

2007

# An Experimental Investigation of Literacy in a Secondary Education Science Classroom

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1-1-2007

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## An Experimental Investigation of Literacy in a Secondary Education Science Classroom

Scientific concepts are applied to one's life on a daily basis. The job of a teacher of science is to open young minds to the fact that they cannot escape science. The classroom setting is an extremely narrow and localized version of real-life. Knowledge, understanding and skills that are presented in the science classroom need to be applicable to the world beyond the classroom doors if students are expected to be successful in society.

Scientific concepts are not the only content learned in the science classroom. Students cannot learn science without literacy skills. Students are constantly asked to read, write, listen, and speak in their science class. Learning will not be meaningful unless students have the skills and know how to interpret and process new information. Most of science is new to students. To truly learn the new material students need to make connections to what they already know or what they think they know.

In this experimental investigation the impact of literacy in science will be explored through consideration of the literature and action research in a secondary education chemistry classroom. The research will address the use of literacy-building activities among high school students. The purpose of the literacy strategies is to prepare students for the scientifically literate society they live in and develop their understanding of chemistry. The research will include approximately 50 students from the age of 15 to 18. The implementation of literacy strategies will involve students in reading, writing, listening, and speaking activities. Societal issues will also be taken into consideration. Students will be asked to draw from their prior knowledge and possible misconceptions

of reality. If the increased use literacy strategies in a chemistry classroom correlate to scientific understanding then students will show greater chemistry knowledge at the end of the study. Students will be able to display their understanding through writing and speaking tasks. As they do so they will be able to relate to texts of interest and the interests of the society beyond the classroom.

### Literature Review

This literature review will explore the meaning of scientific literacy and the importance of scientific literacy. Teachers today need to provide their students with knowledge and skills to become scientifically literate outside the classroom setting (Koballa, Kemp & Evans, 1997). Scientific literacy does not necessarily begin or end in the classroom, "Scientific literacy is a lifelong pursuit." Literacy is important in the science classroom because "All students must become scientifically literate if they are to function in tomorrow's society" (Koballa, et al., 1997, p. 27). For students to be successful today in school and tomorrow in society they will need strategies to help them along the way. This review of the literature will show that literacy can be implemented through reading, writing, listening, speaking and through societal issues used in classroom instruction. Strategies to build literacy skills in science will also be presented.

#### *Scientific Literacy*

In the literature many definitions and descriptions emerged for scientific literacy. Cobern, Gibson and Underwood (1995) described scientific literacy as the application of scientific concepts to everyday situations. Similarly, Blanken (2003, p. 89) explained that "a person is scientifically literate if they can deal with scientific issues in daily life." Scientific literacy was described as the ability to ask, find, and determine answers to questions based on curiosities (Ebbers, 2002). Similarly literacy in science was described as the coming together of inquiry, process, and communication skills (Saul, 2004). To use scientific literacy, is to use the ability to predict, describe, and explain natural phenomena. Reading and speaking are also parts of scientific literacy. To read with understanding and to engage in conversations around a particular topic is incorporating

common literacy skills (Ebbers, 2002). As summarized in Figure 1 on page 10, Cobern and colleagues described scientific literacy ranging from familiarities within the natural world to using scientific knowledge for individual and cultural purposes (Cobern, et al., 1995).

Scientific literacy could be considered on a continuum from illiterate – cannot recognize how words and issues as related to science, to having an exceptional proficiency – the ability to analyze, evaluate and critique science materials recognizing that science cannot be separated from society (Koballa, et al., 1997; Osborne, 2002). Due to the continuum of literacy, scientific literacy is complex and dynamic in nature, and is not easily defined or mastered (Koballa, et al., 1997). Literacy's complexity was also supported by M. Ebbers who described science knowledge as dynamic and tentative (2002). Because scientific literacy is not easily mastered, when teaching science, literacy is “not a characteristic that students acquire automatically by successfully completing several science classes” (Cobern, et al., 1995, p. 28). Even though scientific literacy is not something easily acquired, it is a focus of school science (Bybee, 1995). For literacy to be an attainable goal of science it “must be understood as a community practice” (Roberts, 2005, p. 3). According to Robert Bybee (1997) for the achievement of scientific literacy there has to be consideration given to the purpose, policies, programs and practices in schools that support the literacy effort. Osborne (2002, p. 208) described support for literacy differently yet still touched on the same idea: the “central goal of science education is to help students to use the languages of science and to construct and interpret meaning.” Students have to develop their abilities to read and write in science courses. Reading and writing are crucial skills needed to develop scientific literacy

(Metz, 2006). Osborne (2002, p. 215) referred to literacy in the sense that “literacy is not an additional element but an essential constitutive practice of science.”

Scientific literacy is not just another item on a checklist; it is a process that takes time to develop and mature, “developing literacy is an ongoing process” (Czerneda, 2006, p. 41). Literacy is so important to science because “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... communicate clearly to different audiences” (Worth, Moriarty & Winokur, 2004, p. 36).

#### *Importance of Literacy in Science*

According to El-Hindi (2003, p. 536), “true science learning depends on students’ having the opportunity to own the discourse in the classroom, pose questions, articulate their observations, and disseminate their findings.” Students can truly learn science through scientific literacy. In the science classroom learning is shared through reading, writing, listening and speaking (Schmidt, Gillin, Zollo & Stone, 2002). There is no science without reading, writing, speaking; without literacy (Osborne, 2002). Worth and colleagues (2004, p. 36) stated that “scientific and literacy processes develop simultaneously because science process skills have literacy counterparts.” This conception of literacy and science together is supported by others as well. Metz (2006, p. 8) acknowledged that “to be truly literate, today’s students need to understand a complex mix of visual, oral, electronic, and print media.” Language barriers hinder our students from succeeding in the scientifically literate world (Watts, 2003). Many science terms are concepts or phenomena that are entirely new to students (Groves, 1995). In agreement, Osborne stated (2002, p. 212), “science cannot be understood without an

*Figure 1. Range of Scientific Literacy (Cobern, et al., 1995, p. 30).*

1. Being familiar with the natural world.
2. Recognizing both is diversity and unity.
3. Understanding key concepts and principles.
4. Understanding ways in which science, math and technology depend on each other.
5. Knowing that science, math and technology are human enterprises with strengths and weaknesses.
6. Having a capacity for scientific ways of thinking.
7. Using scientific knowledge and ways of thinking for individual and social purposes.

*Figure 2. Literacy Skills for Expository Texts (Worth, et al., 2004, p. 39).*

- Identifying text features (index, glossary, table of contents, design of the page, relationship between photographs and captions, etc.)
- Skimming
- Identifying important ideas and words
- Making inferences

exploration of its language.” Schmidt and others (2002, p. 29) stated that “thought and language are intrinsically related.” Science facts will lose their power without a broad framework of knowledge, which in many cases is a lack of sufficient language use in science. As a result, students need to be engaged in ways that lead to conceptual understanding (Pasley, Weiss, Shimkus & Smith, 2004).

To develop science literacy skills students must to be actively engaged in their learning (Pasley, et al., 2004). Students need to be motivated to participate in discovering and reasoning activities in which they strive to explain phenomena to themselves and others (Townsend, Boca & Owens, 2003). Ongoing and purposeful interactions and explorations in science lead to increased understanding of science (Pasley, et al., 2004; Schmidt, et al., 2002). According to the literature scientific literacy was teamed with inquiry learning (Creech & Hale, 2006; Osborne, 2002; Pasley, et al., 2004; Schmidt, et al., 2002). In inquiry learning students need to “use current knowledge, concepts and skills to illuminate new problems” (Pasley, et al., 2004, p. 1). Inquiry learning leads to increased understanding and builds literacy skills (Schmidt, et al., 2002). Through inquiry students use critical thinking skills to explore and learn that they cannot base claims for truth on observations alone (Osborne, 2002). Inquiry learning promotes sharing of information, learning from others and learning from mistakes (Schmidt, et al., 2002, Varelas, et al., 2001). Students learn that they can manipulate the material world through reading, writing and communicating the science (Osborne, 2002). The ambiguity of inquiry learning situations simulates real-life – making choices and having options down multiple pathways (Pasley, et al., 2004). Yore and colleagues (2004, p. 348) stated it is necessary to communicate about “inquiries, procedures and science understandings to

other people” within and away from the classroom so that one can “make informed decisions and take informed actions.” When learners are able to relate new information to the prior knowledge through inquiry activities, the understanding developed is meaningful and useful in the classroom and in society beyond the classroom (Pasley, et al., 2004).

