategy to increase scientific literacy in regards to reading strategies. The “Mercury spill closes middle school” engaged the students and piqued their interest in the topic of elements and compounds. The use of primary literature according to Schlichting was a key to getting students interested in science and how it applies to the real world. Once students are interested in a concept or can relate the story to themselves there is a better chance that the students will develop understanding of the concept as a result. As a result of this article students were interested in the article and how mercury affected a middle school but the lack of direction caused students to become frustrated.

The assessment for this strategy was not very clear and did not analyze the students overall understanding of the article and different concepts associated with this article just completion of the framework. As a result the assessment for this strategy should not be considered a success in increasing scientific literacy through a reading strategy. According to Murcia (2005) “It [Science in the News Framework] prompted thinking about science ideas and concepts and generated discussion about the values, assumptions and methods underlying science” (p. 41). The classroom observations by the observing teacher does not support the idea that using real world examples of literature prompts students understanding and thinking about science concepts. The students were able to regurgitate the information found in the article back but unable to analyze and ask questions about what they have just read. The problem may have been the nature of the article or the lack of directions for the students to fill in the framework.



The framework itself that was completed by the students was overly difficult for these eighth grade students to complete which could explain why students did not increase their scientific literacy as a result. Perhaps the directions and framework headings were too vague with not enough direction provided for the students. The students would have increased scientific literacy from specific questions from the reading and then more probing and thought provoking questions related to the article.

Since this study only examined two different eighth grade science classes and four different literacy strategies these results can not be applied to every single science class but the needs of each class and population of students can be met with these different strategies if they are modified slightly to benefit the needs of the students. Since every group of students are different and have different strengths and weaknesses some strategies may be more effective than other strategies in increasing the scientific literacy of each student. In order to determine the most effective strategy for a given class or a given student many different strategies should be tried multiple times and their effectiveness in increasing scientific literacy measured.

The needs of students vary and need to have a variety of different strategies targeted to them and to the topic. For example the Science in the News strategy may have been an effective strategy at the high school level where students have a higher reading level and more ability to process and analyze different concepts that relate to their life and the concepts in class. One way that would have improved the Science in the News strategy would have been to create a prompt or direction in each box in the Science in the News framework so that the students would have understood what needed to be placed in each box of the framework. Also the framework could have been changed

completely to questions that prompted students to the proper information in each box of the framework.

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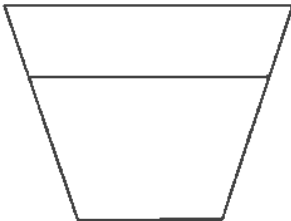
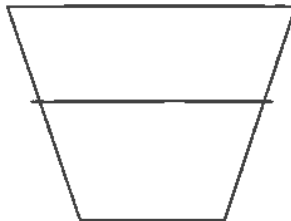
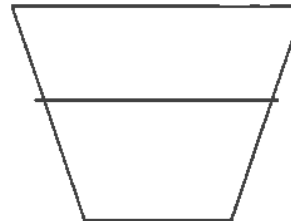
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Appendix A: The learning cycle approach activity: Density and Buoyancy Laboratory  
Activity

Directions: You will perform an activity to determine the relationship between density and buoyancy by investigating what happens to different objects when you drop them into a bucket of water.

**One thing to remember: Density of water is 1.0 g/mL**

**Part 1:**

Object:	Object:	Object:
I predict it will:	I predict it will:	I predict it will:
A drawing of my prediction 	A drawing of my prediction 	A drawing of my prediction 
Test your prediction by dropping the object into the container of water	Test your prediction by dropping the object into the container of water	Test your prediction by dropping the object into the container of water
Draw and describe in words what actually happened.	Draw and describe in words what actually happened.	Draw and describe in words what actually happened.

Object:	Object:	Object
Density Calculation	Density Calculation	Density Calculation:
Density of Object:	Density of Object:	Density of Object:



Have your teacher check your data and sign off in the box to the right.

