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ASSESSING THE IMPACT PARTICIPATION IN SCIENCE JOURNALISM ACTIVITIES HAS ON SCIENTIFIC LITERACY AMONG HIGH SCHOOL STUDENTS

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DISSERTATION

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Abstract

As part of the National Science Foundation Science Literacy through Science Journalism (SciJourn) research and development initiative (http://www.scijourn.org; Polman, Saul, Newman, and Farrar, 2008) a quasi-experimental design was used to investigate what impact incorporating science journalism activities had on students' scientific literacy. Over the course of a school year students participated in a variety of activities culminating in the production of science news articles for *Scijourner*, a regional print and online high school science news magazine. Participating teachers and SciJourn team members collaboratively developed activities focused on five aspects of scientific literacy: placing information into context, recognizing relevance, evaluating factual accuracy, use of multiple credible sources and information seeking processes.

This study details the development process for the Scientific Literacy Assessment (SLA) including validity and reliability studies, evaluates student scientific literacy using the SLA, examines student SLA responses to provide a description of high school students' scientific literacy, and outlines implications of the findings in relation to the National Research Council's *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (2012) and classroom science teaching practices.

Scientifically literate adults acting as experts in the assessment development phase informed the creation of a scoring guide that was used to analyze student responses. Experts tended to draw on both their understanding of science concepts and life experiences to formulate answers; paying close attention to scientific factual inaccuracies, sources of information, how new information fit into their view of science and society as well as targeted strategies for information seeking. Novices (i.e., students), in contrast, tended to ignore factual inaccuracies, showed little understanding about source credibility and suggested unproductive information seeking strategies. However, similar to the experts, novices made references to both scientific and societal contexts. The expert/novice comparison provides a rough description of a developmental continuum of scientific literacy.

The findings of this study including student results and Generalized Linear Mixed Modeling suggest that the incorporation of science journalism activities focused on STEM issues can improve student scientific literacy. Incorporation of a wide variety of strategies raised scores on the SLA. Teachers who included a writing and revision process that prioritized content had significantly larger gains in student scores. Future studies could broaden the description of high school student scientific literacy and measured by the SLA and provide alternative pathways for developing scientific literacy as envisioned by SciJourn and the NRC Frameworks.

Dedication

To my family and friends,

Without your support this would not have been possible.

I love you all.

Acknowledgements

When this idea was tumbling around in my head, I had the good fortune to speak with Dr. E. Wendy Saul about it. From that point what started out as a small change in a single school blossomed into a project that encompassed the entire region. Thank you Dr. Saul for having the foresight to envision the transformative value of this idea and getting me started on my journey.

I was very lucky that Dr. Joseph Polman agreed to be my Dissertation advisor. His help and guidance were essential to completing this project. I am a quantitative analyst at heart and he encouraged me to use this strength when approaching every part of the research. As a result I have learned more than I ever imagined. Thank you Dr. Polman, for your faith in me and your support throughout this process.

I first set foot on this campus as a high school student; I was considering becoming a science teacher so I had to meet with someone named Dr. Granger. This was a meeting that I feel truly changed my life. After walking out of his office I knew that I wanted to become a science teacher and that I would be attending UMSL even though I gave up full ride offers elsewhere to do so. For the past 20 years he has been a resource and a guide. His encouragement and advice has been a driving force in my goal of perfecting my craft. Thank you Dr. Granger!

After taking every quantitative methods course offered on South Campus and writing my dissertation, I can now say with confidence that I get statistics. Thank you, Dr. Ding for your help in achieving this.

It is often difficult as a teacher to let someone into your classroom to work with your students and then step back and let them have control. During the early stages of the project Dr. Alan Newman came into my classroom and worked directly with my students which was an enlightening experience for both of us, I believe. I learned a great deal about the value in explicit suggestions and how science journalism can augment my teaching practice. Thanks to Dr. Newman, I will be a better teacher.

Throughout my teaching career I have had the benefit of meeting and working with a large number of excellent teachers who have the same goal- improving science education in our region. I am very happy so many of these individuals were able to join this endeavor and help us learn about what works to improve student scientific literacy. Your contribution to this project was invaluable and will impact science education. Thank you SciJourn teachers for your help, support, and your willingness to share your students with me so that I can better understand how students think about science. I look forward to many more years of collaboration!

Finally, to the SciJourn team (especially Shannon Briner, Rick Stanton, Brian Huxtable and David Zitko); I cannot describe how much I appreciate your help throughout the past four years. Thank you.

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AAAS- American Association for the Advancement of Science

CDC- Centers for Disease Control

EPA- Environmental Protection Agency

NRC- National Research Council

NCES- National Center for Educational Statistics

NCLRC- National Capital Language Resource Center

NOS- Nature of Science

NSF- National Science Foundation

NSTA- National Science Teachers Association

SES- Socioeconomic Status

SLA- Scientific Literacy Assessment

WHO- World Health Organization

Chapter One

Introduction

Technology has led to changes in the way we communicate. The Internet has altered both the mode (e-mail, blogs, twitter, and social networking) and speed at which information can travel. A side-effect of this change in modes and rates of communication is the rate at which new knowledge is created and shared. With advances in life sciences (such as stem cell research, gene based therapies, and ecosystem complexities) and in the physical sciences (such as alternative fuels, green technology, and nanotechnology) many of the topics students are exposed to through television, radio and the Internet are far removed from what they learn in school textbooks, and often more interesting. This presents a conundrum. The focus in classrooms on broad understandings in science and specific facts about a variety of topics has changed little. However, the world outside of the classroom has changed dramatically in terms of how a student receives and communicates scientific information. This transformation has altered the skill set that students need to negotiate the fast paced, technology enhanced world of the future.

Various organizations have created standards in an attempt to prepare science students to become “scientifically literate”. According to the National Science Foundation, scientific literacy is defined as “knowing basic facts and concepts about science and having an understanding of how science works.” (NSF, 2008) One framework for school science curriculum was outlined by the American Association for the Advancement of Science (AAAS) in the *Atlas of Science Literacy* (2001) which follows the organization developed in *Science for All Americans* (1990). The National Science Teachers Association (NSTA) has developed a similar framework (as a series of position papers) for school science curriculum (2003). Both of these documents focus on developing scientific literacy by mastering core science content. Roberts (2007) describes this approach as having a thorough understanding of science concepts and the process of science. In contrast, another approach advocated by many (e.g., Eisenhart, Finkel, & Marion, 1996; House of Lords, 2000; Roth & Lee, 2004) focuses on the thorough understanding of science related situations (Roberts, 2007). How can something so essential in science education lack a clear definition? This could be part of the reason the way school science is taught does not enable students to engage with science related situations (Roberts, 2007). The numerous definitions and programs that address scientific literacy indicates that although consensus on a definition has not been reached, it is clear scientific literacy is a common goal for both science educators and the science education research communities.

The wide variety of definitions and levels of scientific literacy has resulted in a definition that lacks a focus. The changes in communication modes and the skills all students need to make sense of scientific information mean that a more focused definition of scientific literacy must be established in order to adequately assess these skills. Three underlying premises inform the definition I will utilize:

- The science knowledge base is increasing exponentially.
- Science in practice has moved beyond broad understandings (e.g., cell theory) to more specialized fields (e.g., nanotechnology).
- It is impossible to learn all that there is to know about science; therefore all students need to develop skills to interpret, evaluate, analyze and

communicate new scientific information in order to prepare them for the future.

The growing focus on personal meaning making and civic responsibility as components of scientific literacy means that states, school districts and teachers will need to shift their focus from a checklist of facts to a mastery of skills that students can use to make sense of and communicate their understanding of science that relates to their lives. Such practices do not eliminate the need for science content and process knowledge. Practices as defined by the NRC's *A Framework for K-12 Science Education* (2012, p. 30) takes into consideration that skill is combined with knowledge within the context of science. As such, an over reliance on content knowledge and nature of science processes as the measure of scientific literacy will not prepare students for their future interactions with science as a citizen. This suggests that a different tactic is necessary for students to develop and apply these skills in order to understand both the content and process of science, one such tactic is the incorporation of science journalism practices.

Beginning in the 1860's secondary education adopted a pre-professional function focusing on abstraction in rather than utility of science, for example stressing the mathematical basis of physics compared to how physics is evident in everyday experiences (Jenkins, 1990). Today, few students in high school are planning on pursuing a career in science. Focusing on abstraction in science reduces the relevance for students. This creates a system where students tend to opt out of science during high school. This leads to low enrollment in science majors at the college level. Only 25% of college students under age 25 were enrolled in a science major during the 2003-2004 academic year (U.S. Department of Education, 2009), while only about 1% continue on to a science career (Fensham & Harlen, 1999). Simply adopting the slogan "Science for All" does not alter the ways in which science is being taught in school.

Fifteen years after high school the textbook will no longer serve as the primary source for science information. Much of the learning that occurs outside of school stems from sources such as the Internet, TV and radio (Horrigan, 2006; Kress, 2008). How can we teach students to become better at evaluating expertise outside of textbooks and to make sense of the other types of information available (brochures, websites, podcasts, etc.)? Science educators in particular need to address these aspects of scientific literacy in order to prepare students for a future where science will be a part of their everyday life and communicated in multiple modes (print, web, video, etc.). The role of literacy in a science classroom needs to be redefined to include:

- Changing the focus for writing in science from format and grammar to science content
- Broadening the scope of literacy instruction to include genres other than textbooks and including images, sound, etc.
- Consider how different genres work to inform citizens about science.
- Viewing textbooks as just one source of expertise on science information
- Establishing science discourse (reading, writing, and talking) as an essential component to meaning making.

Viewing science discourse as only reading, writing and speaking, ignores the fact that communication is a social process that is situated within a broader context. All individuals participate in multiple discourse communities which require different "ways of behaving, interacting, valuing, thinking, believing, speaking and often reading and writing" (Gee, 1990). One of the discourse communities students participate in is the discourse of science. Establishing science discourse in a classroom can "help youth gain access to the accepted knowledge of the disciplines, thereby allowing them to also critique and change that knowledge … because it builds an understanding of how knowledge is produced in the discipline" (Moje, 2008, p. 97).

The Science Literacy through Science Journalism initiative provides a variety of activities that help students navigate within the science discourse community to improve their understanding of science. This is achieved by incorporating a wide variety of short mini-lessons focused on targeted skills aimed at preparing students to research and write a science news article. Examples of such activities include topic selection, interviewing skills, research skills and revising. Through it incorporation of such skills students will be building their scientific literacy.

Advocates of scientific literacy expect that an individual can participate in the discourse of science and understand how scientific knowledge is created. However, the currently dominant pre-professional formula for secondary school science combined with the all knowing textbook, does not prepare students to be critical of the discourse. Incorporating multiple modes of literacy and ample opportunity to use and critique science discourse can improve students' scientific understandings (Lemke, 1997; Moje, Collazo, Carrillo, & Marx, 2001; Norris & Phillips, 2003). Edgar Jenkins (1990) proposes that increased scientific literacy may counter unrealistic expectations of science based on prior accomplishments and improve understanding of the limitations associated with science. Improving student scientific literacy through the incorporation of science journalism activities could address both of these concerns and better prepare individuals to be critical consumers of scientific information.

Curriculum reforms aimed at improving scientific literacy typically focus on one of the approaches identified by Roberts (2007): concept and process understanding or application of science related to situations in life. Both approaches benefit all students. Future scientists will benefit from understanding the connections between science and society in much the same ways that others will benefit from a good understanding of basic science principles and processes. Science Literacy through Science Journalism attempts to integrate these two approaches to develop student scientific literacy practices so they can participate in science discussions and investigate personal questions related to science.

Developing Scientific Literacy Practices to Complement Current Curricula

Maintaining the curricular status quo places science education in an untenable position: future scientists as well as those who opt out of science as a potential career, both need to understand and use scientific information as adults. Many organizations have identified a set of curricular objectives that spell out what students need to know and be able to do, focusing on content and the nature of science. The SciJourn project proposes that adopting practices of science journalists in conjunction with the current curricula may better prepare students to handle science and technology related questions as adults.

As part of a National Science Foundation initiative in the Discovery Research-K12 program, the Science Literacy through Science Journalism (SciJourn) program (Polman, Saul, Newman, & Farrar, 2008) developed a science journalism apprenticeship model where teachers learn about science journalism during a two week summer professional development program and are provided ongoing support throughout the school year from an experienced team including a science journalist. Through the implementation of science journalism in the classrooms of these teachers as well as a youth program at a local science center, high school students write articles for a science newsmagazine called *Scijourner*, which is available online (www.scijourner.org) and distributed regularly as a print edition. A key component to this process is the interaction between the science journalist as editor and the students. The articles are written about a variety of science topics selected by high school students with their teachers' guidance. As students submit their articles, teachers learn from reviewing the editing suggestions made by the Scijourner editor. Such situated learning is reflective of the apprenticeship model the program is based on.

Why Science Journalism?: A Model for Scientific Literacy

What practices will a person rely on to participate in the larger discussion that surrounds science topics like global warming, and who enacts them? Science journalists sit at the nexus of science and communication. Their job, in many cases, is to make sense of the science jargon and frame it in a way that anyone can understand. In general, exemplars of science journalism such as the science section of the *New York Times* or National Public Radio's “Science Friday”, provides enough broad background information for the reader/listener to make sense of the more specific science information. It is the ability to make sense of dense scientific information and translate it to a format that serves a general audience, without losing the essence of the science (factual accuracy, context, multiple credible sources, and relevance) that makes good science journalists exemplars of what it means to be scientifically literate.

Science journalism provides an opportunity for the reader to become part of the conversation. This is achieved in multiple ways; by engaging their interest, providing additional resources, or by establishing a base of knowledge to build upon. Becoming a reader of science news invites students to tackle a science related situation, delving into the science to gain a better understanding.

Science journalists learn to be critical of what is written and said, both in terms of the facts and the context surrounding them. Science journalists expend a tremendous effort to review what is known, taking into account multiple perspectives, interviewing stakeholders, and presenting the information in a non-biased form, with an ultimate belief that the reader will be able to make their own judgments about the information (Blum, Knudson, & Henig, 2006). Taking part in the conversation requires similar practices to those used by science journalists. Knowing how to judge a source's credibility, identifying possible biases the different stakeholders might have, assessing the facts that were included, and double checking those facts enables the reader to engage with science in a variety of ways. Navigating through the myriad forms of scientific information while judging the credibility of the source and thereby the information provided combined with an understanding of science concepts and processes is essential for citizens as they make decisions regarding personal health, funding of science initiatives, and political issues.

The action of writing and submitting articles to a real news publication adds authenticity to the student's experience and key to producing good writing (Bruce & Rubin, 1993; Saul, 2004). Writing as a form of interpretation can facilitate conceptual learning (Bruer, 1993). Much like science journalists, students begin by interpreting science information from a variety of sources and then transforming it into a form understandable by other high school students. Such articulation and transformation are hallmarks of science classroom discourse (Lemke, 1990; O'Neill & Polman, 2004; Tabak & Baumgartner, 2004) and scientific literacy.

Assessing Scientific Literacy as Authentic Practice

Changing the curricular focus to encompass both core content and process knowledge and related science situations will require a corresponding shift in how students are assessed. In a recent statewide science assessment in Missouri, there was a question that essentially asked what caused *turgidity* in a cell. Many students missed this question. But was this question truly assessing their understanding of how plants store water or was it assessing the students' vocabulary? If students can describe the way a stem cell loses its ability to be any kind of cell but never uses the term differentiated, does that mean they don't understand what is happening at the cellular level? With this new definition, we can no longer assess understanding of science simply as a static set of facts or vocabulary. Instead we need to assess the practices that enable a student to become "a legitimate peripheral participant" (Lave & Wenger, 1991) in the aspects of the scientific community's work connecting with the public, even if they do not become more central participants in scientific research. Assessing scientific literacy as participation in a science discourse community requires consideration of the following:

- How capable is a student of finding information?
- What influences their choices about relevant information?
- Can the student connect this information to a broader context?