Inquiry supports scientific literacy which strengthens science learning. Whether in the classroom or not students need to effectively communicate what they know and are able to do. Knowledge and understanding can be discovered through inquiry learning and expressed in a form of scientific inquiry; reading, writing, and speaking. To truly learn science students need to learn the language, which is more than just words (Their, 2002). The “words only have value only if used as referents or to represent meaning” (Osborne, 2002, p. 212). Students that develop conceptual understandings of science know more than merely the words. This is accomplished through scientific literacy (Their, 2002).

#### *Incorporating Literacy in Science*

As previously discussed, “scientific and literacy processes develop simultaneously because science process skills have literacy counterparts.” (Worth, et al., 2004, p. 36). The literacy skills used in the classroom lead to students’ expansion of science understanding. Besides just knowing and understanding students must be able to communicate the information they have learned to others (Their, 2002). The science concepts students express through scientific literacy in the classroom will help them outside the classroom as they are influenced by everyday science (Osborne, 2002).

*Literacy through Reading*

According to Ludstrom (2005, p. 60) "science immerses children in content that is so interesting and important to them that they want to learn about it, which motivates them to read." What needs to be understood about science literacy is that "it is not a fixed object; people are not good readers or nonreaders, but evolving readers" (Creech & Hale, 2006, p. 24). Reading is a dynamic process; it is an active problem solving process (Creech & Hale, 2006). Reading is significant to learning science and science is significant to the learning of reading. Though there are other parts to scientific literacy, one must be able to read and gather knowledge from reading (Ludstrom, 2005). When considering reading in the science content, tapping into student interest areas encourages student engagement. When students are engaged they learn. Furthermore, if students participate in conversations involving science and literacy skills they start to see themselves as successful readers (Creech & Hale, 2006).

El-Hindi (2003, p. 536) stated that "reading both fiction and nonfiction goes a long way to support science learning in the classroom." Nonfiction science materials include expository texts and trade books. Trade books are descriptions of scientific field work. Inquiry, curriculum and more importantly, literacy goals are supported by trade books (Isaacs, 2005). To read expository texts, most commonly textbooks, students require certain skills. In Figure 2 on page 10 important literacy skills used for reading expository texts are presented. These are characteristics of good readers of expository texts as well as other texts (Worth, et al., 2004). Worth and others (p. 36) also stated that "to read deeply, students must learn to spot key ideas as they read, distinguish the important from the interesting, and link new information to what they already know."

Fiction texts or narrative texts could include but are not limited to legends, poems, and the science fiction genre (Czerneda, 2006; Loranger, 1999; Ludstrom, 2005). On the surface narrative texts may seem irrelevant to expanding on science knowledge and understanding but they help students become scientifically literate. With regard to science fiction, (Czerneda, 2006, p. 42) students “develop the flexibility of thought and reasoned imagination they will need to succeed in our society.” Using fiction in the science classroom will promote critical thinking and analysis skills (Czerneda, 2006).

No matter the text, students who enjoy science will read science (Creech & Hale, 2006). What teachers and students need to understand is that all scientific discoveries started with inquiry in which literacy passed the results on. Worth and colleagues supported “Scientists read related literature before they embark on investigations of interesting phenomena” (2004, p. 36). As stated previously, “the ability to communicate through writing and reading is a crucial skill for developing scientific literacy” (Metz, 2006, p. 8).

### *Literacy through Writing*

Along with reading related literature, scientists are continuously writing. They document what they think and do – science journals and notebooks, record experiments in detail so others can follow and repeat the investigations to reproduce desired results, and once experimentation is sufficient, investigative results and conclusions are typically written (Worth, et al., 2004).

Writing exists in conjunction with reading in science. From reading sources students can formulate questions, and create investigations to explore their questions, and use inquiry to guide their learning. As students question, create and explore choices are

provided that will motivate and empower them (Ludstrom, 2005). A suggestion from Ludstrom (2005, p. 60); students should “write, write, write every day.” This can be accomplished by using science notebooks for notes, procedural writing, graphs, and charts. Beyond notebooks students could write expository text such as a lab report in which they have found information, interpreted it, and synthesized it (Worth, et al., 2004). For a different genre of writing, students can write poems, science fiction stories or other fictitious yet scientific stories such as a RAFT; role, audience, format, topic (Czerneda, 2006; Loranger, 1999). Non-expository forms of writing builds science understanding though creativity and imagination, students “work through different points of view in a meaningful way – they start telling stories... about science” (Czerneda, 2006, p. 42)

Worth and colleagues (2004, p. 37) stated that “to write well students must know the purpose of their writing; choose an audience; organize ideas; choose a genre; choose words and style to match the intended genre; determine structure, format, organization and text features; and publish.” All students learn differently, providing options in writing assignments will motivate students to demonstrate their understanding. The thoughts that students express through their writing is enhanced by collaboration which deepens knowledge and builds skills in listening and speaking (Ludstrom, 2005).

#### *Literacy through Listening and Speaking*

As discussed previously, Worth and others (2004, p. 36) support the claim that literacy requires “accurate and effective communication” (Metz, 2006; Saul, 2004). Students make meaning by “writing science, talking science, and reading science” (Worth, et al., 2004, p. 36). Students need to be able to express their thoughts through

discussion and debate with others. Worth and colleagues continued on, one of the foundations of literacy is oral language (2004). According to Yore and colleagues (2004, p. 348) the “regular use of effective argument and small group discussion enhances cognitive and affective outcomes.” In agreement with Yore and colleagues (2004), Worth and colleagues (2004) discussed engagement in terms of listening and speaking and how it creates understanding as students are encouraged to discuss their findings and what they have learned to small groups.

Just as scientists present their ideas through writing and speaking, backed by evidence, to be critiqued, students too need to do the same (Worth, et al., 2004). The speaking and listening in science was referred to as “science talking” (El-Hindi, 2003, p. 536) and “accountable talk” (Worth, et al., 2004, p. 38). Science talking is “calling students’ attention to the use of specialized language as a means of understanding science by expressing relationships between concepts and communicating ideas to one another” (El-Hindi, 2003, p. 536). Worth and colleagues (2004) explained that accountable talk is a sequence of serious responses and further developments of what others say in a group which shows good critical thinking and reasoning skills. Whether accountable talk or science talking, students need to have discussions around what they know or what they think they know. As students discuss science they learn to listen to others, interpret meaning of others’ words, and as the discussions continue, students use detailed, meaningful, and clear language to express their own ideas (Worth, et al., 2004).

As with any form of literacy students need guidance to be successful. Students need modeling of appropriate discussion forms. Some examples of discussion forms include think aloud, single focus talk, and interpreting others’ statements (Worth, et al.,

2004). Discussions in science are more beneficial when they are linked to the world outside the classroom.

*Literacy through Societal Issues*

What happens in society is not necessarily an issue in a negative sense, it may not be positive either. As the need for science literacy grows, more and more societal issues are being brought into the classroom (MacKinnon, 1997). According to Cobern and others (1995, p. 28) “students are not necessarily taught how to relate academia to their outside lives.”