Teacher Check
------------------

**\*\*Wait...Don't start the CEI until the class discussion. Start Part 2 until the class discussion\*\***

**Conclusion:** You must write a CEI conclusion explaining how density and buoyancy are related.

Claim:

Evidence: (from lab)

Interpretation: (relate buoyancy and density to building a boat)

**Part 2:** You will obtain four liquids and calculate the density of the four liquids in the space below.

Liquid:	Liquid:	Liquid:	Liquid:
Density of Liquid Calculation:	Density of Liquid Calculation:	Density of Liquid Calculation:	Density of Liquid Calculation:



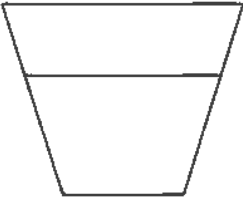
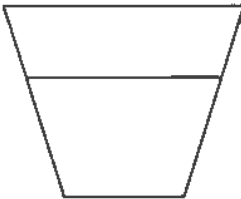
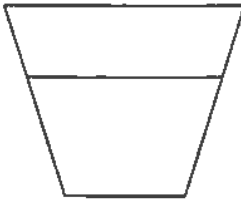
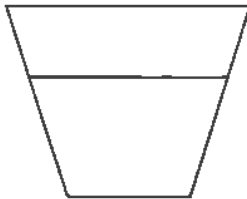
Have your teacher check your density calculations and sign off in the box the right.

Teacher Check
------------------

Now pick one object from the choices you made for Part 1 (you must have already calculated the density of it). You will then draw a prediction of what will happen to the object when you drop it into different liquids, test the object, and compare your results with your prediction.

**The object you have chosen to test:** \_\_\_\_\_

**Its density:** \_\_\_\_\_

I predict it will	I predict it will	I predict it will	I predict it will
A drawing of my prediction 	A drawing of my prediction 	A drawing of my prediction 	A drawing of my prediction 
Liquid:	Liquid:	Liquid:	Liquid:
Test your prediction by dropping the object into the container of liquid	Test your prediction by dropping the object into the container of liquid	Test your prediction by dropping the object into the container of liquid	Test your prediction by dropping the object into the container of liquid
Draw and describe what actually happened	Draw and describe what actually happened	Draw and describe what actually happened	Draw and describe what actually happened



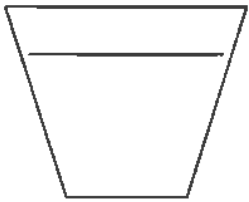
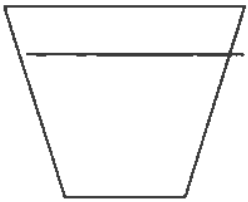
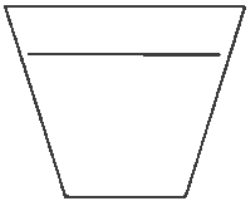
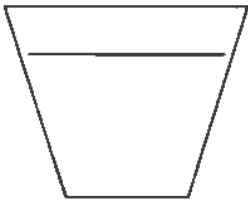
**Conclusion:** You must write a CEI conclusion explaining how you can determine if an object will float in a given liquid. Hint: Pick one object and 2 liquids. Predict if it floats or sinks and why.

Claim:

Evidence:

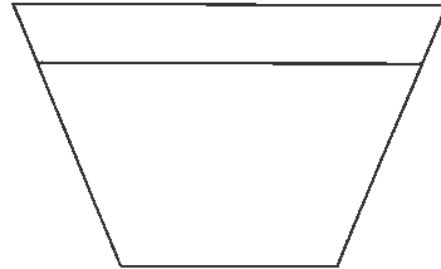
Interpretation:

For the following examples draw where the object would be when placed into the containers filled with water below.