- Can the student assess the expertise of a source?
- Can the student initiate a conversation with an expert to gain more detailed information?
- Can the student engage in the discourse community as a full member by interpreting multiple sources of information and communicating their understanding?

Science journalists rely on these practices. While some science journalists have a strong background in a field of science such as chemistry or ecology, they write about a wide variety of subjects. Additionally, they are expected to take very technical information and transform it so that the average person can understand. It is this ability that embodies the practices necessary to be scientifically literate.

The premise of the SciJourn program is that through a science journalism apprenticeship model student learning will be sufficiently scaffolded to enable students to participate in science discourse communities. Continued participation in science discourse will enable students to develop the scientific literacy practices necessary for them to seek out and utilize scientific information to inform decisions, both personally and politically.

Purpose of the Study

The purpose of this study is twofold. Focusing on scientific literacy practices requires the development of an assessment instrument that measures student ability to use a variety of scientific information (news articles, photo captions, informational brochure, and a graph with associated text). This assessment will in turn be used to investigate how adolescent scientific literacy is affected by participation in a science journalism program that focuses on multiple modes of literacy using an apprenticeship model.

Hypothesis

The proposed study tests the following hypothesis:

Participation in an educative model of science journalism will improve the following student scientific literacy practices of high school students (Saul, Newman, Pearce, Singer, and Turley, 2010);

- Searching for Information
- Identification and use of multiple, credible, attributed sources
- Contextualizing new information
- Establishing personal relevance
- Evaluating factual accuracy

Delimitations

- The data for this study was generated during the first full implementation year of a multi-year grant.
- The study was conducted in a Midwestern metropolitan area with urban, rural, and suburban school districts participating.
- Teachers applied to participate in the SciJourn teacher development program.
- Teachers were selected based on expressed interest and subject area; intent was to introduce this project into multiple subject areas (i.e., various science courses, health, English).
- School based students participated in SciJourn activities as part of the regular classroom practice which is impacted by both state and district expectations.

Limitations

- The teachers are allowed to modify the program to accommodate the time available within their curriculum.
- Constraints placed on topic selection and frequency of article submissions were the discretion of the teacher.
- Some school districts do not allow video-recording, audio recording, or interviews of students.
- Teachers choose which classes to include in the program.

Assumptions

- The student sample was representative of Midwestern high school students.
- The program is integrated into the curriculum so that all students participate in science journalism (but not all chose to participate in the research).
- Most citizens have the need to interpret scientific information found in popular media (e.g., newspapers, magazines, online resources, science-related television programs).
- Good science journalism provides reliable, well-researched science information.
- Authentic science writing provides motivation to learn.

Definitions of Terms

Apprenticeship model. An educational model where students acquire skills through supported learning activities in authentic contexts and communicating with peers and experts.

Alternative assessment. An assessment that utilizes performance tasks to reveal what a student can do with authentic tasks that require the use of language and communication. (National Capital Language Resource Center, 2004)

Assessment. A single task or series of tasks used to evaluate student understanding using some combination of constructed response questions, multiple choice questions, selected response questions and/or performance event questions.

NSF DR-K12 (Discovery Research K12) program. A research initiative through the National Science Foundation to investigate ways to improve STEM education.

Practices. Using both skills and knowledge specific to the practice to engage in scientific investigations. (NRC, 2012, p.30)

Professional science journalist. A person whose primary occupation at sometime has been to report on science topics requiring them to draw on their content knowledge, understanding of how science is practiced, personal experience and training to make new or complex science information accessible to their readers.

Publishable article. An article that meets the standards developed by the SciJourn project team and the student editorial board at a local youth program.

Scientific literacy. A scientifically literate student is able to critically read, integrate information from a variety of sources, communicate across discourse communities, ask appropriate questions to gain clarity or develop understandings, investigate scientific phenomena, and utilize scientific information to make decisions personally, socially and politically. This term is often used interchangeably with science literacy, which is the case within the SciJourn project.

Science journalism. The process of pitching a story idea/angle to an editor, investigating the science topic, interacting with experts and texts on the topic, synthesizing the information, and transforming the information into a journalistic article for an intended audience of lay people (Saul, Kohnen, Newman, and Pearce, 2012).

SciJourn. The NSF funded grant project "Science Literacy through Science Journalism."

Standard or SciJourn Standard. A description of key components and skills of science journalism. The standards used in this study were developed as part of the SciJourn project.

STEM education. Science, Technology, Engineering, and Mathematics education.

Significance of the Study

This project focuses on practices a high school student needs to master in order to be scientifically literate 15 years post graduation. For the majority of students, the science information that they will encounter as adults will come from the popular media (TV, radio, Internet, and magazines). Depending on the situation, some of this information will be trustworthy, while some will not. Being able to determine situational credibility will be essential for making good decisions. Science journalists provide a model of what practices are needed to find, make sense of and to judge the reliability of science information. One hallmark of journalism is being skeptical. Trusting the accuracy of information is based on the critical evaluation of multiple sources. Through this process, good science journalists develop as well as an understanding of the big picture and many science concepts, methods, and theories. Contextualizing information and having an understanding of science concepts, methods and theories is generally accepted as the goal of science education as well.

Practices modeled by science journalists are not currently explicitly taught in high school classrooms. Students are not typically asked to locate, read and evaluate contemporary science and rarely are they able to investigate topics of personal interest. Interest and ability to seek out and understand science information will influence their engagement with science in the future. Additionally, they will need to communicate their understanding of science.

In this project students are writing for a science magazine. Throughout the research and writing of the article students are exposed to and make use of the language of science. The combination of critical evaluation of information, translating that information so a broader audience understands the science content, and creating science news engages students in higher order thinking.

Currently, there are few assessments that utilize multiple modes of science informational text (media reports, images, graphics, and brochures) and none that assess conceptual knowledge, contextualization and skills (Laugksch & Spargo, 1996) in a single assessment. The development of a multimodal assessment using a variety of science informational text and prompts will be essential in order to examine student scientific literacy practices as defined by the new NRC frameworks (2012).

This study will evaluate the usefulness of science journalism in high school classrooms as a means to improving student scientific literacy and critical thinking. The lack of an appropriate instrument necessitated the creation of the Scientific Literacy Assessment (SLA). The assessment was developed, focusing on measuring changes to student scientific literacy skills outlined in the SciJourn standards (Saul, et. al., 2010). The SLA was piloted in classrooms and revised. The version used in this study was analyzed for both reliability and validity (Chapter 3). The validated SLA was then used to measure changes in student scientific literacy (Chapters 4-6).

Chapter Two

Review of Literature

"The ideal of human service is the ultimate goal of scientific effort, to the end of equipping the intellect for a better and more perfect use of human reason" (Dick, 1955, pp. 441). Preparing individuals for a better use of human reason includes the understanding of scientific concepts and methods as well as application of this knowledge. Early attempts at defining what students should know were guided by practicing scientists in an attempt to develop future scientists (DeBoer, 2000; Fensham, 2004). Scientists' view of knowledge as a possession (Hurd, 1998) without considering the influences that their discoveries have on everyday life is clear in the aims for science education. The accumulation of knowledge is often the basis for school science curriculum frameworks (i.e., AAAS, 1990; NRC, 1996; NSTA, 2003); resulting in the listing of a defined set of facts and methods to be mastered. The expectation within these frameworks is for students to adopt the discourse and practices of scientists, essentially becoming little scientists (O'Neill and Polman, 2004; Osborne, 2007), but not necessarily scientifically literate.

In this chapter I will discuss the historical context of scientific literacy, the role of social scientific issues in developing scientific literacy, the intersection of scientific literacy and school science and how the use of scientific discourse provides both affordances and constraints for developing scientific literacy. Included is a review of current communication practices (i.e., talking, writing, and reading) and how these contribute to scientific literacy and how science journalism can be used as a scaffold for these practices. The chapter ends with an analysis of current scientific literacy assessments and the need for an assessment focusing on the communicative aspect of scientific literacy.

What is Scientific Literacy?

Science is not simply a set of facts but is part of a broader context, yet this broader context is rarely acted upon. This lack of action stems from the absence of a clear, concise, and widely accepted definition of scientific literacy (Bybee, 1997; DeBoer, 2000; Jenkins, 1990; Laugksch, 2000; Miller, 1983). In the late 1950's, DeBoer defined scientific literacy as a way "to provide a broad understanding of science and of the rapidly developing scientific enterprise whether one was to become a scientist or not" (DeBoer, 2000, p. 586). This vague definition allowed for multiple interpretations, most of which fore-fronted scientific knowledge. By the 1960s science courses aimed at building student scientific literacy were being developed for schools by practicing scientists (DeBoer, 2000; Fensham, 2004). These courses focused on content knowledge and methodology in order to prepare future scientists (DeBoer, 2000). This focus on content knowledge and methodology is still pervasive in schools today (Hurd, 1998).

This balancing act between content knowledge and application of the knowledge is evident in the varying definitions of scientific literacy:

- Knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs and economic productivity. (National Science Education Standards, NRC 1996, adopted by NSTA)
- An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to

draw evidence based conclusions about science related issues. (US Department of Education, Institute of Education Sciences, n.d.)

- A coherent set of understandings (content knowledge) and skills. (Ahlgren & Rutherford, 1993)
- An awareness of how the science/technology enterprise works, knowledge of what science is about and what can be expected from science. (Shamos, 1995)
- "Matrix of knowledge needed to understand enough about the physical universe to deal with issues that come across our horizon, in the news or elsewhere." (Trefil, 2008, p. 28)
- Able and willing to continue to learn science content, to develop science processes on his or her own, and able to communicate the results of this learning to others. (Sutman, 1996)
- To be aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes (AAAS, 1990)

From these definitions two major themes of a scientifically literate individual can be drawn:

1. Content knowledge including connections within diverse science fields
2. Nature of Science (how science is done and the skills necessary to do science)

The overemphasis of these two aspects—content knowledge and nature of science—limits opportunities to place science into context and the need for students to understand the interconnectedness of science and society (Holbrook & Rannikmae, 2007).

Since scientific literacy is a goal of science education; the field would benefit from a convergence of definitions (DeBoer, 2000; Hurd, 1998; Jenkins, 1990; Yore, Pimm, & Tuan, 2007). Science content knowledge and an understanding of the nature of science cannot be separated from the discourse used in science (Lemke, 1990, Norris & Phillips, 2003, Roth, 2005) or its context (Roth & Lee, 2004, Roth & McGinn, 1997). This does not mean that the discourse of science and its defined content are the only avenues into scientific literacy; student discourse and funds of knowledge are equally as important (Lemke, 1990; Roth, 2005; Vora & Calabrese-Barton, 2004; Yerrick & Roth, 2005).

Most reforms aimed at increasing scientific literacy neglect the reality that exists outside of the classroom (Kress, 2008; Roth & Lee, 2002). For instance, current state and federal standards heavily emphasize content. Teachers use these standards to develop curriculum for their students, resulting in curricula based on the nature of science and an accumulation of facts and terms. Students come to school with a variety of experiences and ways of communicating that influence their understanding of science (Moje, Ciechanowski, Kramer, Ellis, Carrillo, & Collazo, 2004). Additionally, these out of school experiences can provide a wealth of connections between subject matter and student lives; by not making a connection to the students' personal lives, the motivation to learn is often absent as well. Incorporation of students' experiences, language practices, and funds of knowledge can improve motivation to learn (Moje, 1997; Moje et al., 2004; Vora & Calabrese-Barton, 2004). The inclusion of socio-scientific issues as a foundation for scientific literacy has been proposed by many (Fourez, 1997; Korpan, Bisanz, Bisanz, & Henderson, 1997; Laugksch, 2000; Roth and Lee, 2004), and the SciJourn project embraces this recommendation.

Moving Beyond Content Knowledge and the Nature of Science

Laugksch (2000) proposed that there are three main aspects to being scientifically literate – context, content, and skills. This was expanded upon by Norris and Phillips (2003) as they divided scientific literacy into two senses. They refer to the ability to participate in the discourse of science through "comprehending, interpreting, analyzing, and critiquing texts" (Norris & Phillips, 2003, p. 229) as the fundamental sense and the content of science (both facts and processes) as the derived sense. This combination of content knowledge and communicative skill is necessary to develop scientific literacy. This integration of content knowledge and communicative skills has been described as a set of practices in the NRC framework for science education (2012) referencing work by Norris and Phillips on communicative roles in science education.

In 1985, "The Public Understanding of Science", a report of the Royal Society of London, pointed to scientific literacy as a means to ensure the public decision making process was based on an adequate understanding (Laugksch, 2000, p 85). As a result of this report, an effort to increase public knowledge of science and improve attitudes toward science was initiated in Britain. These top-down programs tended to assume public ignorance and superiority of scientists. Based on this view, a new stance for public understanding of science was developed where the "generation of new public knowledge" (Miller, 2001, p.117) is achieved through dialogue. Within this dialogue scientists are often the sources of science facts while other members of the public have "local knowledge and an understanding of, and a personal interest in the problems to be solved" (Miller, 2001, p.117).

A Definition of Scientific Literacy

Despite the call for a single definition of scientific literacy, developing a single definition of scientific literacy will be difficult due to the differing values possessed by scientists and the public. However, there are some aspects that are generally agreed upon as important:

- Content knowledge
- Understanding the nature of science
- Participation in scientific discourse
- Using scientific information for problem solving

Adopting the premise that members of the public need some content knowledge and an understanding of how science is done, what constitutes good science and how to use this information for personal reasons has led to the development of a composite definition scientific literacy: "Scientific literacy is being able to understand and communicate the meaning and significance of science and technology information in order to make personal, social and political decisions" (Polman, et. al, 2010). This definition will be used for the remainder of the paper.

Scientific Literacy and School Science

Over 50 years of science education reforms aimed at developing scientific literacy have not made much progress toward building the skills needed for sense making in science (which are not explicitly taught nor utilized by students). There remains a focus on the derived sense in the form of scientific terminology and facts (Hand et al., 2003; Lederman, 1998). This could be a result of the complexity of science discourse or the curricular focus on standards. Scientific information is often lexically dense (Klein, 2006), dependent on prior content knowledge (Yore et al., 2007), and includes graphs, charts, mathematical equations, and other representations of data (Kress, 2000; Lemke, 1997; Lemke, 2004). The skills needed to make sense of scientific information are not limited to textual representations; discussions, presentation, and media reports about science include many of these challenges as well in terms of meaning making. Interpretation of new scientific information is dependent upon the active engagement of the reader, critical analysis of the text (including photos, charts, and graphs) and an understanding of how new scientific information is based on prior discoveries. Norris and Phillips (2003) describe this as reading from a theoretical perspective:

> By this we mean, not only that [readers] attend to the substantive scientific content of the texts (the focus of traditional science instruction), but also that they read the texts so as to determine such meanings as degree of certainty being expressed, the scientific status of statements, and the roles of statements in the reasoning that ties together the elements of substantive content (p. 235).

This interplay between the fundamental and derived senses of scientific literacy is necessary for individuals to construct meaning.

As the repertoire of representations increases with technological advances the ability to translate between modalities is essential (Kress, 2000; Lemke, 1990; Lemke, 1997; Unsworth, 2001, Roth, 2002). Many of the science reform efforts tackle the data (numbers) aspect of science, focusing on science inquiry or the Nature of Science (Lederman, 1998) in an attempt to develop an understanding of and an appreciation for how science is done. However, sense making in science requires the construction of meaning, using multiple modes, while simultaneously evaluating the information (Lemke, 1997; Kress, 2000; Yore et al., 2007). The Scientific Literacy Assessment (SLA) constructed as part of this study incorporates a variety of information formats (news article, photos with captions, graphs, and informational brochures) to provide students sufficient opportunity to make sense of new information through critical interpretation and proposing sources for additional information.

Sense making in science is situated; whether it is reading and writing (Brown, Reveles, & Kelly, 2005) or through the use of evidence and argumentation (Hand & Prain, 2006; Keys, Hand, Prain, & Collins, 1999). School science is often limited by the cultural values of the institution and its expectations in addition to the cultural values of science (Lemke, 2001; Moje & Handy, 1995). Through the incorporation of natural language and student relevant topics, a bridge can be developed that will help students to adopt the more formal literacies of science while constructing meaning.