In today’s society there are many forms of communication that students are required to gather information from. As stated previously, “to be truly literate, today’s students need to understand a complex mix of visual, oral, electronic, and print media” (Metz, 2006, p. 8). One example of science in society that students may not be aware of is science fiction, it is very popular when movies are considered. Students need to be able to look at a movie or other media and work through multiple points of view in meaningful ways (Czerneda, 2006). Czerneda continued (2006, p. 39) “science fiction has so much more to offer in terms of good science and how science works, while at the same time addressing the basics of literacy.” Students are forced to interpret, analyze and critique the science they see in society. Less and less inferring and evaluating is occurring as supported by El-Hindi (2003, p. 538), “The vast majority of our students today are learning very little science... they’re taught to memorize some facts and vocabulary but almost never to connect the knowledge into a coherent picture of how the world works and how we’ve come to know it.”

As described by Barton and Jordan (2001, p. 39) “In classrooms where science literacy is the goal, teachers plan learning experiences that help students construct meaning rather than simple tasks.” Learning experiences are more beneficial when students are provided with opportunities to “apply text concepts to everyday phenomena” (Barton & Jordan, 2001, p. 43). Meaningful learning experiences are important because society today needs to be scientifically literate so that they can deal with scientific issues in daily life (Varelas, et al., 2001). Scientific concepts need to be applied to everyday situations (Metz, 2006). El-Hindi (2003, p. 538) stated that “connecting knowledge is an important part of learning which can be supported through literacy practices.” Whether developing reading skills or other literacy skills, students need to be involved in learning experiences that are more effective, more meaningful and more lasting for success in today’s society (Daniels & Zemelman, 2004). Building literacy skills around societal issues is important because, according to Comer, “In order for a truly democratic and economically sound society to be maintained, young people must have access to the best knowledge available so that they can understand the issues, express their viewpoints, and act accordingly” (Hirsch, Willingham & Neuman, 2006, p.7).

#### *Strategies to Build Literacy Skills in Science*

Scientific literacy is not an attribute students attain just by attending science classes; it is a dynamic ongoing process (Koballa, et al., 1997). Incorporating literacy building skills bridges the gaps in science knowledge and society (El-Hindi, 2003). To succeed in the classroom and in the outside world, Loranger (1999, p. 239) stated that “students will need a high proficiency in reading and writing.” According to Meichtry (1992, p. 437) scientific literacy in society can be viewed as “acquisitions of fundamental

science concepts, process, and problem-solving skills, and informed attitudes about science.” Jones & Thomas (2006, p. 58) stated that comprehension “depends on the effective integration of appropriate ways of thinking and the appropriate degree of scaffolding by the teacher to support students’ attainment of the intended intellectual outcomes.”

The next part of this literature review will address multiple literacy strategies that can be used with students to reinforce practices in laboratories, reading, writing, listening and speaking, and using societal issues. The strategies presented help students to gain scientific knowledge and develop understanding of science and literacy alike.

*The Learning Cycle – An Approach to Laboratory Instruction*

The learning cycle is a multifaceted approach to lab experiences. Meichtry (1992, p. 437) explained that lab experiences “sequence 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.” The learning cycle approach to lab experiences helps students develop an understanding of new content through three phases: concept exploration, concept introduction, and concept application. The following is a description of each. Refer to Figure 3 on page 21 for an example with a Stream Study (Meichtry, 1992).

Phase 1 is called Concept Exploration. During the first phase of the learning cycle students are directly involved in activities in which they explore with a new science concept. The desired outcome is for students to learn as a result of the actions they take and their reactions to different objects and events.

Phase 2 is called Concept Introduction. During the introduction phase students are encouraged to participate in a discussion around their observations and inferences made in the exploration phase. The teacher helps the students to make meaning from what they saw and did in their explorations.

Phase 3 is called Concept Application. Once the students have an understanding of the learning that took place in the first two phases they are asked to apply what they have learned to new situations. Student interactions with each other and the teacher help them “apply a new pattern of reasoning to their experiences” (Meichtry, 1992, p. 438).

Throughout this process students are asked to collaborate with class members and the teacher. Through collaboration students develop cooperative skills, a sense of acceptance, increased verbalization skills, production of more and better ideas, increased motivation, positive attitudes, and most importantly, an increased responsibility for their own learning (Meichtry, 1992).

### *Reading Strategies*

As referred to previously by M. Ludstrom (2005, p. 60), “not only is reading critical to the learning of science, science is critical to the learning of reading.” Reading is not a passive activity though it may seem so at first; reading is an active problem-solving process (Creech & Hale, 2006). Because of this students need to be equipped with strategies to help them comprehend what they are reading, whether expository or narrative texts (Loranger, 1999).

HEART is a reading and study strategy to help students make meaning of what they read. As students read they need to do the following to be successful: H – determine how much they already know about the topic, E – establish a purpose for reading or

Figure 3. The Learning Cycle – Stream Study (Meichtry, 1992, p. 438).

*Concept Exploration Phase*

Materials to be provided for each group of 3-5 students:

- cake pan 3/4 full of sand
- plastic cup with small holes in bottom
- water
- empty pail

*Activity*

Each group of students is given the following instructions:

1. Shape the sand in the cake pan into different land contours and prop one end of the cake pan on a stack of 3-4 books.
2. Hold the cup about one foot above the highest end of the cake pan and slowly fill the cup with water.
3. When the cup of water has emptied into the cake pan, record your observations.
4. Slowly add one more cup of water and record your observations.
5. Pour excess water in the lowest end of the cake pan into the pail.

*Concept Introduction Phase*

1. Each group is asked to share their observations of events which occurred during steps 3-4 of the exploration phase.
2. Through a discussion and synthesis of student observations, the concepts runoff, stream, channel, slope, and tributary are deduced by students.
3. Using the stream table as a demonstration tool, the teacher defines each concept. Further instruction is provided through the use of overheads and geographical maps.
4. Each student diagrams the land contours, stream channel, and any tributaries that formed in their group's cake pan model.

*Concept Application Phase*

1. Working in the same groups, students repeat steps 1-4 of the exploration phase, using only one book to prop the same end of the cake pan. Observations are recorded and diagrams are made of stream channels and tributaries.
2. Students repeat the same process, using 7 books to prop the end of the stream table. Observations are recorded and diagrams made of stream channels and tributaries.
3. Students are asked to compare the results of the exploration activity and steps 1 and 2 of the application phase.
4. The teacher facilitates a discussion of the effects of land contours and slope on the formation of stream systems. The terms divide and drainage basin are introduced.
5. Working in pairs, students conduct a topographical map study of stream systems.

studying, A – ask questions as they read, R – record answers to the questions they ask, and T – test themselves on the topic and material that has been read. The HEART strategy is an easy way for students to organize new and/or review material from a text so that it will be useful and it helps them comprehend the text they are reading (Loranger, 1999).

Think Aloud is a strategy in which students actively explore meaning as they read. As a skilled reader reads, they are asking questions and making meaning of the words on the page. According to Daniels and Zemelman (2004, p. 102), “many students are quite unaware of the mental activity that takes place during effective reading.” A think aloud activity will help bring attention to the mental processes occurring while reading. A teacher should model the process before asking the students to do so. As the teacher reads he/she stops at points to verbalize his/her thoughts aloud to model the mental processing that is occurring during the reading. As students do this they can write their thoughts down within the text if applicable or if not, small post-it notes also work. More on how a think aloud activity works is shown in Figure 4a on page 23 along with an example, Figure 4b from a teacher reading the introduction to a text the students will be using. She modeled how to recognize key ideas, ask questions, make connections and take notes (Daniels & Zemelman, 2004, p.102-103).