Bouncy Ball D= .8g/mL	Kiwi D= 1.0g/mL	Marble D= 1.7g/mL	Marshmallow D= .2g/mL
			

## Appendix B: Ticket out the door density and buoyancy

1. How is density related to buoyancy?
2. Predict where these five objects will go when placed in a container of water.  
Object A: Density = 1.4g/mL  
Object B: Density = 0.5g/mL  
Object C: Density = 1.0g/mL  
Object D: Density = 5.7g/mL  
Object E: Density = 0.9g/mL



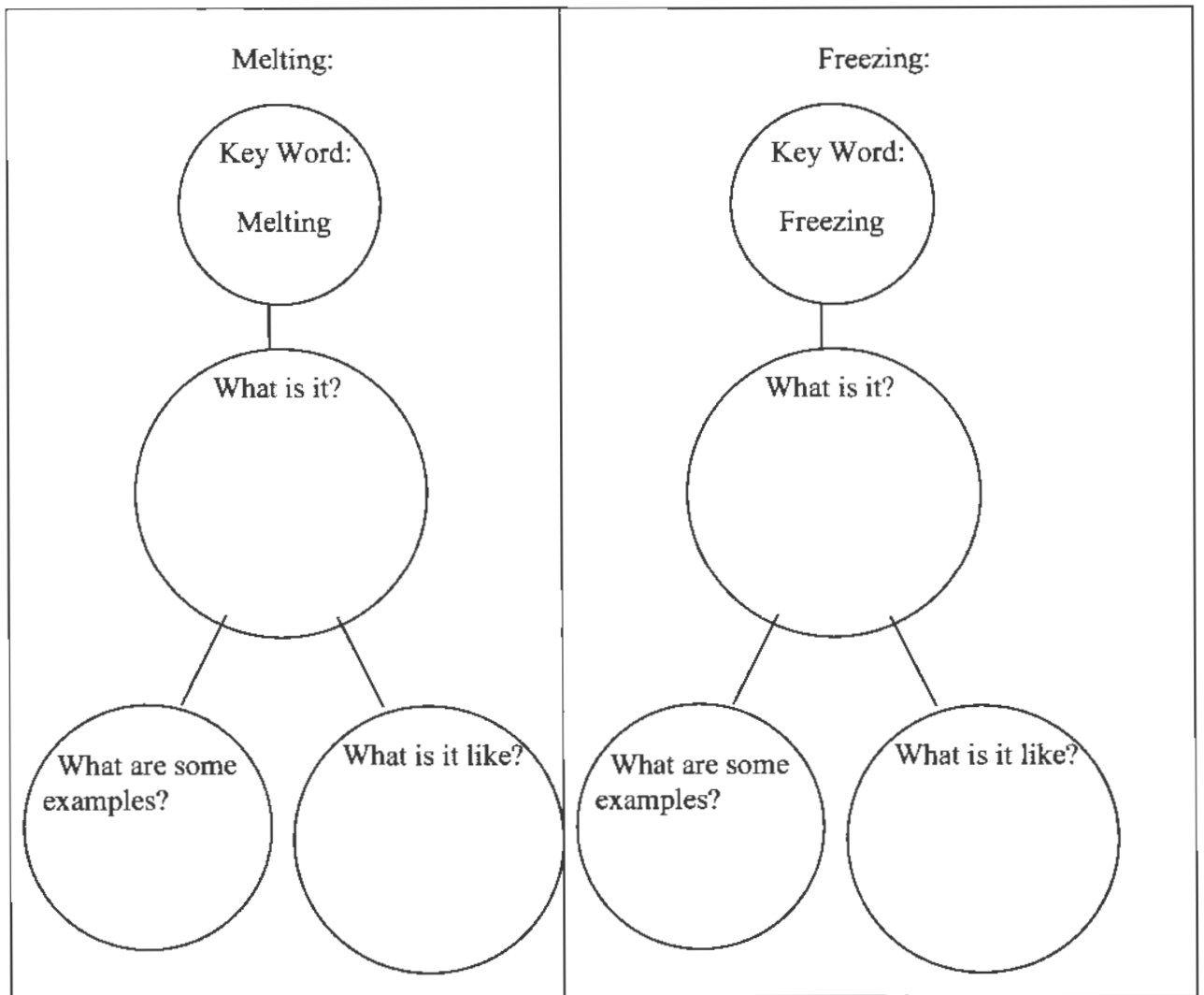
Appendix C: Density and buoyancy rubric

Category	4	3	2	1
Density and Buoyancy Part I	*Student is able to describe the relationship between density and buoyancy with evidence from lab	*Student is able to describe the relationship between density and buoyancy but no evidence from lab	*Student is able to describe the relationship between density and buoyancy but supports it with incorrect evidence	*Student does not describe the relationship between density and buoyancy.
Application to Part II	*Student is able to explain how the density of the liquid and object affects the buoyancy of the object. Provides evidence from Part II.	*Student is able to explain how the density of the liquid and object affects the buoyancy of the object. Provides no evidence	*Student is able to explain how the density of the liquid and object affects the buoyancy of the object. But is supported with incorrect evidence.	*Student does not explain how the density of the liquid and object affects the buoyancy of the object.

Appendix D: Definition Map

**Directions:** Complete a definition map for each of the following vocabulary words. In each circle around the vocabulary word fill in What is it? (definition), What is it like? and What are some examples?

Evaporation:	Condensation:
<p data-bbox="430 481 654 705">Key Word: Evaporation</p> <p data-bbox="383 750 702 1064">What is it?</p> <p data-bbox="263 1131 534 1400">What are some examples?</p> <p data-bbox="550 1131 845 1422">What is it like?</p>	<p data-bbox="1045 481 1268 705">Key Word: Condensation</p> <p data-bbox="997 750 1316 1064">What is it?</p> <p data-bbox="877 1131 1149 1400">What are some examples?</p> <p data-bbox="1204 1164 1508 1456">What is it like?</p>