Use of Scientific Discourse: Affordances and Constraints

Yore, Pimm, and Tuan (2007) stated that in order to be scientifically literate, an individual must be proficient in the discourse of the discipline:

> This involves discourse communities' vocabulary, language traditions, conventions, practices, and procedures, cognitive and metacognitive actions, emotional dispositions, and technologies and tools used to construct and communicate discipline-specific knowledge claims (p. 567).

However, the complexity of science discourse may be overwhelming to students with limited experience and knowledge. This is compounded by the fact that high school students generally take three to four years of science; often in three distinct disciplines (Biology, Chemistry and Physics).

Roth (2005) asserts that “knowing a language and knowing one’s way around the world really are indistinguishable” (p. 5). Being able to navigate the world of science is important to both future scientists and non-scientists. Moje et.al. (2004) suggest that the inclusion of student funds of knowledge and home language can create a third space where students can begin to navigate the world of science. Creating an environment that gives value to students’ prior experiences, their culture and home language can be a way for students to enter into the dominant discourse of science and participate in ongoing discussions. Talking, scientific inquiry, reading and writing are some of the entry points suggested by research.

Developing Scientific Literacy – What works?

Scientific literacy has been a goal since the 1950’s. Many of the educational reforms stemming from this have focused on developing content knowledge. James Rutherford and Andrew Ahlgren outline in *Science for All Americans* (1989) aspects of content that individuals need to know while placing emphasis on the role of teaching and teaching strategies to make connections between the sciences. Others suggest that laboratory exercises contribute significantly to student understanding of the process of science (Millar, 2006; Singer, Hilton, & Schweingruber, 2005); yet there are many scientists who will never be able work inside a laboratory to gather evidence (Osborne, 2002). Science curricula limited to science facts and processes will not prepare scientifically literate students for participation in science discussions of the future. Alternative approaches such as incorporating student talk, reading, and writing into science classroom curricula and assessments have shed light on how these strategies contribute to the development of scientific literacy.

Talking.

Talking is a necessary part of science learning (Yore, Bisanz, & Hand, 2003) and can help students move from natural language to the dominant discourse (Lemke, 1990; Roth, 2005). Research on science talk suggests that as students discuss concepts, processes and results, initially their language will be vague and at times contradictory. However, as their understanding develops, the language they use to describe the phenomena will converge. These changes will build toward using science discourse effectively. One aspect of the SciJourn project that teachers have adopted is called a read aloud-think aloud. In this classroom activity, teachers select a science news article and read the article aloud to their students. While reading, teachers model how they make sense by thinking aloud. This particular strategy can help students find and use new strategies for understanding science news articles such as imbedded hyperlinks, asking questions while reading, re-reading parts to improve comprehension, and evaluating sources of information using attribution within the article. Through the incorporation of read aloud-think aloud articles, classes have incorporated several aspects of scientific literacy; teachers often choose articles that teens will find relevant, many of their questions help place this new information in the broader context of science by making connections to other knowledge, use of links to clarify meaning or to find more information, model searching strategies, introduce concepts such as credibility, attribution and the need for multiple sources, and using prior knowledge as a filter for the accuracy of the new information.

As students participate in the classroom discourse they will begin to adopt a shared vocabulary, set of practices, and routines that are constantly negotiated and used by the members of the class. This community of practice (Lave & Wenger, 1991) will meet the needs of the students in terms of learning goals and facilitate the development of a scientific discourse. However, the classroom community of practice will be vastly different from the scientists' community of practice. Bridging these two communities by improving scientific literacy will allow students to become legitimate peripheral participants (Lave & Wenger. 1991). The majority of high school students will not choose a career in traditional science research. However, within fifteen years after graduation they will have the opportunity to vote on a science related issue, encounter health related questions, use new technology, and participate in discussions with family, friends or co-workers about science in the news. This tangential participation in science discourse will continue throughout their lives. Current science knowledge and processes will most certainly change over the course of their lives. The questions and discussions that they will participate in cannot be predicted. It is clear that at some point all citizens will need to take on the role of a legitimate peripheral participant. Developing their scientific literacy practices is an essential step. SciJourn lessons encourage participation in classroom discussions about credibility, sources, questions, and context. These skills will be of use to students long after they leave the classroom.

Writing.

Scientists engage in a variety of writing activities (Yore, Hand, & Prain, 2002). Lab reports are often considered an essential component in high school science classrooms. Many studies have aimed at improving the quality of this type of writing (Singer, Hilton, & Schweingruber, 2005) yet students often see this type of task as busy work or something to just get done with. *America's Lab Report* suggests that this type of hands on experimentation with analysis can be done in other ways and achieve better results (Singer, Hilton, & Schweingruber, 2005). Labs often provide opportunities for students to experience phenomena and to begin to understand the limitations and processes associated with science inquiry (Jenkins, 2007). Improving student understanding of how science works by examining the role of evidence, claims and argumentation in science through writing and discussion with peers is one widely used approach. This writing to learn strategy is used during lab exercises to improve student understanding of both the content and the processes used to investigate in the lab exercise (Hand, Prain, & Wallace, 2002; Hand, Prain, & Yore, 2001; Keys et al., 1999).

Other writing to learn strategies such as writing for a younger audience require the student to translate what they know into a form more appropriate for the audience. This translation process can increase student understanding of science concepts (Hand, Eun-Mi, & Bruxvoort, 2006). Authentic literacy activities have been found to motivate elementary and middle school students (Duke, Purcell-Gates, Hall, & Tower, 2006). Writing to learn strategies such as those described above incorporate student science discourse in order to provide opportunities for students to form their own understanding about the phenomena in ways that traditional lab reports do not.

Reading.

Content is often thought of as a set of specific details within a subject. However, conceptual understanding of the subject is also important. Reading can be used to develop conceptual understanding in science rather than relying on lab experiments (Feynman, 1998). The primary text used in classrooms is generally the textbook.

Until the early 1990's science textbooks were text driven (Yore, Bisanz, & Hand, 2003). Newer science textbooks focus more on the interaction between the reader, the text, and their personal experiences beyond the text. Using science tradebooks (Saul, 2004) and informational text such as brochures and news reports (Adendorff & Parkinson, 2004; Alvermann & Heron, 2001; Elliot, 2006; Hapgood & Palincsar, 2007; Norris & Phillips, 1994) as alternatives to the textbook can help to contextualize the information. Home and school literacies are often mismatched (Duke & Purcell-Gates, 2003; Moje et al., 2001). Alternative texts can help mediate the students' school science discourse and that of scientists and the public.

Reading, writing, and talking.

Learning is situated (Gee, 1992; Purcell-Gates, Jacobson, Deneger, & Soler, 2002). Scientific words hold multiple meanings and the correct interpretation is dependent on the context of the words' use. Most science classes attempt to develop student science discourse by immersion in discourse, whether it is listening, reading, writing, talking, or gesturing. However, students would benefit from explicit instruction in these areas (Moje, 2008; Purcell-Gates, Duke, & Martineau, 2007; Wilson, 2008) as it pertains to science discourse. Speech and writing (Kress, Ogborn, & Martins, 1998) and reading (Purcell-Gates, Duke, & Martineau, 2007) provide different opportunities to engage with science, represent understanding, and avenues to build conceptual understanding. Incorporating alternative approaches to combining reading and writing can promote sense making (Holliday, Yore, & Alvermann, 1994). Science journalists use reading, talking, listening, writing, and contextualizing to maximize their understanding of science content which is then translated into a form that others can understand. It is because of this that science journalism was chosen as representative of the set of practices needed to be scientifically literate.

Science Journalism: Scaffolding Instruction, Developing Scientific Literacy

Young children can ask never ending questions when they want to know about something. Older students are typically a little more pragmatic. It is possible to satisfy a need to know with a close approximation of the technical truth (Jenkins, 1990; Rutherford & Ahlgren, 1989). Getting to the point where they are satisfied with their own understanding requires students to make choices about what information to pay attention to and how much information is necessary. The SciJourn project utilizes the journalism model (Polman, et. al, 2010) to focus on these facets of individual understanding while asking students to write for a broader audience.

In 2010, the SciJourn team, led by Dr. E. Wendy Saul, engaged in a conversation about what constitutes standards for scientific literacy. Through these discussions led to a set of standards[1] that included five ideas: relevance, context, factual accuracy, multiple credible sources, and information seeking. While these discussions were occurring, the

[1]The SciJourn standards have been developed over a period of years using an iterative process. The original version, developed in conversation with Alan Newman, Laura Pearce, Wendy Saul, Nancy Singer and Eric Turley, were first offered in 2010 and is the version used for this dissertation. An elaborated description of the current standards can be found in *Front-Page Science* or on the Project website, Teach4SciJourn.org.

SciJourn team was working with students in both formal and informal educational settings to learn how to bridge the world of science journalism and the classroom. The scientific literacy standards outlined by SciJourn, authentic assessment practices, and the definition of science literacy adopted by the SciJourn program were used as a framework for developing the SciJourn Scientific Literacy Assessment (SLA).

There are five aspects of scientific literacy identified by the project that have been adapted from the practices of professional science journalists for high school classrooms to provide students experiences carrying out STEM-related information gathering, analysis and communication that should equip them for the kind of situations they will face 15 years after high school graduation. These aspects were used to develop standards for science news article writing that can guide instruction (Polman, et al., 2010; see Appendix A for complete standards):

1. Students are able to **search effectively** for and recognize relevant, credible information sources, especially on the Internet.
2. Student articles are based on **multiple, credible, attributed sources.**
3. Scientific information, discoveries and technologies are **contextualized**; broader implications as well as reflections on past and future understandings are noted.
4. Scientific information is **relevant** to readers.
5. Information is **factually accurate** and important information is fore-fronted.

As a whole these standards indicate what a student needs be able to do in order to make decisions while answering a question about a science topic. As the students complete their research, write and revise their articles the practices developed are used in a variety of ways. It is the incorporation of the fundamental sense (reading, interviewing, talking, and writing) with the derived sense (the science content within their article) that distinguishes this project from traditional classroom practice. Student journalists are supported by their teachers and the members of the SciJourn project as they draft and revise their articles. It is through this iterative process that students develop content knowledge, identity, and critical literacy (Moje, 2008).

Measuring Scientific Literacy

There are a large variety of types of scientific literacy assessments. This is in part due to the large variety of definitions. Laugksch & Spargo (1996) describe scientific literacy in terms of conceptual knowledge, contextualization and skills. Evaluated together these three areas provide a good representation of scientific literacy. Tests that focus on specific content knowledge stem from the view that in order to be literate, one must know certain things. Other assessments focus on political hot topics, such as stem cells or HIV or how connected an individual feels to the environment or science in general. These tests only look at one aspect of scientific literacy. PISA (Bybee & McCrae, 2009) assesses both students' content knowledge and their ability to interpret science writing (text and graphs). Korpan, Bisanz, Bisanz, & Henderson (1997) developed an assessment using science news articles and questions about the process of science. Both of these assessments evaluate more of an individual’s scientific literacy than the others. However, these are still incomplete assessments; Laugksch (2000) asserts that there is a need for assessments that evaluate all three areas of conceptual knowledge, contextualization and skills. Based on the lack of current assessments that focus on all three areas and stemming from the standards described above—which include conceptual understanding, contextualization, and skills—an assessment was developed for the project.

One challenge of assessments is to be authentic. Moje & Handy (1995) describe a way to improve assessments by incorporating authentic tasks. The incorporation of authentic tasks within the SLA utilizes open ended questions about student relevant topics such as health and travel. Roth and Lee (2004) provide an example of how the construction and communication of scientific information is facilitated by incorporating local environmental issues and community presentations into the curriculum. Other research has provided examples of how student funds of knowledge and home language can be used to construct science understanding (Alvermann & Heron, 2001; Moje, 2000).

With these ideas in mind (authentic assessment within a socio-scientific context) I created an assessment that consists of four parts each with a different focus. The first section has a science news article and a set of questions associated with the story. Two science journalists wrote the science news articles, which have errors purposefully imbedded within them, these errors include factual inaccuracies, incomplete attributions, and sources with doubtful credibility. Another section consists of a set of images, i.e., the aftermath of a flood or other natural disaster. Questions in this section are intended to provide indications of students' ability to place information in context and to establish relevance. Section three uses informational text, made to look like a brochure. Questions in this section focus on the application of information to making decisions, identifying additional credible sources of information, and placing this information into context. The last section includes a graph with some associated text (made to look like a presentation slide). Students are asked to provide feedback to a peer and suggest some additional sources of information. Several questions on searching and search strategies are found throughout. Questions included have varying difficulty; easy (most students will get right), medium (about half will get right), and hard (few will get right) based on Item Response Theory (Baker, 2001). SLA development and the subsequent reliability and validity studies are presented in Chapter 3.

Summary

Over the past 50 years many definitions of scientific literacy have resulted in a variety of initiatives aimed at improving content knowledge and the understanding of the practices of science. The Science Literacy through Science Journalism project has developed a set of standards influenced in part by the intersections of these various definitions, and using science journalists as a model. The SciJourn definition of scientific literacy, conversations with science journalists and evaluations of other scientific literacy assessments influenced the development of an assessment that evaluates scientific literacy in its entirety, as described in the standards. This assessment will be used to study the impact participation in science journalism activities has on student scientific literacy practices.

Chapter Three

Assessment Development

This research examines the impact participation in SciJourn activities has on student scientific literacy. The study looks at changes in student scientific literacy as related to locating sources using search engines, critically examining credibility of research and sources, recognizing the relevance of scientific information, understanding its societal and scientific contextualization, and determining its factual accuracy.

The three main goals of this study are as follows:

- Development of an instrument that measures student scientific literacy through a series of authentic tasks, the SLA.
- Analyzing the SLA instrument for content validity and reliability.
- Using the SLA to determine if participation in educative science journalism activities impacts high school students' scientific literacy. This goal will be discussed in Chapter 4.

This chapter is divided into two sections. The chapter begins with a description of the development and refinement of the Scientific Literacy Assessment (SLA); then the statistical evaluation of the assessment will be described.

Assessment Development

Unlike some other attempts at assessing scientific literacy, the research team's approach is premised on the notion that scientific literacy is not limited to an accumulation of facts and concepts, but includes the ability to critically consume and produce science information in order to make decisions personally, socially, and politically. Research on scientific literacy stems from three broad interests: social scientists and public opinion researchers, sociologists, and science educators (Laugksch, 2000). Although many of these groups agree on a multidimensional nature of scientific literacy (conceptual knowledge, contextualization, and skills) rarely is scientific literacy measured in its entirety (Laugksch & Spargo, 1996). Other approaches to assessing scientific literacy focus on smaller components of scientific literacy separately, providing an incomplete picture of student scientific literacy. Few composite measures of scientific literacy have been published (Laugksch, 2000). While there are a multitude of assessments designed to assess conceptual understandings in science, an instrument that captures a more complete view of scientific literacy is needed. The types of tasks selected and methods of analysis were influenced by other endeavors (Chatterji, 2003; Cohen, Manion, & Morrison, 2007; Norris, Phillips & Korpan, 2003). The SciJourn Scientific Literacy Assessment has been created as a composite measure that can provide information about the individual's understanding of science as it applies to societal concerns but also how it relates to the world of science. This is accomplished using science journalism as a springboard for the assessment.

As part of the Science Literacy through Science Journalism project, teachers participate in a two-week professional development program based on an apprenticeship model. Working directly with a literacy expert and a professional science journalist/editor, participating teachers research a topic, interview experts, examine relevant literature and write a science news article. While doing this, the process is dissected with teachers discussing and reflecting on the practice being addressed (Figure 3.1) and how implementing these strategies in the classroom will help students improve practice in these areas. In the following school year, teachers work through this process with their students (Figure 3.2) using a variety of lesson ideas from the summer professional development and from other resources. This iterative model focuses attention on the practices described in the SciJourn Standards (Appendix A). These standards cannot be measured by current scientific literacy assessments due to the focus on practices of scientifically literate individuals described by the standards. While content (specific facts and nature of science methods) is necessary to answer some of the questions, tasks explicitly assessing this information are not included. The focus of the SLA is on the communicative skills needed to make sense of scientific information.