### *Writing Strategies*

To reiterate the words of Ludstrom (2005, p. 60) students should “write, write, write every day.” Writing can be done before learning, during learning or as a summary of learning. Writing is a means to show the knowledge one possesses; writing is a “cause and means of thought” (Jones & Thomas, 2006, p. 61). The following strategies:

*Figure 4a. How Do Think-Aloud Activities Work? (Daniels & Zemelman, 2004, p 102).*

#### HOW DOES IT WORK?

1. Before you begin, let students know you'll be stopping to think as you read, and indicate what they should notice in your thinking—e.g., *Watch how I use the information in the passage to figure out what's really going on. We call this "inferencing."*
2. Use a short passage, and provide students with copies so they can follow along. Stop after a couple of sentences to tell what you think is coming next, make a connection to your own experience, question what a statement might mean, or express confusion about some idea, etc.
3. When you stop to think, shift your voice to indicate that you've moved from reading the words to your own thinking.
4. After modeling, have students try it in pairs or taking turns in the whole class. If students have difficulty putting thoughts into words, point out a key spot or two where they can stop, and ask them if they have questions, are reminded of something in their own lives, etc.

*Figure 4b. Think-Aloud Example (Daniels & Zemelman, 2004, p 103).*

Kenya Sadler, of Foundations School in Chicago, uses a think-aloud to introduce students to the biography collection, *Black Stars of the Harlem Renaissance*.

Kenya reads aloud from the book's introduction and shares her thoughts as she goes:

... The real estate speculators envisioned a new suburb of downtown Manhattan. They built beautiful town houses and apartment buildings abroad tree-lined avenues. Then the real estate market declined, and rather than pay huge mortgages on empty buildings, the speculators rented to Blacks for the first time.

*Wow. So if the real estate market hadn't declined, then there may not have been a Harlem Renaissance, because they wouldn't have rented to Blacks. Okay, I need to make a note to myself about that, because that's something important.*

The Black population of New York grew fast, fueled by the large northern migration of Southerners. It could no longer be contained in the scattered Black enclaves downtown. Blacks were desperate for living space and willing to pay the high rent prices of Harlem.

*But where would they get the money? Hm. If the market is declining, then that means that people don't have as much money. How is it that Blacks were able to afford to pay the high rent prices of Harlem? I also made a connection here. This reminds me of Bronzeville, the area in Chicago from 26th Street up to, like, 43rd Street, where you have the huge boulevards, King Drive Boulevard, with all of these mansions. And back in the 20s and 30s they were all owned by whites. And then somewhere in the 50s and 60s they started to turn them into apartment buildings for Blacks. So they went from the white mansions to these Black apartment buildings, and one house would end up holding maybe four families. And now they're actually being converted back to the mansions.*

Before long, Harlem became the largest residential center for Blacks in the United States.

*That's a really big statement. There are a lot of Blacks in Chicago now. So there weren't that many at that time? Hm.*

Kenya has modeled a number of important reading strategies: 1) noticing important ideas; 2) asking questions; 3) making connections with her prior knowledge; and 4) taking notes, which she had been previously teaching her students to do.

definition maps, Frayer model and RAFT activities are ways for students to express what they know and have learned through writing.

Definition Maps and Frayer Models are models of expanded meanings of science vocabulary. Students are asked to develop meanings from context and relate to their prior conceptions (Jones & Thomas, 2006). Through using this activity students will arrive at a comprehensive understanding of important vocabulary (Young, 2005). The Frayer model is similar to a definition map. Both include a definition and student connections. The difference lies in how those connections are presented. A definition map includes items such as drawings, sentences, synonyms or key words, and personal relationships made by the students (Jones & Thomas, 2006; Young, 2005). The Frayer model includes characteristics of the term, example and non-examples from ones own life (Barton & Jordan, 2001). Two different definition maps (Jones & Thomas, 2006, p. 60; Young, 2005, p. 15) are shown on page 25-26 in Figures 5a and 5b as well as an example of a Frayer model, Figure 5c (Barton & Jordan, 2001, p.54).

RAFT: a form of writing that activates higher level thinking skills (Loranger, 1999) and as Jones and Thomas (2006, p. 62) stated “this strategy works so well to provoke more meaningful writing that speaks with voice... it invites empathy and perspective.” The acronym stands for Role, Audience, Format, and Topic. Students are asked to assume a particular role or have a certain point of view – e.g. a hydrogen atom; and with that role address a given audience – e.g. a drop of water. The format of the writing varies – e.g. a letter, a poem, a skit; and the topic is the science content that the student is to address – e.g. a day in the life of an element (Loranger, 1999). RAFT examples are displayed on page 27 in Figure 6 (Barton & Jordan, 2001, p. 123).

Figure 5a. Example 1 of a Definition Map (Young, 2005, p. 15).

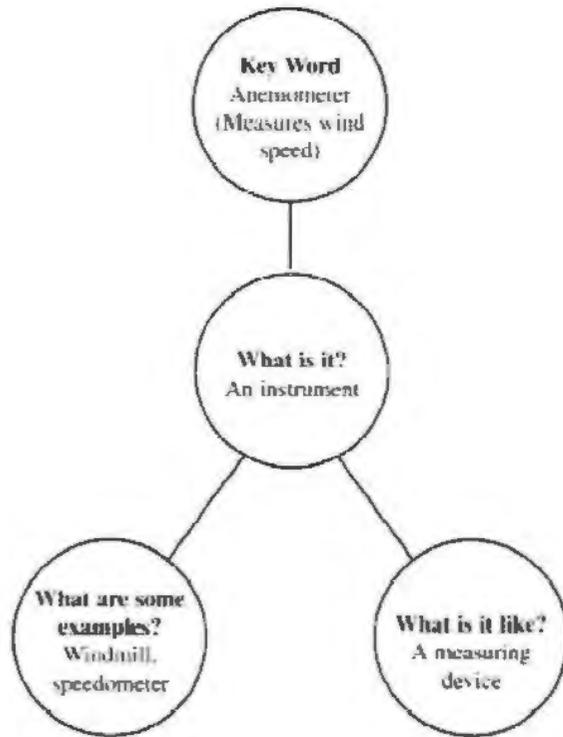


Figure 5b. Example 2 of a Definition Map (Jones & Thomas, 2006, p. 60).

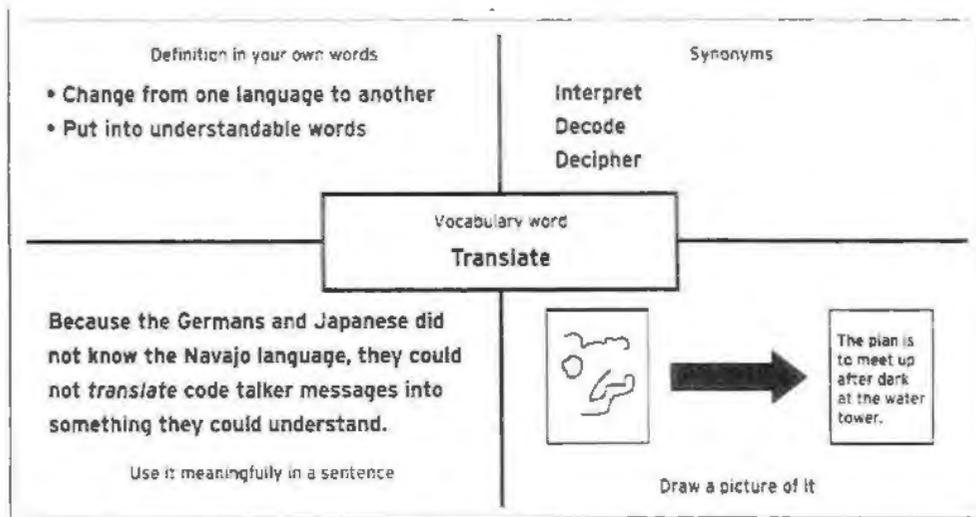


Figure 5c. Example of the Frayer Model (Barton & Jordan, 2001, p. 54).