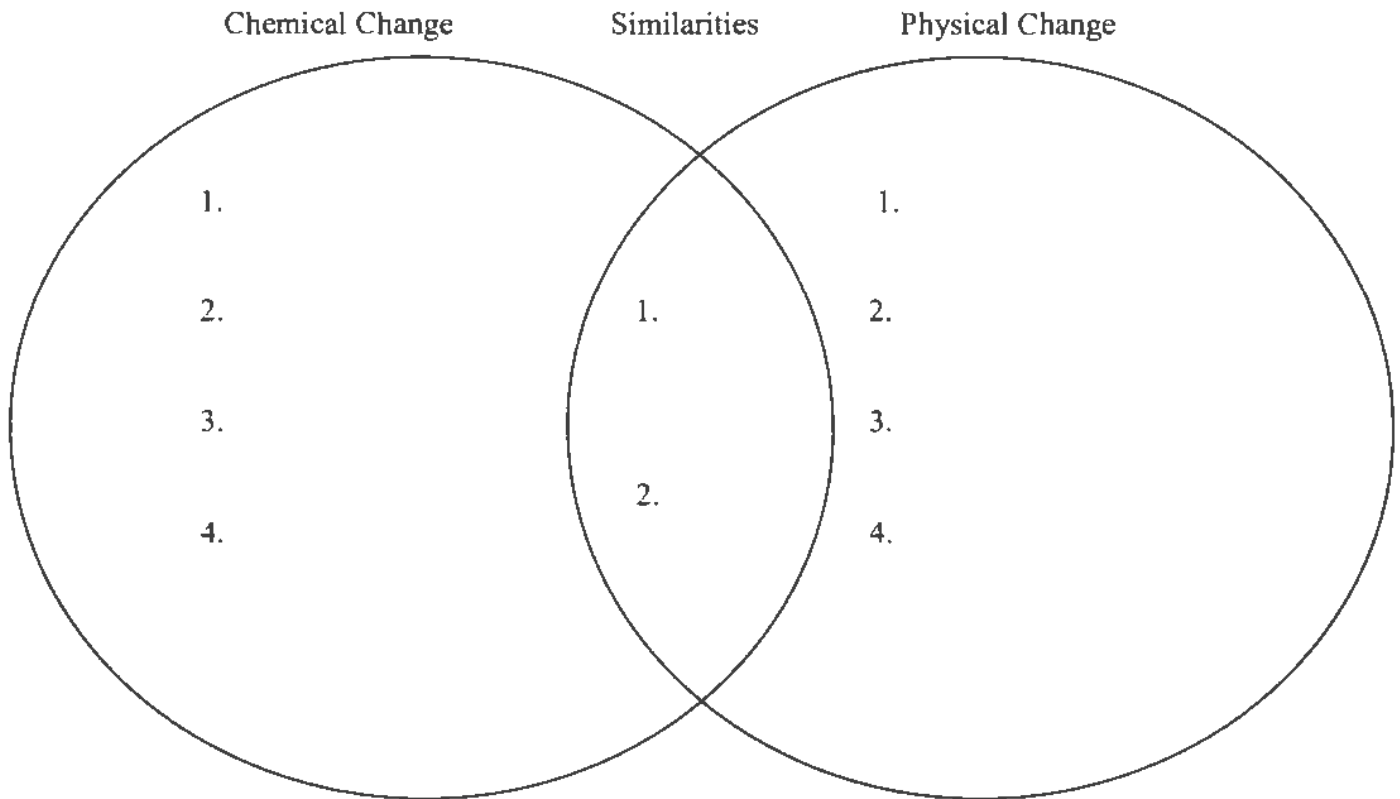


## Appendix E: Definition Map Rubric

Category	4	3	2	1
Vocabulary Words	*A definition map is completed for each word	*A definition map is completed for three words	*A definition map is completed for two words	*A definition map is completed for one word
Definition Accuracy	*An accurate definition is written for each word	*An accurate definition is written for three words	*An accurate definition is written for two words	*An accurate definition is written for one word
Accurate Examples	*An accurate example is given for each word	*An accurate example is given for three words	*An accurate example is given for two words	*An accurate example is given for one word.

## Appendix F: Chemical and Physical Change Venn diagram activity

**Directions:** Complete the venn diagram below using what you know about chemical and physical changes. Be sure to include at four characteristics of each chemical and physical changes. Complete the center area with two similarities between chemical and physical changes.



## Appendix G: Science in the News Article

Calloway County, KY

**Mercury spill closes middle school**

## Mercury spill closes middle school

By: Erica Byfield

CALLOWAY COUNTY, Ky. - Administrators, parents and students in a heartland school district got quite a scare. Federal and state EPA investigators found mercury on a bus, in the school and on children.

At one time you could find mercury just about everywhere like in thermometers and thermostats. Now, it's not as common but one child found a lot of it on his grandmother's shelf. "A grandparent had some mercury in what looks like a small aspirin bottle for many years," said Calloway County Schools Public Information Officer David Dowdy.