Extant Scientific Literacy Assessments

Current standardized scientific literacy assessments such as the NAEP were studied along with a wide variety of other available scientific literacy assessments. Early on it was noted that most of these assessment were multiple choice and relied on students to recall science facts or apply basic laws or principles. As a result critical thinking assessments were studied as well. Taking into consideration the goals of the project, the SciJourn standards and what was already available, it became clear that existing assessments would not meet the needs of this study. Korpan, Bisanz, Bisanz, and Henderson (1997) posit that one of the hallmarks of scientific literacy is "the ability to make effective requests for information or to ask good questions about scientific research" (p. 518). Their study provided some insight into how to assess these communicative skills.

A series of assessment tasks were developed in 2008 to measure the scientific literacy practices that enable high school students to be critical consumers and producers of science information. These tasks stem from the broader goals of educating students to think, talk, and write critically about what they read, hear, and see in the media in several ways:

- Understand what counts as science
- Recognize the risks and benefits of scientific discoveries and new technologies
- Develop the confidence and skills to tackle science and technology issues independently
- Seek out experts to answer questions and solve problems
- Understand the nature of science as an ongoing process of exploration with varying opinions or general consensus on theories, different stakeholders, and levels of expertise
- Recognize and utilize norms for both claims and evidence in science

Many of these early tasks asked students to suggest sources and pose questions that the source could answer about a science topic. Other tasks focused on research and writing. While working with students, it was noticed that their ability to locate credible information on the web was limited; additional tasks were created to look at changes to their searching abilities. By the end of the summer of 2009, over 15 types of tasks were identified as potential assessment tasks. With such a variety of practices being addressed, it was necessary that the structure of the final assessment would be varied as well.

Using the SciJourn standards as a guide, I generated a list of communicative skills to be targeted by the assessment: evaluate expertise, identify appropriate questions for experts, select and use multiple credible sources to gain more information, determine coherence between an image or graphic and accompanying text, and employ effective search strategies for more information. The assessment has been designed to evaluate each of these using a combination of science news articles, informational text, images and graphs with associated text.

The National Research Council (NRC) framework for developing assessments (Pellegrino, Chudowsky, & Glaser, 2001) was used as a guide for the development of the SLA. Accordingly, assessment development will be presented in the three component parts of this framework: cognition, observation, and interpretation.

Cognition.

Stemming from informal and formal discussions with practicing science journalists, science educators and educational researchers, looking at student articles and observing classrooms, a set of standards were developed (introduced briefly in Chapter 2; shown in their entirety in Appendix A). These standards outline five aspects of scientific literacy: information seeking, multiple credible attributed sources, contextualization, relevance, and factual accuracy. Each aspect is an integral part of scientific literacy that allows an individual to gather and evaluate information for both credibility and factual accuracy to make decisions personally, socially, and politically. The standards were used as the target for what students should know and be able to do when designing and selecting the assessment tasks. Scientific literacy is a latent trait and therefore unable to be directly assessed; as a result open response questions were used to assess the five aspects of scientific literacy.

Observation.

A wide range of SciJourn related tasks were identified as potential assessment tasks such as: original reporting, article construction and deconstruction, searching for information, identifying experts, analyzing science news reports and evaluating sources. A total of 13 assessment tasks were drafted for classroom use. Each of these tasks was created to address multiple standards. During the fall of 2009, 11 teachers piloted three different assessment tasks in their classrooms; two tasks of their choosing and one that was assigned. There were three tasks that were not chosen by any of the teachers because they would require too much time in the classroom. Initially student responses were coded according to standard and then examined for quality of answer. This information was used to identify tasks that provided a range of scores and answers that could distinguish between levels of scientific literacy. Analyzing an article, photo captions, graphic/text analysis, and informational brochure tasks were chosen to be incorporated into a larger assessment. The revised combined assessment was piloted in six teachers' classrooms during May of 2010. These responses were coded and scored. These data were used to finalize the scientific literacy assessment used during the full implementation year (Fall 2010 to Spring 2011). Two versions of the assessment were created using the piloted template (Appendix B and C). Each assessment consists of four sections (news article, health brochure, photo captions, and student PowerPoint presentation). Within these sections are questions of both varying difficulty and targeted standards (Table 3.1).

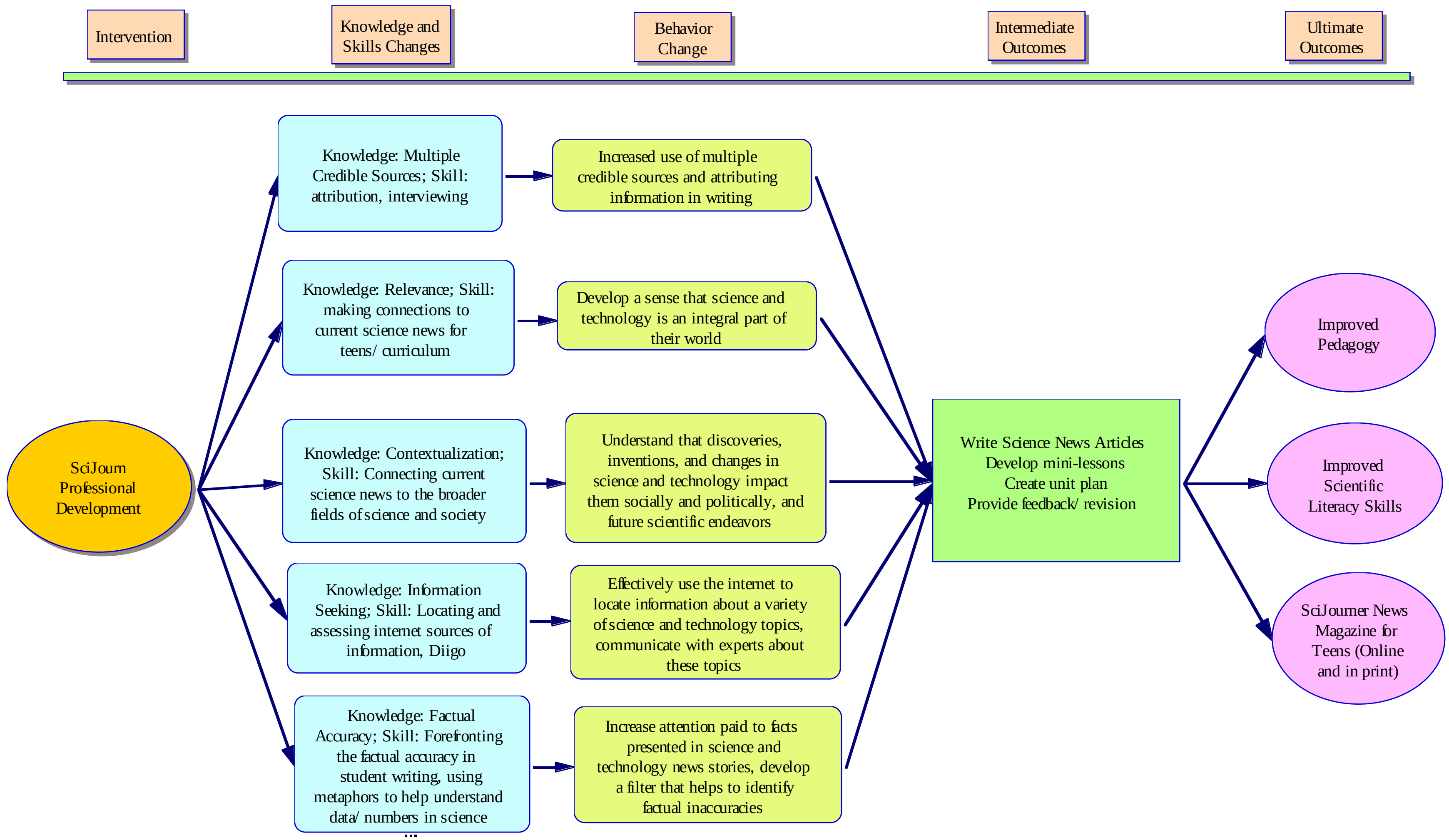

Figure 3.1. Targeted understandings and intended outcomes for SciJourn Professional Development

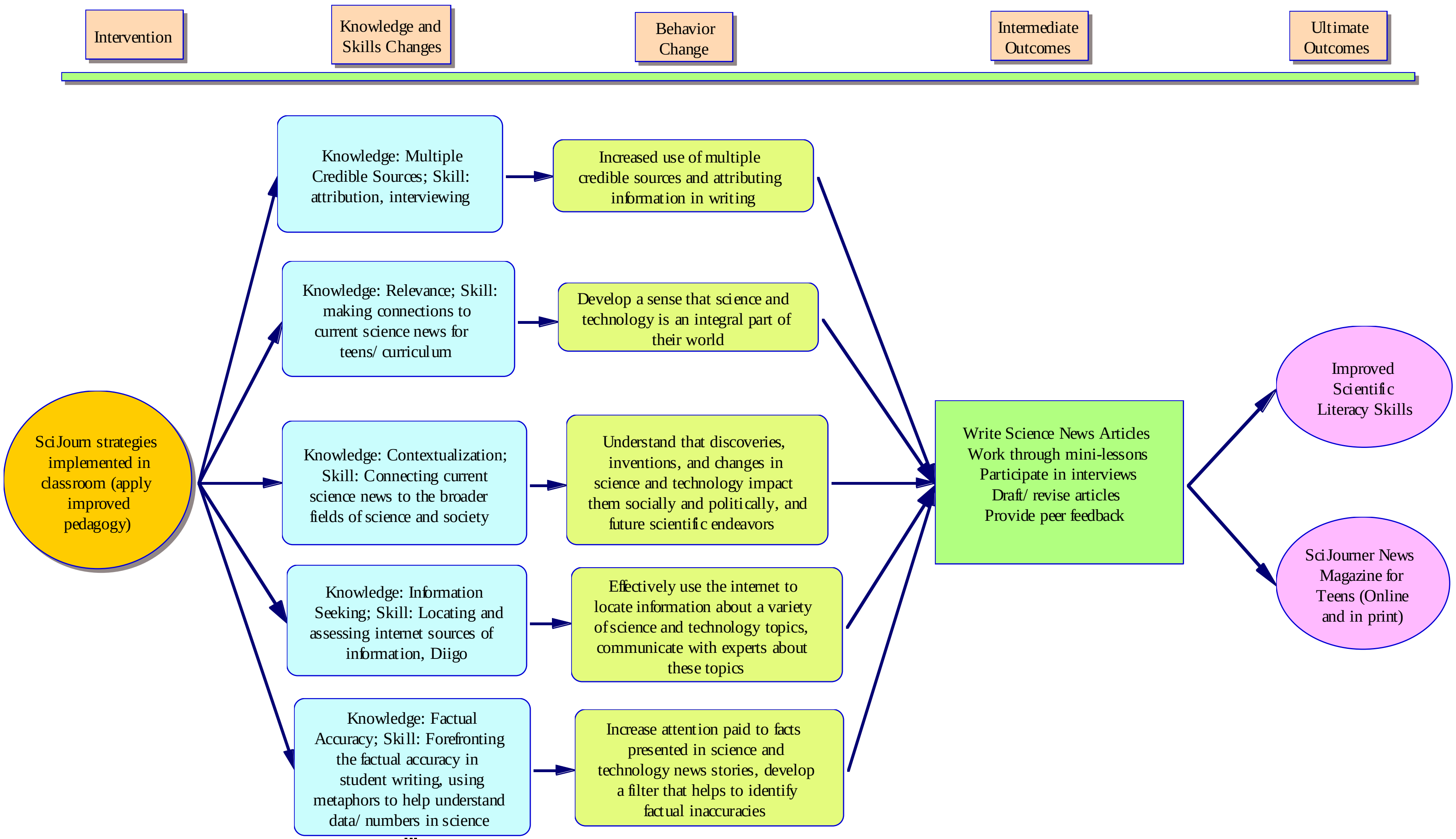

Figure 3.2. Targeted understandings and intended outcomes from implementing SciJourn in classrooms

Table 3.1

Questions: Section, Targeted Standard, Task Description, and Difficulty Level

Question Number	Targeted Standard[a]	Task Description	Difficulty Level
Section 1: Article			
1	R	Suggest a local audience	Low
2	R	Suggest a wider audience	Med
4	FA	Indicate facts that need clarification	Low
5	FA	Request additional factual information	Med
6	MCS	Suggest an interviewee for a follow-up article	Low
7a	MCS	Determine credibility and explain reasoning	High
7b	MCS	Determine credibility and explain reasoning	Med
7c	MCS	Determine credibility and explain reasoning	High
8	IS	Request information to evaluate a website	High
9a	IS	Select appropriate hyperlinks	Low
9b	IS	Use of hyperlink correlates to expected results	High
10	MCS	Select appropriate source for additional information	Low
11	MCS	Select appropriate source for additional information	Low
12	MCS	Select appropriate source for additional information	Low
Section 2: Photo Caption			
13	R	Describe a directly affected audience	Low
14	R	Describe an indirectly affected audience	High
15	C	Identify possible direct impacts	Med
16	C	Identify possible indirect impacts	High
Section 3: Health Brochure			
17	FA	Apply information to evaluate health risk	Low
18a	MCS	Suggest a credible source on specific health topic	Low
18b	MCS	Suggested source is appropriate for questions posed	Med
19	IS	Explain why search term will be ineffective	Med
20	C	Place risk in the broader context of science and society	Low
Section 4: Student Presentation			
21	FA	Identify factual error in presentation	High
22a	MCS	Suggest a credible source	Low
22b	MCS	Suggested source is appropriate for questions posed	Med
23a	IS	Suggest search strategy for additional information	Low
23b	IS	Search strategy is aligned to search expectations	Med
24	FA	Make suggestions for improvement targeting FA	High

Note. [a]FA= factual accuracy, MCS= multiple credible sources, IS= information seeking, C= contextualization, R= relevance.

Interpretation.

The 24 question assessment combines open ended questions targeting the five standards strands using low, medium and high difficulty questions. The responses to these questions were evaluated quantitatively and qualitatively. The scoring guide was created using an expert novice comparison. The coding scheme was developed using emergent themes and used to describe changes to student abilities. This qualitative analysis will be discussed in Chapter 5.

The scoring guide was used to quantitatively evaluate student responses on pre-implementation and post-implementation assessments. The methods for quantitatively analyzing student scientific literacy using the SLA will be discussed in Chapter 4. An examination of variables and their effects on student SLA achievement will be conducted using factor analysis and hierarchical linear modeling, the results from this quantitative analysis will be discussed in Chapter 6. A qualitative analysis of student responses was conducted using emergent theme coding and will be discussed in Chapter 5.

Expert novice comparison.

Experts (*n*=18) including scientists, science journalists, and science educators completed the assessment to inform the creation of a scoring guide for the SLA. Using these responses and a selection of student responses (*n*=100) an expert novice comparison was conducted. The responses of both novices and experts were coded according to standards and inter-item commonalities within each group were identified. A broad picture of differences between experts and novices was established using themes within responses from their assessments, the SciJourn standards and reflection on what constitutes scientific literacy. As mentioned previously, student abilities to find credible information on the web were very limited, but we needed to understand what constituted expertise in this area, as well as determining credibility of sources, identifying factual inaccuracy, contextualizing new information and establishing relevance to self and others.

Information Seeking.