|   |   |
|---|---|
| <p><b>Definition</b> (in own words)</p> <p>A change in size, shape, or state of matter.</p>         | <p><b>Characteristics</b></p> <p>New materials are NOT formed.<br/>Same matter present before and after change.</p> |
| <p>Physical Change</p>  |   |
| <p><b>Examples</b><br/>(from own life)</p> <p>Ice melting<br/>Breaking a glass<br/>Cutting hair</p> | <p><b>Nonexamples</b><br/>(from own life)</p> <p>Burning wood<br/>Mixing baking soda &amp; vinegar</p>              |

Figure 6. Sample RAFT's (Barton &amp; Jordan, 2001, p. 123).

| Role             | Audience              | Format         | Topic                              |
|------------------|-----------------------|----------------|------------------------------------|
| Water drop       | Other water drops     | Travel guide   | Journey through water cycle        |
| Bean             | Self                  | Diary          | Process of germination             |
| Frog             | Tadpole               | Letter         | Life cycle                         |
| Electron         | Fourth grade students | Letter         | Journey through a parallel circuit |
| Limestone rock   | Cave visitors         | Postcard       | Chemical weathering process        |
| Statue           | Dear Abby readers     | Advice column  | Effects of acid rain               |
| Trout            | Farmers               | Letter         | Effects of fertilizer runoff       |
| Duck             | U.S. Senator          | Letter         | Effects of oil spill               |
| Star             | Self                  | Diary          | Life cycle                         |
| Peregrine falcon | Public                | News column    | Effects of DDT                     |
| Red blood cell   | Lungs                 | Thank-you note | Journey through circulatory system |
| Liver            | Alcohol               | Complaint      | Effects of drinking                |
| Lungs            | Brain                 | Thank-you note | Quitting smoking                   |
| Rusty old car    | Previous owner        | Letter         | Chemical change                    |

*Listening and Speaking Strategies*

According to El-Hindi (2003, p. 536) “instructional conversations promote the kinds of rich discussions that help students develop their ideas along with linguistic competence.” To build understanding of science concepts students need to have conversations around what they know as well as what they think they know. Misconceptions will be uncovered through discussions with other students and the teacher. Because communication is such an important part of scientific literacy, students need to expand their speaking and listening skills (Worth, et al., 2004). According to Yore and colleagues (2004, p. 348) the “regular use of effective argument and small group discussion enhances cognitive and affective outcomes.” The following activity addresses this statement.

In a Discussion Web, all students have the same opportunity to assume the responsibility for learning and share their ideas in a discussion. A discussion web is a way for students to organize their thoughts and research about a particular topic before having group discussions. As Barton and Jordan stated (2001, p. 111), “students gather facts, statistics, examples, expert authority, and logic and reasoning for their discussion.” Because every student creates a discussion web, each student is equally responsible and prepared for the discussion. This method protects students from adverse consequences within the classroom discussion because each student had the same opportunity to prepare. On page 31, Figure 7a shows a blank discussion web and Figure 7b shows a web completed for a discussion on nuclear power (Barton & Jordan, 2001).

*Using Societal Issues to Enhance Literacy*

One of the goals of scientific literacy is to prepare students for society. The growing concern over literacy skills in society is bringing societal issues into the classroom. By bringing these issues into the classroom setting students who may have been indifferent to most content will be motivated to actively participate in classroom activities. The objectives still include student knowledge and understanding but the study of society's issues helps to increase comprehension and critical thinking skills. Activities around societal issues promote communication among students and other members of the school and community, not necessarily just class members (MacKinnon, 1997). A creative debate requires students to "engage intelligently in public discourse and debate, exploring past and present matters of scientific concern" (Barton & Jordan, 2001, p. 109).

In a Creative Debate; students debate a topic from different view points which promotes original thinking and discussion. A creative debate is not different from a typical debate. Students are asked to look at different viewpoints around a central topic and asked to support one of them, not necessarily their own point of view. Throughout the debate students must weigh the facts presented and use those facts to make informed decisions. In Figure 8, page 32, a list of possible debate topics are listed (Barton & Jordan, 2001).

As stated by Young (2005, p. 12), "without a clear understanding of the language of the science content, students will certainly experience difficulty and a lack of interest with their science content-area material." The science content material exists outside the classroom as well as in the classroom. The strategies presented will help address literacy concerns of the students so that they can be scientifically literate outside the classroom

(Koballa, et al, 1997). This literature review has explored the meaning of scientific literacy and why it is important. As it was stated previously, scientific literacy does not begin or end in to classroom, "Scientific literacy is a lifelong pursuit" (Koballa, et al, 1997, p.27).

Figure 7a. Blank Discussion Web (Barton & Jordan, 2001, p. 112).

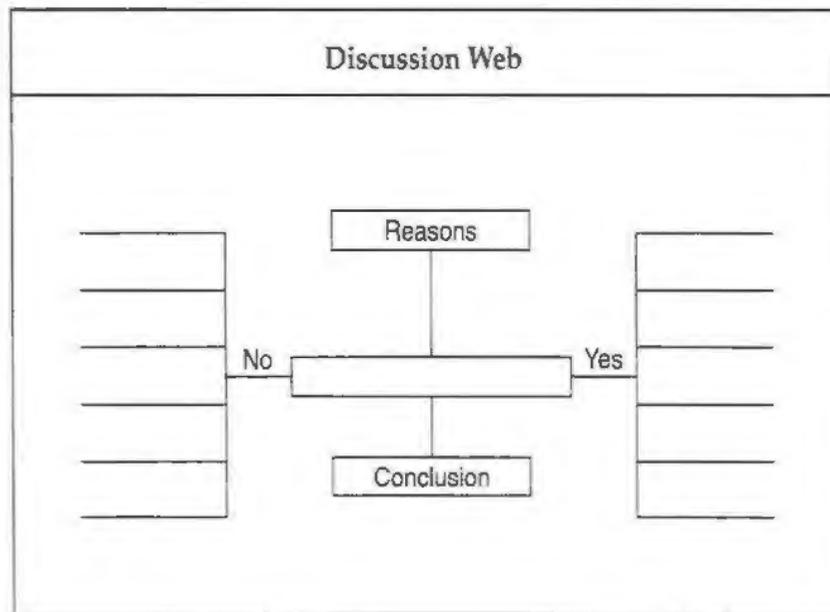
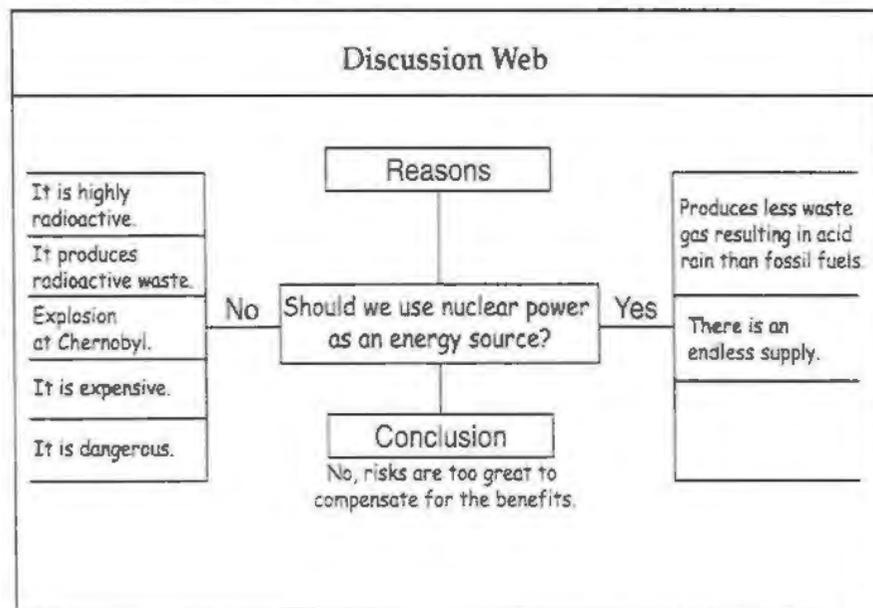


Figure 7b. Example of a Discussion Web (Barton & Jordan, 2001, p. 112).