Somehow the little bottle made its way on to a school bus and inside Calloway County Middle School. "It was slivery like a ball and splashed everywhere," said eighth grade student Chelsea Snyder. "We have located that bottle, unfortunately there's not too much mercury left in it," added Dowdy.

District leaders closed up the school on Monday, Tuesday and Wednesday. They also created an assembly line in a non contaminated area where all students, like Chelsea, are asked to have their shoes tested.

Chelsea said she actually played with the mercury in class on Friday (November 3<sup>rd</sup>), "I'm not going to touch it again." Lee Ann Myers, her mom, said after hearing about the spill she did a little research, "we found out that it can be very deadly and it's dangerous and it stays with you forever and it's easy to transport around."

Liquid mercury becomes hazardous in warm temperatures, around 75 degrees, therefore cleaning crews set up large fans to keep the building cool. Also in an effort to ensure the spread they've ripped out carpet in 4 classrooms and hallways.

District leaders don't know who, how much or even where their students may have tracked the mercury, so they're putting the word out to make sure your student doesn't get sick.

There is still no official word when school will re-open and as of Wednesday afternoon no one at school has been hospitalized because of the exposure.

Symptoms of mercury poisoning include chills, a metallic taste in your mouth, mouth sores, swollen gums, nausea and vomiting to name a few.



Appendix H: Science in the news framework

News report's heading: \_\_\_\_\_

What is the researcher's conclusion? \_\_\_\_\_

Science in the News	List information from the article	What questions need to be asked?	Finding answers
Science ideas and words			
Science Procedures			
Attitudes and values			
Effect on our lives and how we live			