Several aspects of finding and evaluating information constitute information seeking. Students need to first find information on the web. This is generally accomplished using search engines such as Google, Yahoo, and Bing. These types of searches provide a wide selection of websites, documents, blogs and articles. With so many choices, students need a strategy to identify what are credible sources of information. Once they have located a credible source of information, students may need to locate other similar sources or find new sources to improve their understanding of science. During our project implementation across 25 diverse public and private schools in 2009-2011, we have found that there is an unwritten rule in many schools and classrooms that using sites like Wikipedia should be avoided. However, as our editor has noted, Wikipedia can provide background information which helps students to know what words to use when searching for credible information. In essence what seems like a fairly straightforward task, finding information on the web, is much more complex. Due to this complexity it was important to look at how experts approach a similar task. One question on the assessment asks for students to suggest search terms. Often students suggested terms that were directly from the title of the presentation or the question itself. Experts however used a much different strategy. While they also used key words from the title or question, these were often paired with other words making the request clearer and narrowing the results of the search. For example:

Carbon dioxide and temperature correlations

“global climate change” research

Pub Med obesity and adult diabetes

In each of these examples experts combined key terms (carbon dioxide, temperature, diabetes, obesity) with words that narrowed the search (research, Pub Med, correlations). Additionally, the experts often linked two ideas with and in their search terms. Students had one particular strategy that occurred frequently, phrasing the search terms as a question. Students and experts were also asked to describe what type of information they hoped the search would provide. Experts tended to have very specific information targeted with the search such as the following:

Search phrase suggested: *”global climate change” research*

Expected results: *“some scholarly articles to get an idea of who may be key researchers, some research summary sites, some unreliable sites that claim their thoughts are research based” (Expert 13)*

With student responses, the search terms tended to mirror the expected results exactly for example:

Search phrase suggested: “*carbon dioxide levels”*

Expected results: *“facts on carbon dioxide levels*” (025-019)

Expert searches were narrower, used terminology targeting specific search goals and their expected results often took into consideration that some of the results would contradict one another or not be credible. Student searches were often very broad and expected results generally mirrored the search terms without explicitly taking into consideration that some of their results could be irrelevant or not credible. This lack of searching ability was targeted through several mini-lessons developed for the professional development workshop, and teachers developed many of their own lessons.

Search results generally include websites. Through observations in classrooms students often based website credibility on logos, design, and advertisements. Experts used a variety of cues to determine credibility of websites (see Table 3.2). Similar to the search expectations, experts had specific information that they expected the website to provide in order to determine if the website was a credible source of information. In general, expert suggested search terms, expected search results and website credibility cues were more specific than students. However, websites are not the only source of information that Internet searches provide. Student searches often result in millions of hits. One rule of thumb students' use is to look at the ending of the URL; if it is a .org, .edu, or .gov then it is deemed an acceptable site. However, if it is a .com that implies that it is not an acceptable site. This simple heuristic ignores the fact that if you are looking for information on a product, the manufacturer may be a very credible site and a .com. This heuristic does not equip students to evaluate the websites beyond the URL. There are other important considerations when determining credibility such as bias, mission, funding, and currency of information. Experts use multiple cues to judge credibility rather than relying on the URL.

Table 3.2

Website Credibility Cues Used by Experts

Cue	Example Responses
Who are they	Who founded it? Who runs this website? What expertise do they have?
Affiliation	What organization runs the website? Who uses their services and for what reasons?
Funding	Who finances it? How is it funded?
Oversight	Are the entries reviewed by doctors? Are the facts referenced? Who regulates it?
Factual accuracy	Where does the information come from? How up to date is its knowledge? Where is the data come from? Do scientists agree that is true?

Multiple Credible Sources.

Articles in pdf and html formats from journals, blogs, and websites are often included in the search results. Experts can rely on prior experiences to know if a journal is reputable or if a specific author is to be trusted. Students have limited experience with science information beyond their textbooks. On the assessment, several sources of quotes and facts are included in the news article section. Students and experts were asked to judge the credibility of these sources and explain their reasoning. While there was some overlap in the criteria that experts and novices used to determine credibility the frequency (Table 3.3) and manner of use were vastly different.

Table 3.3

Most Commonly Used Criteria for Determining Credibility by Experts and Novices

EXPERTS	NOVICES
Government sponsored	General knowledge
Field of expertise	Experience or training
Use of evidence	Opinion
Reputation or credentials	Title

Both experts and novices relied on expertise or experience to determine credibility. Experts often questioned the expertise or experience of an unknown group such as the Lead Pipe Initiative, a fictitious citizen group identified in one of the articles within the assessment. Experts used this strategy to not only question the group’s factual accuracy but also to qualify the group’s expertise (example 1), limiting its credibility (example 2).

Example 1:

A nonprofit made up of citizens with an interest in this issue for some reason. Do they have medical backgrounds, or chemistry backgrounds? What makes them so convinced? That makes me trust them less– but they must have some reason to be concerned. (Expert 5)

Example 2:

While they may not be experts and critical officials trained in lead or water issues, they are the residents living with the problem. Their experiences and perceptions are important to consider. (Expert 2)

In both of these examples experts weigh the evidence provided in the article (a concerned citizen group) against what was missing (clear expertise or experience) with the final evaluation that the group was credible but their comments could be suspect. Students were more likely to say the Lead Pipe Initiative was not credible (example 3, 4, and 5) using some of the same reasons as the experts. This black and white approach to credibility was seen throughout the assessment on questions where students were evaluating expertise. In example 5, the student clearly questions the expertise of the group, concluding that they are not credible; although the citizens have an important part in the discussion about lead pipe replacement. This type of response may be due to the students not having an understanding of the role of citizens in public issues that involve science.

Example 3:

> *They are not creditable [sic] because they don't like lead and don't have much knowledge on the subject. (020-009)*

Example 4:

> *They are citizens, not scientists or experts on the subject (035-036)*

Example 5:

> *They are a citizen organized group and some/most of them may not know what they're saying. (021-013)*

Experts considered government agencies to be very credible, in part due to their affiliation but also because of reporting requirements. Students also considered government agencies very credible, but did not consistently identify the EPA, CDC, or the WHO as governmental agencies. This is another example of where the life experiences and accumulated knowledge of an expert increases their ability to identify credible sources of information. Interestingly there were two criteria that students used but experts did not, title (example 6, 7, and 8) and opinion (example 9 and 10).

Example 6:

To earn the "Institute" status, means it must be credible (025-074)

Example 7:

They are an institute dedicated to that kind of stuff (029-007)

Example 8:

Institutes usually have very credible information. (025-034)

Example 9:

Sounds credible (025-015)

Example 10:

If the person is a scientist who has studied the topic then it should be credible but if it's just a random person then it might not be very credible. (025-049)

The last two examples were surprisingly common. Students often remarked that because the source was included in an article it must be credible. It seems as if experts assume a lack of credibility first and use information provided to establish it. Students on the other hand assume credibility and rely on information provided to discredit the source when confronted with official sounding organizations (Institute for Earth Science) and individuals with titles or as demonstrated by example 9, they use a gut feeling to establish credibility. In both instances students are at a disadvantage for establishing credibility. Their own experiences are limited and therefore they do not have a clear understanding that expertise is situational and the presence of a title does not ensure that the individual actually has the expertise required to answer the questions correctly. Unfamiliarity with governmental organizations and non-governmental organizations such as the American Heart Association prevents them from discerning credibility from the title of nationally known organizations. Finally, their inexperience also causes them to make generalizations about sources. In example 10, the student was referring to an individual who was simply identified as a public health expert, and there was not enough information to establish her expertise or her credibility. The student struggles with determining credibility were a common issue in both research and writing science news articles for *Scijourner*.

Factual Accuracy.

There were specific factual inaccuracies embedded in the new articles. One statement claimed that lead paint was made of 100% lead and in another article a statement claiming that the plume from a volcano was only 30 feet tall. These factual inaccuracies were easily identified and questioned by experts; however few students were able to identify them. In another section of the assessment a simulated student presentation is provided where the graph of carbon dioxide and global temperatures clearly correlate but the text indicates that there is no relationship. Again, experts consistently identified this factual inaccuracy as a problem with the presentation, while students rarely noted it. In addition experts often made additional suggestions of facts that should be included or checked that were intentionally fuzzy or ambiguous in the articles. The ability to identify factual inaccuracies, even when blatant, was markedly different between experts and novices.

Contextualization.

One common goal of science education is to help students place new information into what they already know about science and society. The ability to contextualize information in such a way allows the student to infer a purpose or need for the new technology or understand the impact of a new discovery. There were three ways in which experts answered the contextualization questions: providing both specific science and specific societal connections, providing a combination of broad and specific science and societal connections, or providing broad connections to either science or society. Students tended to only be able to make broad connections (Table 3.4).

Table 3.4

Sample Answers within Contextualization Categories

Both specific societal and specific scientific connections	
Experts	*Because oil spills can harm underwater ecosystems, kill or injure birds (and I think fish, too), and foul public beaches (Expert 3)*
Novices	*It can kill very important animals in the Gulf. People eat and make a living off of. (034-019)*
Combination of broad and specific connections to science and society	
Experts	*It could affect wildlife, fisheries, tourism (Expert 1)*
Novices	*Lose of fish, and other resources of income (034-053)*
Only broad connections to either science or society	
Experts	*Could destroy ecosystems in the water and in the land near the water (Expert 6)*
Novices	*Kill marine life (030-004)*

Relevance.

Students are often heard remarking “why do I have to learn this?” or “What does it matter, I will never use this”. These types of statements reflect the fact that students often do not see the relevance between what is taught in school and their own future. Several questions ask students and experts to suggest who should read this information. Both students and experts approach these questions in two ways, identifying individuals that have a direct specific need to know and identifying individuals that as members of the society should know about it (Table 3.5). However, students often lack specificity, using words like everyone or anyone. Experts make a clear connection between the group and the purpose.

Students often identify a need to know that is both important and relevant, but they suggest an audience that includes individuals that may not have that need. In the second novice example in Table 3.5 the student includes all parents, yet not all parents live in areas where there are lead pipes or areas where there are pipe replacement projects underway. In the first example the student makes a stronger connection between homeowners and a possible need to replace lead pipes but makes a leap that every homeowner with lead pipes should have them removed when there is no recommendation to do so in the article. With the expert answers, there is a clear connection between who should read the article and why. Their reasoning often includes members of the general population as well as those who are more directly affected by the information. Specificity of audience and need is exemplified by the experts. Understanding the relevance of science and technological information is an important aspect of scientific literacy.

Table 3.5

Establishing Relevance by Suggesting Who Should Read <u>*Citizens Block Lead Pipe Replacement*</u>

Experts	Novices
I think that parents who live in areas where lead pipes are used in the water distribution systems would be especially interested. I think the topic itself would be of interest to many Americans, however. Because children can be most impacted by being exposed to lead while they are growing, parents and members of society interested in helping ensure that children aren't exposed to lead need to know about this. (Expert 3)	*I think that anyone who has lead pipes in their home should read this article. This is a very serious issue that is effecting children's ability to learn so I think that it is very important for people to make sure that they do not have lead pipes in their house. Anyone who does have lead pipes should ask their local government if any effort is being made to have them all removed and if not, then the individual homeowner should have the pipes removed themselves. (025-080)*
Absolutely. Citizens, city planners, child care providers, etc. Citizens and child care providers need information similar to this presented in this article simply to gain awareness of the potential for lead contamination and its effect on children, and it can also inform them if and when action may need to take place. City planners, of course, to determine the reach of their decisions. (Expert 2)	*I think people with young children should read this article. I think most parents would want to know that it could be harmful to there children. (026-019)*

The comparative analysis of the expert answers with the novice answers allowed for a clear distinction to be made about what constituted a high quality answer, a mid-quality answer, a low-quality answer and answers that were insufficient or incorrect. As a result a four tier scoring (0,1,2,3 points) guide (Appendix D) was created using both expert and novice answers to provide guidance in scoring. This scoring guide will be used to evaluate student scientific literacy assessments.

Assessment Development – Assessment Validation and Reliability Studies

Assessment evaluation stemmed from several questions about face validity, content validity, temporal reliability, form equivalence, and internal consistency, each of which will be addressed in this chapter.

Face validity.

Several questions regarding face validity were identified for this analysis:

- Do high school students interpret the questions in the manner intended?
- Why do students leave questions blank?
- Do high school students feel that this test is written at an appropriate level?

To answer these questions, 10 student interviews were conducted where they completed the assessment orally. The students included some who had previously taken the assessment, some who had not, both males (6) and females (4) and different ethnicities (3 black, 7 white). During the interview student answers were recorded on the assessment by the interviewer. The assessment questions were read exactly as written, when a student asked for clarification it was noted on the assessment paper. Three follow-up questions were used once the assessment was completed.

- Were there any questions that were hard to understand?
- Do you feel that this test is written at an appropriate level for high school students?
- If they did not answer a question: why were you unable to answer (or had difficulty answering) xx question?

All ten students stated that the assessment was easily understood and appropriate for high school students, regardless of how they scored on the assessment. When students were unable to or had difficulty in answering a question, they stated that it was because they did not know the answer, not because they did not understand the question. Question 3 which asked students “what connections can you make between the article and what you have learned in school” was the only question that students asked to be re-stated (Appendix B and C). When re-stated they still could not provide an answer. When asked about this, they stated it was because they did not see a connection between the article and their school experience. (This particular question is not included in the score nor was it included in the analysis described in this study). Based on these student interviews, the assessment can be considered valid in terms of face validity.

Content validity.

Experts were engaged to determine content validity. Each of the experts (2 science journalists, 5 science educators, and 3 scientists) held a minimum of 10 years experience in their field. The assessment was administered to each of them, after which they were asked to score each item as essential to developing scientific literacy, useful but not essential, or not necessary. Using Lawshe’s formula for determining content validity a CVR score for each item was determined (Table 3.6). Based on this data two items fall below the acceptable score of 0.62. Question number 1 addresses relevance, asking students to suggest someone that this article might be of interest to and question number 21 which asked students to provide feedback to a peer on a PowerPoint presentation slide. No reason was given for scoring question 1 as such. For question 21, there was one individual concerned about the need for prior knowledge and another concerned about student computer skills. This particular question has a factual inaccuracy embedded in the presentation (graph and textual analysis contradict each other). The purpose of the question is to measure the students' ability to interpret the graph and to compare data and textual analysis for factual accuracy. Their ability to answer correctly to some extent does rely on prior knowledge and/ or skill, although as with any assessment the object is to make evident how prior knowledge is applied to new situations, as such this particular item has been retained. Question one will be recommended for removal upon revision.

Concurrent validity.

The rationale for including such a wide variety of tasks and difficulty levels is to ensure discrimination between individuals who are scientifically literate from those who are less scientifically literate. One measure of this is concurrent validity. A one-way t-test was used to compare experts and novices. Experts scored significantly higher ($p < 0.001$) than novices (Appendix E) for all questions and standard strands.

Internal reliability.

Each assessment consists of 24 questions. Five questions address factual accuracy using embedded factual errors in three sections and one question where students apply information. Four questions require students to establish relevance using a media report or images of a natural disaster. Multiple, credible, attributed sources are addressed in five questions spread throughout all four sections of the assessment. Four questions assess contextualization using the media report, images, and an informational brochure. There are six questions directed at search strategies. Within each of these question categories there are low ability, medium ability and high ability questions. This was intentionally designed in this manner to distinguish between ability levels.

Internal validity was determined using a test/ re-test approach (Gay, 1987). A one-tailed paired sample t-test revealed that students' pre-test scores (m = 1.11, s =0.58) were not significantly different $t(50) = 1.191$, $p>0.05$ from their post test scores (m = 1.04, s = 0.044).

This indicates that student overall scientific literacy scores are fairly stable over a short period of time (one school year).

The assessment was organized to include questions of low, medium and high difficulty across the standard strands (Table 3.1). Questions within each level assess different tasks within the standards, as well. Therefore the Cronbach Alpha levels are sufficient to indicate internal reliability based on difficulty level (Table 3.6).