*Figure 8. Examples of Creative Debate Topics (Barton & Jordan, 2001, p. 110).*

- Everybody can do science.
- Potential research subjects should be told about both the risks and benefits of the research projects.
- New technology can change cultural values and social behavior.
- Any belief about the world is as valid as any other.
- Animals should not be used as research subjects.
- The international community should adopt and enforce laws to prevent further global warming.
- Companies should be allowed to drill for oil in protected wilderness areas.
- Cloning of humans should be allowed.
- Funding for future space programs should be reduced.
- Unwanted, frozen, human embryos should be used for genetics research.
- Genetically engineered food crops are safe for human consumption.

### Methodology

The purpose of the research was to use literacy strategies in a secondary science classroom to help students develop their own scientific literacy skills. The development of these skills should help students in the world outside the classroom. The method of research was designed to introduce students to new strategies for developing literacy and have them apply it to new and/or relevant situations.

#### *Participants*

The participants for the research consisted of 51 Regents Chemistry students. These students are in the course with the intension of taking the New York State Regents exam in June 2007. The 51 students were divided into two sections one class consisted of twenty-eight students, eight males and twenty females. The second class consisted of twenty-three students, seven males and sixteen females. All students were between the ages of fifteen and eighteen. Based on the activity used students were grouped heterogeneously and homogeneously based on learning profiles and assessments were most commonly done individually.

#### *Materials or Apparatus*

Each activity used required different materials. These materials ranged from relevant reading materials from the newspaper and magazines to guided notes and activity handouts and manipulatives where necessary. The strategies used include: HEART (Loranger, 1999), think-aloud (Daniels & Zemelman, 2004), definition maps (Jones & Thomas, 2006; Young, 2005) and/or Frayer models (Barton & Jordan, 2001) for definitions, RAFT (Barton & Jordan, 2001; Jones & Thomas, 2006; Loranger, 1999), discussion webs (Barton & Jordan, 2001), and creative debate (Barton & Jordan, 2001).

The materials for data collection varied depending on the activity being used. Most of the data collection was done by teacher and student observations communicated verbally and through writing. Students were asked on most occasions to reply to questions at the end of a class period. The activity is called As You Leave, AYL. In some cases the AYL was a quick quiz that was counted for a grade. The overall performance and improvement on the students' part was measured by the change in their course work as well as their reactions and summaries of how they felt the activities affected their learning of chemistry and how it's used.

#### *Procedure*

As a result of the review of the literature, six different strategies were chosen to be used in the classroom to promote scientific literacy. Each activity fell under the category of reading, writing, listening or speaking, and society. To investigate the effectiveness of the strategies on increasing scientific literacy among the students each class was exposed to each strategy during their respective class time on the same parts of the content. The first round of activities was done during Class A, twenty-three Regents Chemistry students. Class B, twenty-eight Regents Chemistry students followed class A. This format provided the opportunity for modification from Class A to Class B. The unit of study in the chemistry curriculum was focused on the periodic table and a study of the elements and their properties. After the first round of activities in Class A, slight modifications were made based on teacher and student feedback for Class B. The second round of activities in Class B was done with the modifications in an attempt to better the student engagement in the learning.

Each activity was a part of the study of the periodic table. The unit started with the history and organization of the periodic table and continued through the properties of elements and the trends that exist amongst the organized elements of the periodic table. The unit also included a brief history of the atom to explain electron configuration. Students were exposed to the new literacy strategies throughout the entire unit. Between the two classes the activities varied due to modifications at similar times but the learning was consistent throughout. The goal of the activities between the two classes throughout the unit was to determine if the effectiveness of the strategies varied with class size, content, and modifications made from teacher and student observations.

## Results

The research was designed to introduce students to new strategies for developing literacy and have them apply it to new and/or relevant situations. Throughout the research students used literacy strategies in a secondary science classroom to help them develop their own scientific literacy skills. The purpose in using these skills is for the development of literacy strategies to help students in the world outside the classroom. Reading, writing, listening, and speaking strategies were used with the study of the periodic table, elements, and their properties in two Regents Chemistry classes. The strategies chosen included: HEART (Loranger, 1999), think-aloud (Daniels & Zemelman, 2004), definition maps (Jones & Thomas, 2006; Young, 2005) and/or Frayer models (Barton & Jordan, 2001) for definitions, RAFT (Barton & Jordan, 2001; Jones & Thomas, 2006; Loranger, 1999), discussion webs (Barton & Jordan, 2001), and creative debate (Barton & Jordan, 2001).

HEART (Loranger, 1999) was a strategy used to help students before, during and after reading. Students were given a content rich reading about the periodic table and asked to follow the steps of the HEART acronym: H – determine how much they already know about the topic, E – establish a purpose for reading or studying, A – ask questions as they read, R – record answers to the questions they ask, and T – test themselves on the topic and material that has been read. The H and E parts were accomplished before the reading through a class discussion between the teacher and students. Parts A and R were completed by the students individually, a minimum of five questions were required to be asked, as they read. For part T the students tested each other with the questions they had asked themselves as they read. See Appendix A for the student activity sheet.

Through the HEART entire activity the students were very focused on the task at hand. The class discussion brought up many pre-conceived notions about the periodic table and the teacher was able to assess the students' prior knowledge of the periodic table. The teacher worked with the students to create the purpose for the reading. The students read the passages, recorded questions and answers as they read. When finished, the students worked in groups of two or three to test each other on the new material. The groups were heterogeneously mixed based on who they were sitting with at their table. Students knew what needed to be done and they completed each part of the activity in a timely manner.

The HEART activity increased student's awareness to material that is proposed in scientific writing. This was observed through student conversations around the reading and class discussions in which students used the material from the reading to link to new material in later classes throughout the unit. Positive results in students' attitude and engagement were evident in both research groups.

The think-aloud activity (Daniels & Zemelman, 2004) was demonstrated for the students by the teacher with a reading about the Hindenburg and its tragic accident (Appendix B). The teacher example was much more in depth than the student activity. The teacher asked questions about locations, numbers and made connections between life today and life during the time of the Hindenburg. After the exemplar, students read one of two short articles about the element mercury. As they read students were asked to write their thoughts on post-it notes to keep attached to the reading. Their thoughts could be questions or general comments, as shown by the teacher.

For the think-aloud the students were very willing to use the post-it notes to jot down quick ideas and/or questions. Through class discussions and As You Leave activities students expressed that they liked making short notes and questions as opposed to writing a summary or taking notes given by the teacher. The students expressed that they learned more about the reading through their few comments and sharing the information with the class. The activity promoted the students independence and showed the students that it is okay to ask questions throughout the process of learning new material.

The definition map (Jones & Thomas, 2006; Young, 2005) and Frayer model (Barton & Jordan, 2001) activities were used for students to make sense of new and different vocabulary. The students used both models for the new terms, electronegativity and ionization energy. These strategies were used in small groups on poster paper and presented to the class. Afterwards, the students were provided a choice as to which method they wanted to record in their own notes to build upon their own knowledge.

One of the purposes of both the definition map and Frayer model is for students to relate the new vocabulary to content they already know as well as make connections outside the content. This was evident in their maps and models. Electronegativity was linked to relationships, i.e. a boy likes a girl, there is lots of attraction between them, electronegativity is an atoms attraction to its electrons. Ionization energy was linked to an item, i.e. if a boy really likes his bike it would take a lot of energy to take the bike away from him, ionization energy is the energy required to remove an electron from an atom. Students learning and understanding was evident through their choice of connections outside chemistry and the link back to chemistry using the new vocabulary in

conversations. Students were using the new vocabulary correctly and linking the terms to prior and new knowledge.