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Figure 3.3. Cronbach's Alpha

Table 3.6

Internal Reliability for Difficulty Levels (Low, Medium, and High)

Difficulty Level	Number of Questions	Cronbach's Alpha
Low	12	0.763
Medium	8	0.694
High	8	0.631

Due to the variation in task and difficulty level using Cronbach's Alpha to determine internal reliability within the standard strands is not optimal. For example, within the multiple credible source strand, several practices are being assessed such as determining credibility, suggesting credible expert sources, and identifying questions appropriate for experts in addition to varying difficulty levels. This assessment is designed for high school students and time available in classrooms prohibits a longer test that would allow for multiple questions on practices at equivalent difficulty levels. Although scores are too low to claim reliability, they do indicate some correlation between scores within standard strands (Table 3.7). Additionally, one goal of this assessment is to assess scientific literacy in its entirety, therefore while looking at the standards independently may shed some light on components of scientific literacy, I contend that that these practices are related and combine to enable a person to tackle scientific issues in their lives. Therefore looking at the standards individually has limitations.

Table 3.7

Internal Reliability for Standard Strands

Standard	Number of Questions	Cronbach's Alpha
Information Seeking	4	0.514
Multiple Credible Sources	9	0.661
Contextualization	3	0.562
Relevance	4	0.405
Factual Accuracy	5	0.480

Confirmatory Factor Analysis

Scientific literacy has many components (see Figure 3.3). SciJourn activities target a small but important part of scientific literacy. The SLA was developed with SciJourn standards as a content framework. Confirmatory factor analysis did not support the divisions within the assessment based on standards targeted resulting in an unidentifiable model. This supports my contention that the individual described in the SciJourn standards are highly correlated making assessment of the five aspects separately difficult. Initial factor analysis indicated that there were 8 factors that could be identified. Further analysis indicated that the factors were closely associated with the section of the assessment (Table 3.8) and the task type as noted by the shading rather than the specific aspect being targeted. Dimensional analysis for the sub-scale categories indicated that there is a single construct being assessed using the SLA (Figure 3.4). Within this construct the aspects are highly correlated (Table 3.9); therefore the assessment is associated with one component of scientific literacy—practices associated with interpreting, evaluating and engaging in the communication of scientific information—and this component is influenced by and influences other components (i.e., subject matter knowledge, scientific practices, the application of scientific practice, life experiences). However the SciJourn standard framework provides a useful way of describing this part of scientific literacy. Throughout the remainder of the analysis the SciJourn standards framework will be used to illustrate the single component of scientific literacy involving the practices needed to interpret, evaluate, and engage in the communication of scientific information.

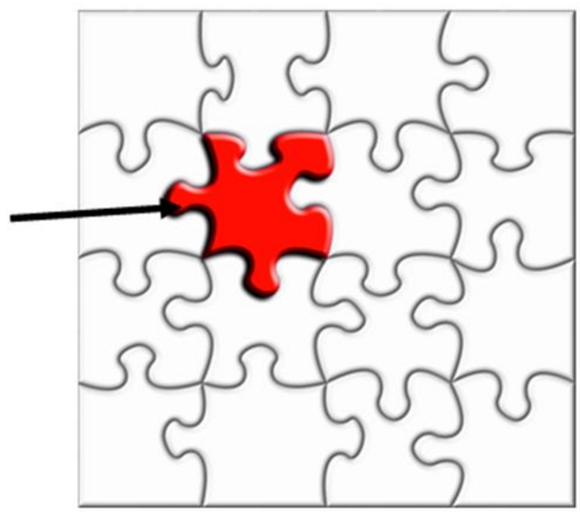

Figure 3.4. Communication as a component of Scientific Literacy.

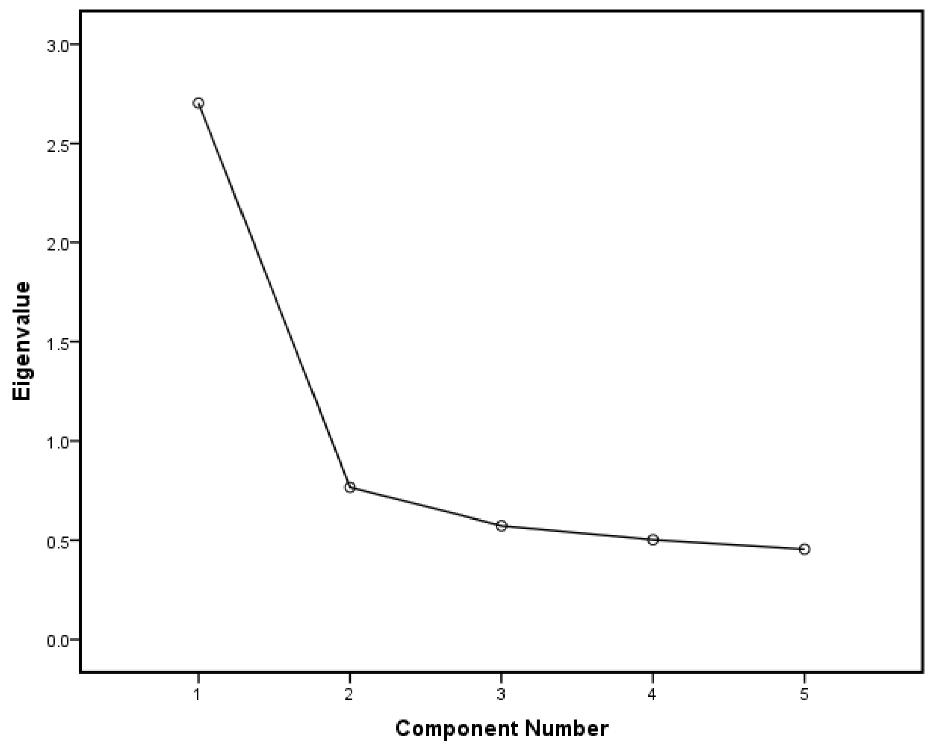

Figure 3.5. Scree plot for dimensional analysis of aspects of scientific literacy based on the SciJourn scientific literacy standards.

Table 3.8

Rotated Component Matrix[a] for All Questions on the SLA

Question	Component							
	1	2	3	4	5	6	7	8
Post 20	.629	.256	.180	.082	.151	-.018	.105	.000
Post 15	.610	-.030	.035	.127	.193	.172	.046	.200
Post 19	.581	.303	.075	-.028	-.028	-.024	.028	-.104
Post 17	.510	.054	.196	.070	.141	-.195	.202	-.035
Post 23b	.105	.888	.083	-.022	.002	.092	.144	.039
Post 23a	.150	.863	.128	-.016	.058	-.054	.144	.038
Post 24	.180	.500	.214	.132	.030	.175	-.087	.098
Post 21	-.041	.366	.051	.340	.235	.300	-.291	-.017
Post 18	.289	.237	.671	.070	.075	.036	.070	.025
Post 6	.060	-.130	.616	-.072	-.067	.022	.339	.108
Post 22	.309	.260	.601	.068	.046	.127	-.031	.026
Post 16	-.131	.188	.533	.107	.289	-.022	-.103	.076
Post 7C	.053	-.100	.041	.683	-.045	.222	.079	.003
Post 7B	-.033	.177	.088	.669	.041	-.111	.200	.158
Post 7A	.367	.013	-.098	.543	.073	-.261	.322	.129
Post 8	.380	.022	.270	.435	.055	.147	-.185	.048
Post 13	.147	.044	-.030	-.029	.773	.008	.099	.161
Post 14	.199	.025	.175	.057	.721	.020	.131	-.016
Post 12	-.217	.181	.124	.080	-.052	.701	.128	-.167
Post 9	.330	.011	-.001	.020	.081	.664	.195	.191
Post 10	.078	.139	.168	.172	.142	.145	.658	.020
Post 11	.287	.106	-.022	.197	.174	.207	.572	-.034
Post 2	.001	.071	.055	.120	.111	-.149	-.130	.716
Post 1	.448	-.069	-.087	-.064	.081	.131	.195	.535

Table 3.8 continued

Rotated Component Matrix[a] for All Questions on the SLA

Question	Component 1	2	3	4	5	6	7	8
Post 5	-.234	.102	.281	.032	.161	.247	.235	.474
Post 4	.055	.088	.377	.205	-.115	.028	-.001	.438

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 11 iterations.

Note: Section 1 of the SLA contains questions 1-12, Section 2 contains questions 13-16, Section 3 contains questions 17-20, and Section 4 contains questions 21-24.

Table 3.9

Component Matrix[a] for the Single Component of Scientific Literacy Indicated by Dimensional Analysis

Scientific Literacy Aspect	Component 1
Context	.759
Relevance	.603
Factual Accuracy	.745
Multiple Credible Sources	.776
Information Seeking	.778

Extraction Method: Principal Component Analysis.

a. 1 component extracted.

Summary

The SLA can be considered a composite assessment only if the responses are both analyzed quantitatively and qualitatively. The scoring of the assessment provides an indication of proficiency, whereas the qualitative analysis provides information about how students use the other three components of scientific literacy to construct responses.

According to the SLA analysis, it is a valid assessment for the practices targeted by the SciJourn standards and reliability in the assessment is connected to difficulty levels of the question. The SciJourn standards division of scientific literacy into five distinct aspects (relevance, factual accuracy, multiple credible attributed sources, context, and information seeking) was not supported by factor analysis. However, the standards help to describe the communicative component of scientific literacy targeted by the science journalism activities incorporated into participating classrooms. Based on this analysis, the quantitative analysis (Chapter 4 and 6) focuses on the single construct, scientific literacy, and the qualitative analysis (Chapter 5) looks at the student responses using the framework described in the standards.

Chapter Four

Findings: Quantitative Analysis of Student Scientific Literacy

Embedded in this chapter is a discussion of the methods and procedures for data collection, a description of the study participants, and analysis of the Scientific Literacy Assessment (SLA) looking at the effects of implementation on overall SLA score, by aspect and by implementation level.

Analyzing Student Scientific Literacy Using the SLA

A quasi-experimental research design (Gribbons & Herman, 1997) was chosen based on the study question, the type and quantity of data that would be collected, and the inability for true random selection of participants (Campbell & Stanley, 1963; Cangelosi, 1982; Caporaso, 1973; Cohen, Montague, Nathanson, & Swerdlik, 1988). The theoretical frame for the SLA was derived from the National Research Council (NRC) framework (Pellegrino, Chudowsky, & Glaser, 2001) for assessment and the SciJourn scientific literacy standards described previously in Chapter 3. Using these standards, observable indicators were identified and used to create an assessment. Finally the assessment was piloted, the pilot data was used to inform revisions, and two versions of the Scientific Literacy Assessment (Form A and Form B) were created and used for comparative analysis of the implementation group and the non-implementing comparison group. Using a balanced crossover design students were randomly assigned either Form A or Form B as a pre assessment by their teachers and the opposite form was administered as a post assessment.

Participants

Participation in the SciJourn project began with the teacher submitting an application. The research team reviewed applications and selected participants with the intent to include a variety of science classes as well as other subject areas and include a diversity of student socio-economic levels, geographic location (urban, suburban, and rural) and school types (private and public). Twenty five teachers representing this diversity agreed to participate in this research. The majority of teachers are science teachers (23 out of 25), although there was one Communication Arts and one Social Studies teacher as well. They are all secondary education teachers (9-12th grade).

Teachers participated in a two week intensive summer professional development focused on incorporating science journalism into their classrooms (Pilot in Summer 2009, and Cadre I in Summer 2010). The non-implementing comparison group consists of an additional eight teachers whose students served as a control group (Cadre II) during the 2010-2011 school year. Participation in either the Pilot group, Cadre I or Cadre II was determined primarily by teacher preference (i.e., which summer they were available to participate in professional development).

Under approved IRB procedures for the SciJourn grant, all students in Pilot, Cadre I and Cadre II teachers' classes were informed of the project and asked to participate in the research during 2010-11; only those who gave their assent and whose parents consented and consenting 18 years and older students were included in the research.

Over 3,000 students were assigned to the 25 participating teachers’ classrooms, approximately 50% agreed to participate in the study (*n*=1470). Due to the pre/post assessment comparison design of this analysis, only 914 matched pairs are included in the final analysis (implementation *n*= 673, comparison *n*= 241). The following descriptions refer to the 914 pairs sample (Table 4.1). Participating schools tended to be suburban (12 of 17) with fewer rural (3 of 17) and urban (2 of 17). The sample included both public schools (14 of 17) and parochial schools (3 of 17). The majority of students (81%) were in 9^{th} and 10^{th} grade. Fifty eight percent of the students were enrolled in physical science courses (chemistry, physics, physical science), 38% enrolled in life science courses (mainly biology), and the remaining 4% were enrolled in communication arts courses, with a single student in a sociology course. The comparison group had a greater percentage of participants in urban schools than the implementation group.

Table 4.1
School, Teacher, and Participant Descriptives

	Whole Group	Implementation	Comparison
Schools			
School Location			
Urban	2 (12%)	1 (8%)	1 (17%)
Suburban	12 (71%)	9 (75%)	4 (67%)
Rural	3 (18%)	2 (16%)	1 (17%)
School Type			
Public	14 (81%)	10 (83%)	4 (66%)
Parochial	3 (19%)	2 (17%)	2 (33%)
Teachers			
Participation Group			
Implementation	18*		
Comparison	7*		
Field			
Science	23 (92%)	16	7
English	1 (4%)	1	0
Social Studies	1 (4%)	1	0
Teacher Gender			
Female	17 (68%)	12 (66%)	5 (71%)
Male	8 (32%)	6 (34%)	2 (29%)

Table 4.1 Continued
School, Teacher, and Participant Descriptives

	Whole Group	Implementation	Comparison
Participants		673 (74%)	241 (26%)
Grade			
9		271 (40%)	55 (23%)
10		274 (41%)	147 (61%)
11		87 (13%)	22 (9%)
12		41 (6%)	17 (7%)
Subject Area			
Life Science	345 (38%)	270 (40%)	75 (31%)
Physical Science	531 (58%)	365 (54%)	166 (69%)
Other	38 (4%)	38 (6%)	0 (0%)
School Location			
Urban	125 (14%)	1 (0%)	124 (51%)
Suburban	579 (63%)	491 (73%)	88 (37%)
Rural	210 (23%)	181 (27%)	29 (12%)
School Type			
Public	673 (74%)	519 (77%)	154 (64%)
Parochial	241 (26%)	154 (23%)	87 (36%)

***** One teacher participated in both implementation and comparison groups

Data Collection

The pre-assessment was administered in August/September of 2010 and the post assessment was administered in May of 2011. Teachers were instructed to split their students into two groups with one taking Form A assessment and the other taking Form B assessment. In April, teachers were provided a list that detailed which form their students should take as a post assessment; as a result 93% of the students completed the opposite form of the assessment (A-B or B-A) and 7% completed the same form as their pre assessment (A-A or B-B) (Table 4.2). Teachers were given the option of having their students complete the assessment online or on paper. Due to technological constraints at schools, 76% of the teachers opted for the paper version. One concern in the assessment development phase was that students would be exposed to content during the regular school year that would improve their score on a particular form of the post assessment, but sequence of form administration had no significant effect on student scores

$F(1, 671) = 2.322$, $p > 0.128$ (Table 4.3). As shown in Table 4.4, there was no significant difference in overall post assessment scores $F(1,671) = 7.413$, $p < 0.007$ between formats (online and paper).

Table 4.2
Assessment Administration Descriptives

Administration Characteristic	Whole Group (*n*=914)	Implementation (*n*=673)	Comparison (*n*=241)
Form Sequence			
A-B	415 (45%)	317 (47%)	98 (41%)
B-A	410 (45%)	309 (46%)	101 (42%)
A-A	49 (5%)	21 (3%)	28 (12%)
B-B	40 (4%)	26 (4%)	14 (6%)
Format of Assessment			
Paper	693 (76%)	519 (77%)	174 (72%)
Online	221 (24%)	154 (23%)	67 (28%)

Table 4.3
ANOVA Results for Form Sequence Comparison Implementation Group Only (n=673)

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	246.869	1	246.869	2.322	0.128[a]
	Residual	71347.439	671	106.330		
	Total	71594.308	672			

Predictor: (Constant), AB Sequence, BA Sequence
Dependent Variable: Overall Post-Assessment Score

Table 4.4
ANOVA Results for Format (Online or Paper) Comparison Implementation Group Only (n=673)

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	782.359	1	782.359	7.413	0.007[a]
	Residual	70811.949	671	105.532		
	Total	71594.308	672			

Predictor: (Constant), Online or Paper
Dependent Variable: Overall Post-Assessment Score

Therefore all data was used in subsequent analyses, regardless of form sequence, or assessment format (online or paper).

Pre-Post Assessment Data Analysis

The assessment was scored using a scoring guide designed to evaluate responses in relation to the SciJourn scientific literacy standards. The scoring guide was based on a four point scale (0,1,2,and 3), higher scores including a greater focus on science-related responses. Pre-assessments and post-assessments completed on paper were converted to a digital form and collected in an excel file before scoring. Assessments (both pre and post) completed online were exported to an excel file for scoring.

A paired sample t-test was used to evaluate the impact participation in science journalism had on student scientific literacy based on the following assumptions being met: a large normally distributed data set (914 paired pre/post student assessments); equal variances between implementation and comparison groups; overall score and the five aspect sub-scores as dependent variables; and participation in the implementation group or comparison group as the independent variable. Sub-scale scores for each of the five aspects were calculated using an average of the questions that assess each specific aspect (as described in Table 4.5 below).

Subsequent testing included both additional paired *t*-tests and ANOVAs looking at additional factors.

Descriptive analysis

Using pre-assessment scores for both implementation and comparison groups, it was determined that there was equal variance for the pre-assessment overall and the five sub-scale categories (Table 4.5). Further analysis indicated that each of these sub-scale categories as well as the overall scores approximated a normal distribution (Figure 4.1-4.6).

Table 4.5

Levene's Test for Equality of Variances Overall and by Aspect (Pre-Assessment) (n=914)

Aspect	Levene Statistic	Sig.
Relevance	0.28	0.597
Context	0.331	0.565
Factual Accuracy	0.714	0.398
Multiple Credible Sources	8.008	0.005
Information Seeking	2.052	0.152
Overall	5.581	0.018

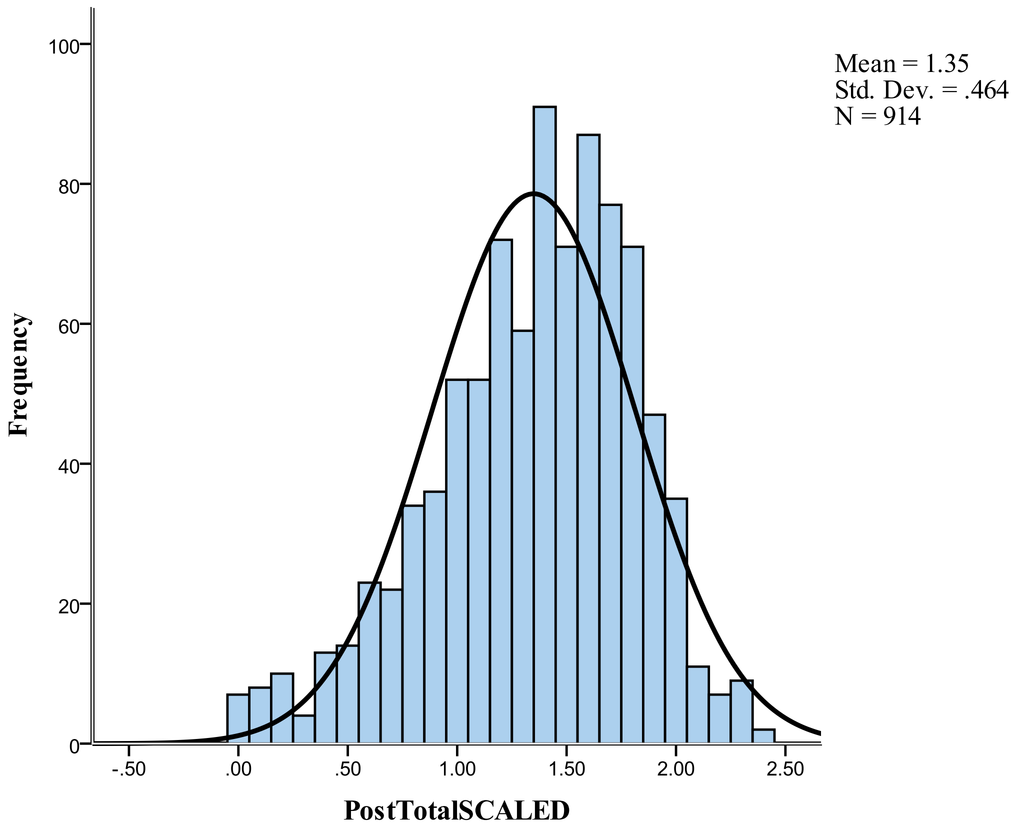

Figure 4.1. Scaled overall post assessment scores (0-3 point scale) frequency distribution for all participants.

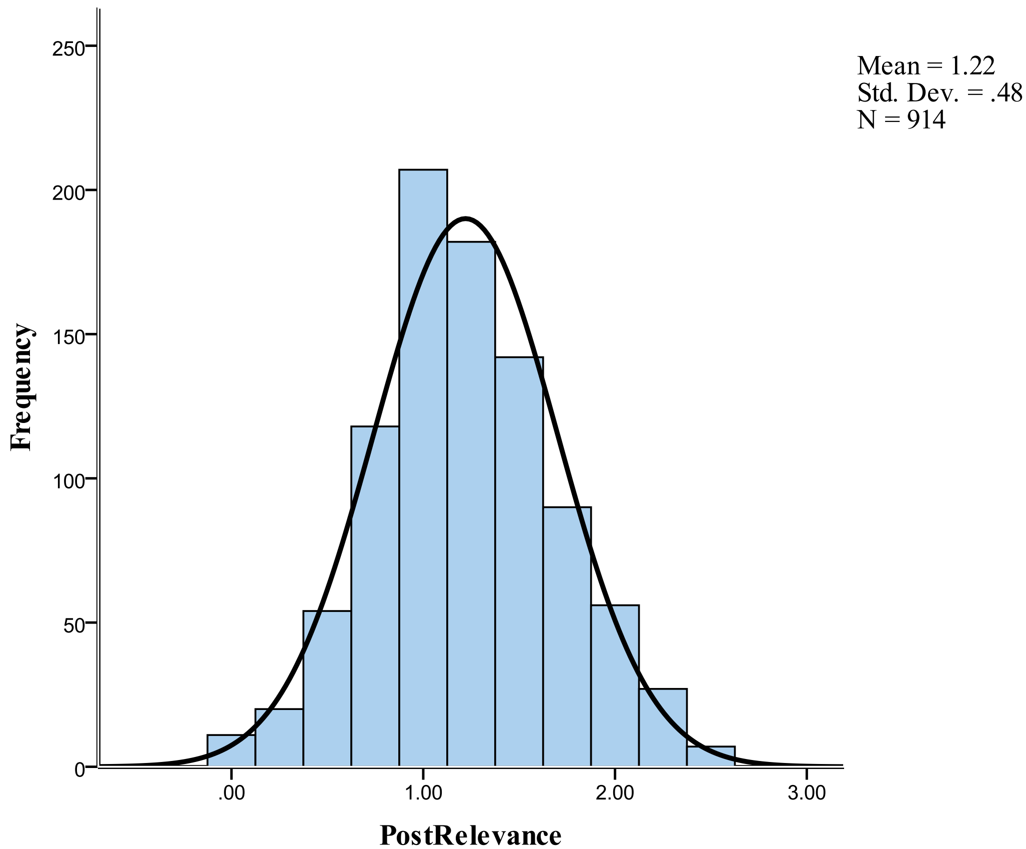

Figure 4.2. Scaled relevance (R) post assessment scores (0-3 point scale) frequency distribution for all participants. Post assessment aspect scores are an average of all questions within the aspect. For further information on scoring categories see Appendix E – SLA Scoring Guide.

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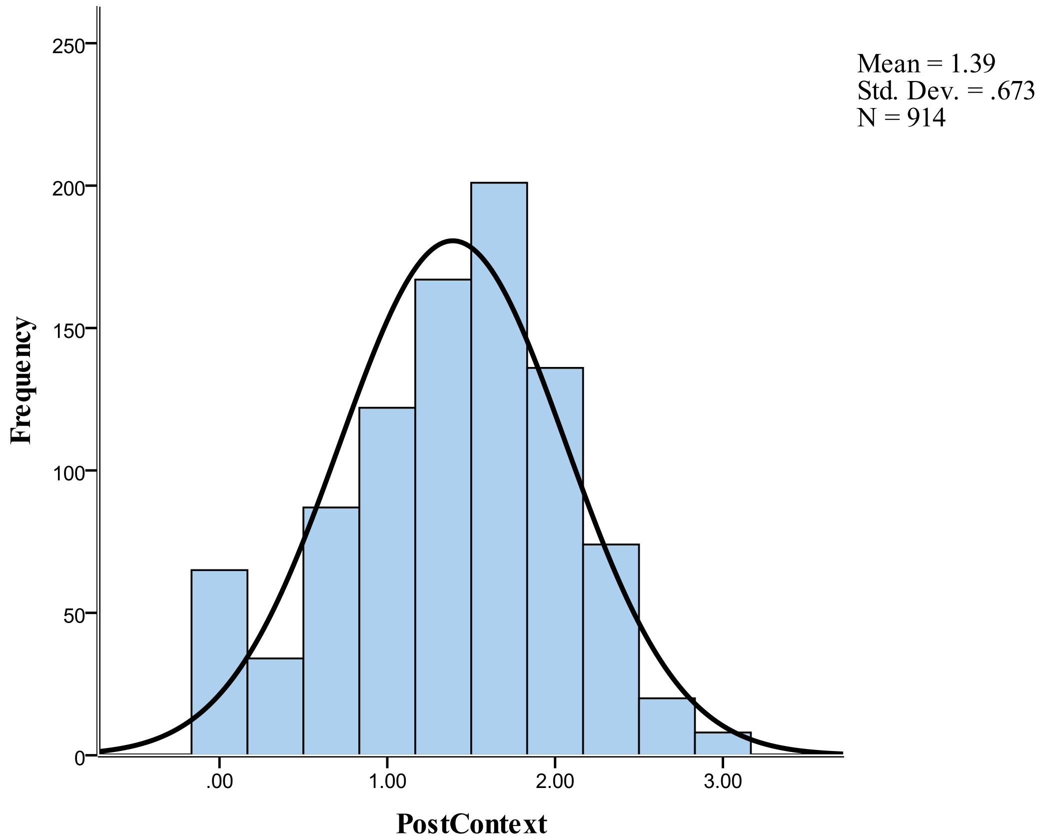

Figure 4.3. Scaled context (C) post assessment scores (0-3 point scale) frequency distribution for all participants.

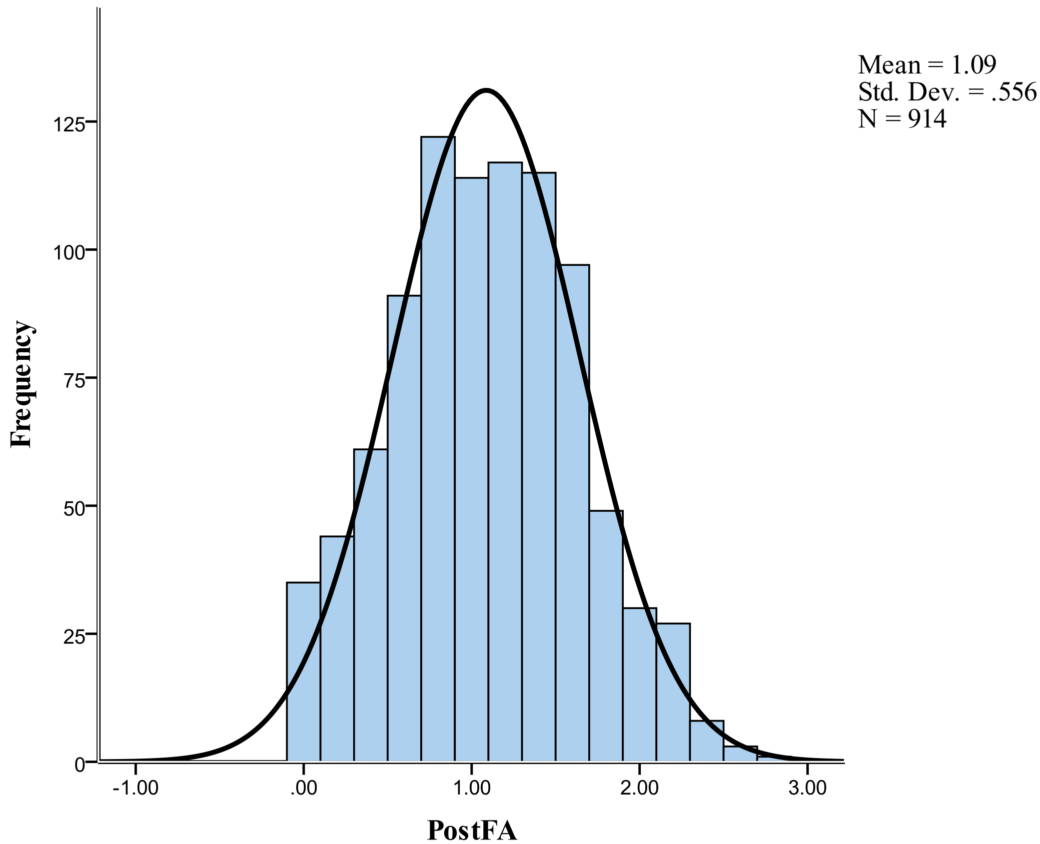

Figure 4.4. Scaled factual accuracy (FA) post assessment scores (0-3 point scale) frequency distribution for all participants.

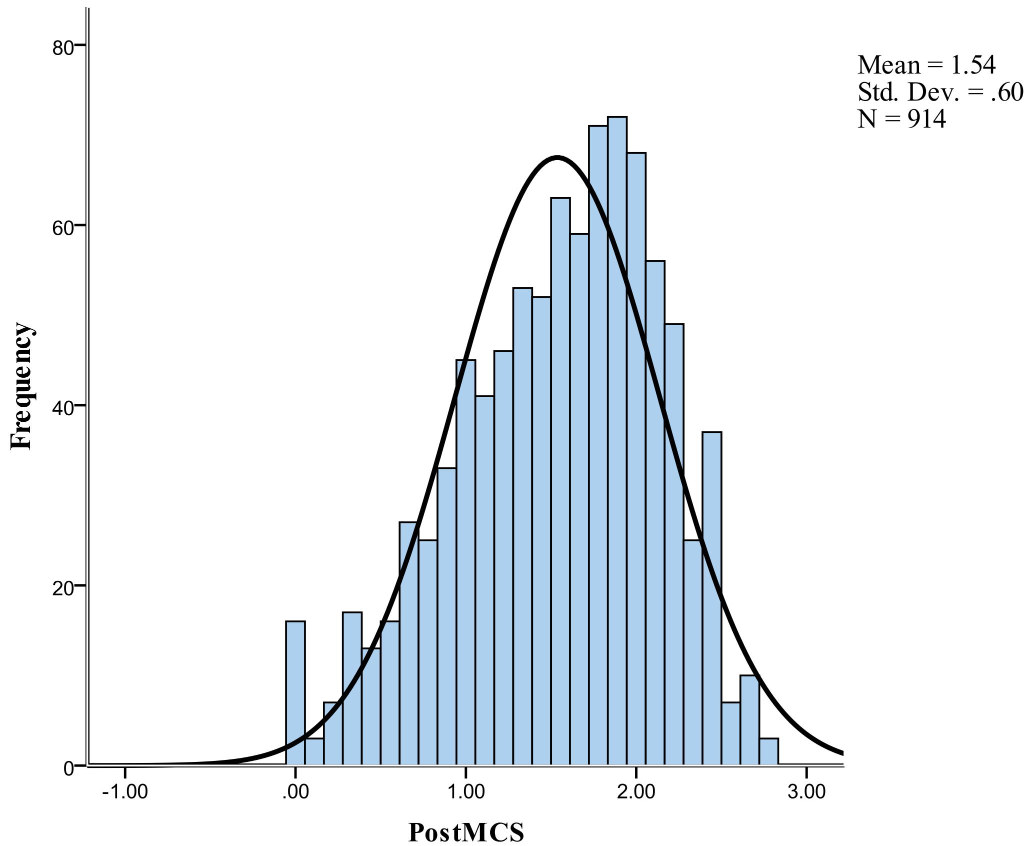

Figure 4.5. Scaled multiple credible sources (MCS) post assessment scores (0-3 point scale) frequency distribution for all participants.