The RAFT activity (Barton & Jordan, 2001; Jones & Thomas, 2006; Loranger, 1999) asked students to write a summary to a demonstration from the perspective of an electron or a photon. Students needed to use the terms electron, excited state, ground state, energy and photon. The format was a letter to a proton, from the electron, or a thank you note to the electron from the photon. To write this RAFT, students needed to understand the vocabulary and how each term was related to each other.

The student products were very concise and to the point for both Class A and Class B. There was a clear understanding of the vocabulary due to the connections made in the writing assessment. In Class A the students knew that their summative assessment for the lesson was going to be a RAFT. Student engagement level was not as high as expected during the writing. The students completed an As You Leave activity in which their opinions about the activity were shared. Students responded that many of their teachers are asking them to write RAFT's and they do not necessarily like them. As a modification for Class B, the students were informed that they were going to have to write a creative piece for a summative assessment, omitting the term RAFT. The interest and engagement in the activity were much higher and the responses in As You Leave were much more positive in nature. See Appendix C for the RAFT assessments.

The discussion web (Barton & Jordan, 2001) was used as a tool to prepare students for a class or group discussion. For the periodic table unit of study the material is mostly factual, not opinion or decision based. Students were asked to briefly research the evolution of the atom through time to understand the electron configuration of

elements listed on the Periodic Table of Elements. Students in small groups of four were each asked to complete a discussion web for the different models of the atom including the year, the scientist, the experiments with results and the conclusions made and accepted at the time of the model. Appendix D provides a discussion web template for this activity. Following the creation of the individual discussion webs students entered into a discussion about the atom's evolution and what was proven at each stage. As a summative assessment to the activity students were to create a timeline of events discussed and turn it in.

The discussion web kept the group on task and promoted discussion, not just copying. The students were able to record notes as others in the group discussed the model of the atom but they were asked not to share their webs visually, only verbally. The teacher played the role of a facilitator and answered questions as they arose amongst the groups.

The student discussion webs were very thorough as were the timeline assessments. Students accurately identified the correct model with the correct time frame, scientist and experiment. During the As You Leave activity students expressed their level of comfort with the activity, their enjoyment of learning from their peers and not just from the teacher, and the students expressed that even though they were responsible for knowing all of the information, they personally only had to research one part of it.

A creative debate (Barton & Jordan, 2001) was used to promote students to create original thoughts to support group and class discussions. In Class A and Class B the creative debate was used to springboard a discussion about the man-made elements.

After being given a few facts about the man-made elements, students were asked to respond first individually in writing to the statement; Man-made elements should not be considered elements at all. They were asked to consider both sides of the issue and be able to support either side. As partners they debated the issue and then the discussion was opened to the whole class. Students came up with relevant points to the issue; i.e. if a scientist can get it to exist with the correct atomic number that it's an element or how is it an element if it's only around for milliseconds. The conversations also took to analogies outside of chemistry such as the debate over abortion, is it a baby or not? Is abortion murder or not?

The creative debate promoted student thought and their ability to justify the claims they make. When asked in class what their response was to the debate, students from both Class A and B responded that they had never thought about elements like that as well as the wonder of how many elements could really be made. The Periodic Table of Elements displays up to atomic number 118, students asked if the table will expand based on what scientists observe. The creative debate helped students to use creative thinking skills and questioning skills.

Overall, the use of the literacy strategies in the science classroom promoted original thought amongst the students and supported group and class discussions. Students were engaged and participated in the activities with little hesitation. The modifications made between Class A and Class B were useful in increasing students' engagement and participation. Using two classes of students for was a useful tool for modifications made. The size of the classes mattered only in the amount of time spent between individual students and the teacher, but because of the nature of the activities

students were encouraged to question each other and learn from each other not necessarily to rely on the teacher.

### Discussion & Conclusion

The job of a teacher of science is to open young minds to the fact that they cannot escape science. The research of literacy strategies in the science classroom was done in an effort to build student literacy skills that are applicable to the world beyond the classroom doors. Students need to be successful in society and literacy skills are a key component to scientific knowledge and understanding within the classroom and society.

Throughout the research six different literacy strategies were used in a secondary education chemistry classroom. The use of literacy strategies was to support the building of literacy skills among students to prepare them for the scientifically literate society to which they belong as well as create and develop a deep understanding of the chemistry content. As both Class A and Class B used each of the strategies they proved to be more confident and proficient in their literacy skills, particularly reading, as each activity was done. Students responded to each new task with a positive attitude and worked through it even if it did not seem like it would work for them. The most successful strategies were the HEART activity and the definition map or Frayer model. Through these activities students strengthened their reading and study skills along with their development of vocabulary. Throughout the entire research period the students were successful at all of the tasks. Through student work in small groups and class discussions their learning of the chemistry content was evident through their connections made and language used during the conversations. The activities proved to be literacy building through the increased comfort and ease that each student made apparent as the research progressed. It was also evident through scientific classroom discussions that the students were

building upon their literacy skills. Whether the task was a reading, writing, listening, or speaking, the students excelled and they were highly engaged.

The review of the literature provided guidance for the use of the strategies chosen as well as the possibilities for scientific literacy building activities. The results of the research done with these strategies are coupled with the information given in the literature. Each strategy was well planned and applied in the chemistry classroom because “in classrooms where science literacy is the goal, teachers plan learning experiences that help students construct meaning rather than simple tasks” (Barton & Jordan, 2001, p. 39). The strategies used in the research and the connections to the review of the literature are discussed in the sections to follow.

The HEART strategy used in the research in the chemistry classroom was completed through individual, small group, and whole class tasks. Through each part of the literacy strategy application students were actively engaged. As the HEART strategy was applied the students participated in conversations involving the science content. According to Creech and Hale (2006) when students are engaged they will learn. Creech and Hale (2006) continued stating student involvement in conversations involving science content it will build their literacy skills. As stated in the research the HEART strategy was an easy way for students to organize new and/or review material from a text source (Appendix A). In the classroom, the HEART strategy helped students comprehend the reading (Loranger, 1999). This was evident through their written work and conversations with classmates and the teacher. If students did not comprehend the new information they would not use the vocabulary correctly. Since a majority of the students were correctly using the terminology the strategy showed to be effective.

According to Creech and Hale (2006) reading is a dynamic process and an active problem solving process. The think-aloud activity worked very well to support reading as an active, not passive, experience. During the think-aloud activity students were asked to read a passage and record their thoughts and questions as they were reading on post-it notes. Recording while reading promoted the active process the students should be doing every time they read. Before the students were set on their own think-aloud activity a model was given for them by the teacher (Appendix B). Models of how a skill can successfully be accomplished are important for students to see and experience (Worth, et al., 2004). Throughout the research it was evident that the think-aloud was a very personal activity for the student. The think-aloud promoted their independence with the material in recognizing key ideas, asking questions, making connections and taking notes (Daniels & Zemelman, 2004). The think-aloud encouraged the students to think critically.

A key component to understanding science is to have an understanding of the meaning and use of scientific vocabulary. Students need to accompany the ability to write and speak the using the language of science with reading of scientific language. The definition map and Frayer model were used to help students develop an expanded meaning for the vocabulary. Because all students learn differently, these two methods were provided as a choice for them to put in their notes to demonstrate their own understanding (Ludstrom, 2005). For the classroom application of these vocabulary building strategies students first worked in collaborative groups which Ludstrom (2005) also commented on stating that writing enhanced by collaboration will deepen understanding and build listening and speaking skills. The reason these strategies were

effective was because they required the students to develop meanings from context and relate the new materials to their prior conceptions (Jones & Thomas, 2006). After the activity students were able to show that they arrived at a comprehensive understanding of the important vocabulary. The understanding was apparent through future activities and conversations as Young (2005) stated vocabulary building activities would do.

The RAFT activity was presented to the two classes differently. Class A was told up front that their summative assessment for the demonstration was going to be a RAFT. The assessment was presented in a table, see Appendix C, in which the terms Role, Audience, Format, and Time/Topic were clearly shown. Students had the choice of two possible RAFT's. After students completed the activity, with some opposition, they expressed in the As You Leave activity that too many other teachers make them do RAFT's when they would rather just write something than call it a RAFT. For Class B a modification was made, Appendix C, from the table format to the assignment written in paragraph form. The student's reactions in Class B were very positive and there was no opposition. The result is that the students are getting wrapped up in the name of an activity rather than the activity itself.

The RAFT activity was chosen as a writing activity for the students because it builds science understanding through creativity and imagination; students write with a voice. Students work through a concept in different ways and tell a story about the science (Czerneda, 2006; Loranger, 1999). Students are motivated when they are provided choices in what they are to write (Ludstrom, 2005).

Along with reading and writing students need to express their understanding through discussion and debate with others (Worth, et. al., 2004). The purpose for using

the discussion web was to promote discussion amongst students. The web is a strategy for students to use to prepare themselves for discussion and it is designed so that each student will have the same opportunity to prepare (Barton & Jordan, 2001). Worth and colleagues (2004) stated that when students are listening and speaking the content it creates understanding of their findings and what they have learned. This can occur in small groups or in a whole class setting. During the research students were asked to prepare a discussion web for part of the evolution of the atom (Appendix D). Students were teamed up with three other students with different versions of the atom and asked to discuss the information with each other, no copying of discussion webs. The students could take notes as their other group members spoke but they were not to view each others webs. The discussion was supported by the work of Worth and colleagues (2004) in which they stated that as students discuss science they learn to listen to others, interpret meaning of others' words, and make meaning so they can express the new learning as their own. El-Hindi (2003) was in agreement with this in that students need to use the language of science to communicate ideas with each other and build better understandings.

A creative debate is a typical debate but may include more creative topics than what may seem typical. A debate in any sense promotes original thought and discussion. Students must weigh the facts presented and use those facts to make informed decisions (Barton & Jordan, 2001). Students need to be able to support their decisions and relate those decisions to themselves and their prior knowledge. Students need to be able to express their thoughts in a clear and concise manner through discussion and debate (Worth, et. al., 2004). This debate is also supported by Yore and colleagues (2004, p.

438), the “regular use of effective argument and small group discussion enhances cognitive and affective outcomes.”

The creative debate that was used during the research asked the students to consider the man-made elements and support or oppose the statement: man-made elements should not be considered elements as all. The students brought up many good arguments. A particular student related the man-made elements issue to abortion and that this debate is in the eyes of the individual, it’s a choice. The student went on to draw the analogy of the man-made element, existing for only milliseconds, compared to the embryo in a mother’s womb and abortion. When is it a baby? Is abortion murder? The thought process that this student went through for an engagement activity extended beyond the original expectations of the activity. El-Hindi (2004, p. 538) stated that “connecting knowledge is an important part of learning which can be supported by literacy practices.” Due to the path the debate took and the level of student’s participation, the students were asked to write a free response to the statement about man-made elements and to link it to parts of the class debate and discussion as they felt applicable.

The creative debate was a strategy used to promote student involvement in group and class discussions as well as enhance students understanding though connections to prior understanding. The debate proved to be a tool for students to use critical thinking as a basis for gaining knowledge.

When students leave school, the narrow and localized version of real-life, they need to use all of the skills they have acquired along the way if they are expected to be successful in society. Through science classes students should build up a wealth of

strategies and methods to use to understand science outside the classroom. Scientific literacy is a part of everyone's life, one cannot escape it. In school learning of the content is imperative but so is the learning of scientific literacy skills. Learning needs to be meaningful if a student is required to use what they have learned outside of school.

Through this research students in two classes experienced six different learning strategies and activities that can help them in the future, beyond high school, in college and in society. These strategies are not limited to the science classroom. Many teachers use many different strategies to promote student literacy as was evident in the review of the literature. When considering literacy strategies to apply to a classroom a teacher should consider the activities carefully and make sure the activity is applicable to the content. Future research can continue with the same motive, enhance student learning through literacy strategies and continue to train students to use the strategies explored.

The purpose of the science course was to teach chemistry but more importantly to teach students that they can accomplish any task involving scientific literacy with the right tools. This research provided the teacher and students with six different tools but there are many more that could be found and used effectively.

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## Appendix A

## HEART Format / Student Activity Sheet

Name:  
Mrs. Nerrum

Chemistry



**You HEART Reading!**



HEART is a strategy used for reading. Reading is an active process not a passive process. Your mind should be working while you read and HEART is here to help.

Fill in the following sections Before, During, and After you read the assigned passage.

*Before you read* \_\_\_\_\_

**H** How much do you already know about the topic? Record your prior knowledge.

**E** Establish a purpose for reading.

*During reading* \_\_\_\_\_

**A** Ask questions as you read (at least 5).

**R** Record answers to your questions. (Use the back of this paper if you run out of space.)

*After reading* \_\_\_\_\_

**T** Test yourself and a partner on the material that you just read.

Appendix B

Think-Aloud Exemplar – The Hindenburg

**Tragedy at Lakehurst**



*A fateful day for the Hindenburg.*

Lakehurst is a town in New Jersey.

Hindenburg on its way to Lakehurst - May 6, 1937

What type of "vehicle" is the Hindenburg?

The following text was taken, with permission, from William Althoff's book, *Sky Ships*.

Almost 70 years ago!

Frankfurt is in which country?

On 3 May 1937 Hindenburg lifted off the Frankfurt airfield for Lakehurst on the first of eighteen scheduled visits to North America. Aboard the ship were thirty-six passengers and a crew of sixty-one. Delayed by persistent head winds, Hindenburg did not reach the Lakehurst area until late afternoon on the sixth, hours behind schedule.

This is military time. 1900 hours. Midnight is like hour zero. What time did this landing occur?

Where do you think head winds come from?

What's the total head count on the Hindenburg?

Finally, at 1900, an immediate landing was recommended. The first line thumped to earth at 1921 and the high mooring operation began. The station log matter-of-factly records the events which began four minutes later.

If you go to [www.nhs.com/tragedy](http://www.nhs.com/tragedy) you can here an actual broadcast!

During the landing operation, the Airship Hindenburg burst into flame at an altitude of about 200 feet and was burned to destruction by hydrogen fire originating at or near the stern.



Hydrogen is a diatomic molecule. Write the chemical formula for hydrogen.

The back.

The Hindenburg, several seconds after bursting into flames.

## Appendix C

## RAFT Assessment Descriptions for Class A and Class B

**Class A:**

Choose one of the two RAFT's below as your summary to today's demonstration. Assume the Role, write to the specified Audience, in the specified Format during the correct Time and using the correct Topics.

| <i>Role</i> | <i>Audience</i> | <i>Format</i>  | <i>Time / Topic</i>   |
|-------------|-----------------|----------------|---|
| Electron    | Proton          | Letter         | 1913 – Neils Bohr laboratory<br>Use the vocabulary:<br>electron, excited state, ground state, energy and photon |
| Photon      | Electron        | Thank you note |   |

**Class B:**

Choose one of the following tasks to write as your summary to today's demonstration.

- *Choice #1*

You are an electron and you are so pumped about what has happened today in the laboratory of Neils Bohr (1913). You want to tell your friend Proton all about it. Write a letter to proton explaining everything that happened. Be sure to include the following terms so Proton knows what you are talking about: electron, excited state, ground state, energy and photon.

- *Choice #2*

You are a photon and you are so grateful about what has happened today in the laboratory of Neils Bohr (1913). You want to thank Electron for all that he/she did for you. Write a thank-you note to Electron explaining your every gratitude for what happened today. Be sure to include the following terms so Electron knows what you are talking about: electron, excited state, ground state, energy and photon.

Appendix D

Discussion Web Template – Atom Evolution

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