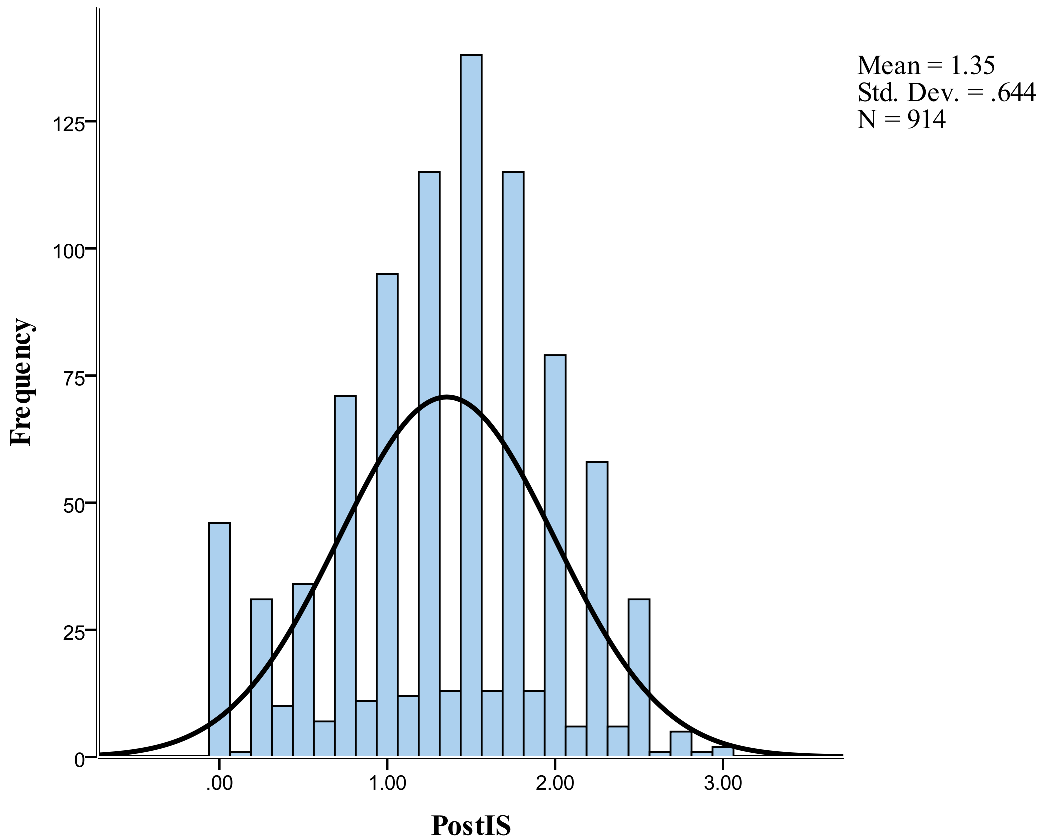

Figure 4.6. Scaled information seeking (IS) post assessment scores (0-3 point scale) frequency distribution for all participants.

Pre Assessment - Post Assessment Analysis (Implementation/Comparison)

Overall scores for scientific literacy showed a significant difference $F(1,912) = 181.347$, $p < 0.001$ between the scores of students in the implementation and comparison groups (Table 4.6) on the post assessment.

Table 4.6

Comparison of Post Assessment Scores by Participation Group (Comparison and Implementation Groups)

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	20375.616	1	20375.616	181.347	.000[a]
	Residual	102469.430	912	112.357		
	Total	122845.046	913			

a. Predictors: (Constant), Participation; Comparison or Implementation
b. Dependent Variable: Overall Post-Assessment Scores

A paired t-test, analyzing implementation and comparison group post assessment scores revealed that students in implementing classrooms scored significantly higher overall as well as in each aspect (Table 4.7). Although greater gains were made within the implementation group, students in the comparison group improved as well.

Table 4.7
Paired t-Test Comparing Implementation and Comparison Group Pre Assessment and Post Assessment Scores

	n	*M*	*SD*	*F*	Sig. (α= 0.001)
Relevance				34.336	0.000
Implementation	673	1.28	.475		
Comparison	241	1.06	.454		
Context				65.061	0.000
Implementation	673	1.47	.649		
Comparison	241	1.16	.686		
Factual Accuracy				53.172	0.000
Implementation	673	1.17	.536		
Comparison	241	0.84	.538		
MCS				61.429	0.000
Implementation	673	1.68	.534		
Comparison	241	1.25	.574		
Information Seeking				71.650	0.000
Implementation	673	1.50	.582		
Comparison	241	0.94	.636		
Overall				95.538	0.000
Implementation	673	1.46	.413		
Comparison	241	1.03	.454		

Pre Assessment, Post Assessment Analysis (Implementation Level)

Implementation in terms of frequency and focus on SciJourn standards and practices varied among the teachers. Based on classroom observations, participation in professional development, contact with SciJourn team for assistance, and student product creation, implementation levels were determined for each participating teacher by committee (Table 4.8).

Table 4.8

Implementation Level Descriptors and Teacher Assignments

Implementation Level Descriptors	Teachers
High: Teachers met the objective of production and submission of a written article and incorporated a large variety of SciJourn activities into the process	TCH 003, TCH 006, TCH 007, TCH 015, TCH 019, TCH 020, TCH 021, TCH 023 TCH 025, TCH 026, TCH 029, TCH 035
Medium: Teachers incorporated a wide variety of SciJourn activities but did not have students complete and submit an article	TCH 010, TCH 031, TCH 033
Low: Used a limited number of SciJourn activities focused mainly on reading strategies such as the read aloud think aloud.	TCH 005, TCH 009, TCH 026, TCH 032

Using this categorization, an *ANOVA* was conducted to evaluate the relationship between implementation level and gains on the SLA. The analysis revealed that implementation level was correlated to gains on the SLA overall $F(2,672) = 36.318$, $p < 0.001$ (Table 4.9) and in all sub-scales except relevance. From this it can be surmised that increased implementation and the incorporation of student created products had a significant impact on the SLA post assessment scores. Specifically, students improved at placing information into a specific scientific/societal context (context: pre $p = 1.28$, post $p = 1.47$); requesting factual information necessary to draw conclusions or make a decision (factual accuracy: pre $p = 1.00$, post $p= 1.17$), seeking out credible information on the internet (information seeking: pre $p = 1.11$, post p= 1.50), and evaluating the credibility of sources and suggesting specific credible sources (multiple credible sources: pre p = 1.34, post p = 1.68) (Figure 4.7).

Table 4.9
ANOVA Results for Implementation Level Comparison for Post Assessment Scores, Implementation Group Only (N=673)

		Sum of Squares	df	Mean Square	F	Sig.
Overall	Between Groups	11.204	2	5.602	36.318	.000
	Within Groups	103.347	670	.154		
	Total	114.551	672			
Relevance	Between Groups	1.099	2	.549	2.441	.088
	Within Groups	150.788	670	.225		
	Total	151.887	672			
Context	Between Groups	16.669	2	8.334	20.960	.000
	Within Groups	266.406	670	.398		
	Total	283.075	672			
Factual Accuracy	Between Groups	10.646	2	5.323	19.555	.000
	Within Groups	182.375	670	.272		
	Total	193.021	672			
Multiple Credible Sources	Between Groups	14.584	2	7.292	27.154	.000
	Within Groups	179.918	670	.269		
	Total	194.502	672			
Information Seeking	Between Groups	19.555	2	9.777	31.456	.000
	Within Groups	208.258	670	.311		
	Total	227.812	672			

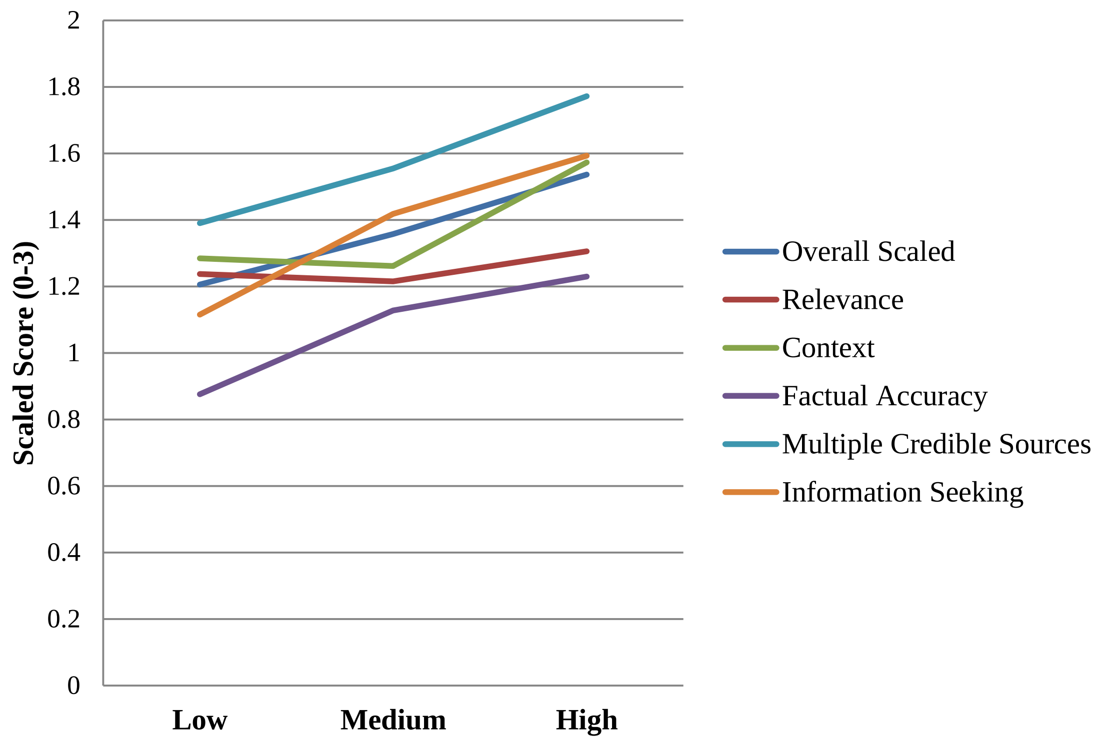

Figure 4.7. Post assessment scaled score (0-3 point scale) comparison for overall scores and each individual aspect of scientific literacy based on implementation levels (low, medium, high (see Table 4.8 for descriptions).

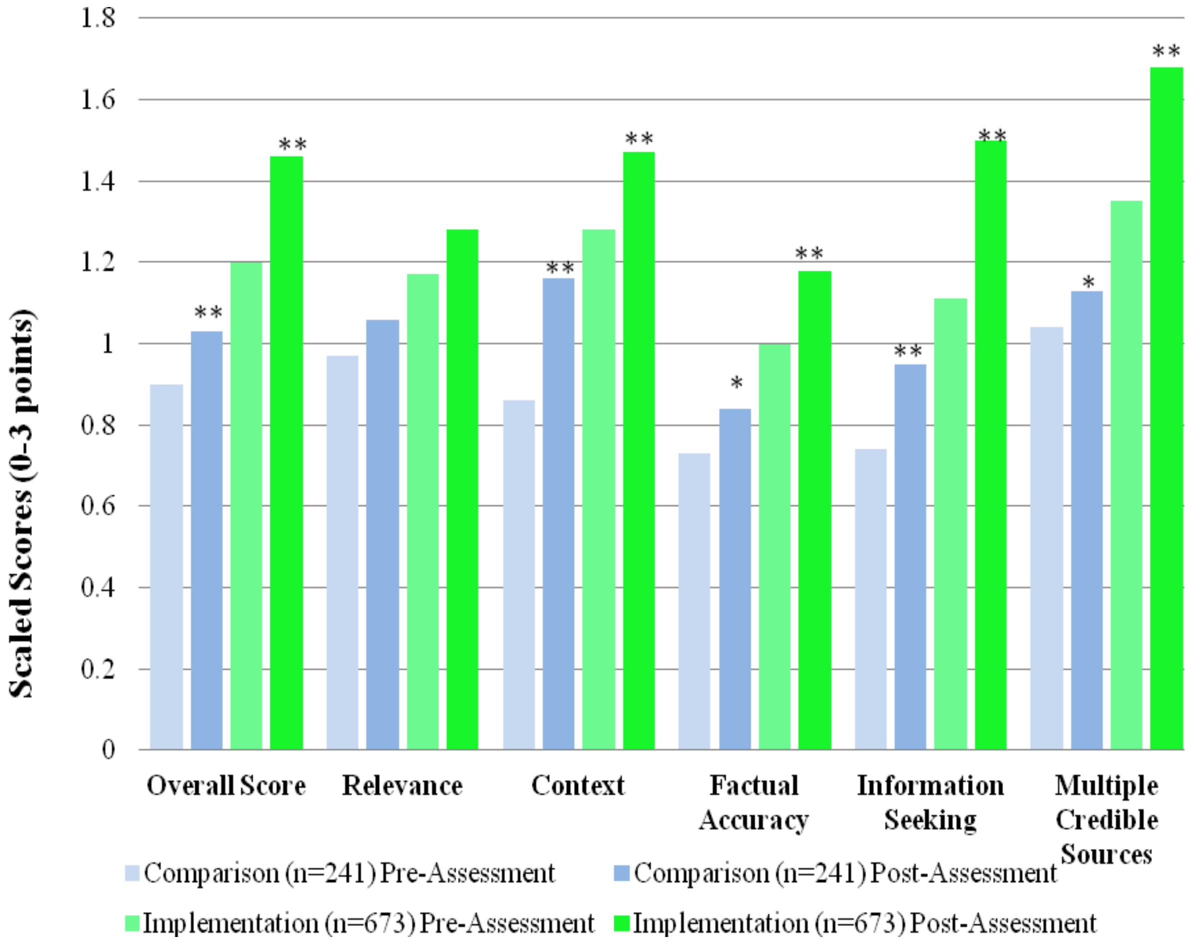

Figure 4.8. Implementation and Comparison group pre-assessment/ post-assessment scores (using scaled scores 0-3 points). * p> 0.01 and ** p> 0.001.

Reliability

The reliability of the Scientific Literacy Assessment was established in the assessment development phase (Chapter 3). In order to address the issues that arise with a non-equivalent groups design, a comparison group was used.

Validity

Purposeful selection of teachers to ensure diversity within the sample was used to increase population validity. Ecological validity was created by purposeful selection of schools based on location, school type, and socio-economic status.

Summary

In order to evaluate the impact incorporating science journalism-related activities into a high school class has on student scientific literacy, a balanced crossover administration of the pre and post scientific literacy assessment developed as part of the SciJourn project was conducted. Increases in scores for all sub-scales and overall scores were observed for all participants with students in the implementation group scoring significantly higher on the post assessment. A qualitative analysis of what constituted these changes is described in detail in Chapter 5. Other factors were studied using hierarchical linear modeling (HLM) and are described in Chapter 6. These further evaluations strive to make evident the specific impact science journalism activities had on student scientific literacy.

Chapter Five

Findings: Qualitative Analysis of SLA responses

This chapter focuses on the methods and procedures for qualitatively analyzing student SLA responses. A basic interpretive study was completed focusing on emergent themes and patterns (Merriam, 2009). Student responses were compiled in an Excel spreadsheet. All student responses were coded by question with the form, pre or post assessment identifiers, student ID, Teacher ID and score hidden. Themes were initially identified in the expert novice analysis described in Chapter 3. New coding categories were added when necessary. Upon completion of the item analysis, some categories were collapsed due to commonalities. Responses were then divided by pre or post assessment. Totals were calculated for each code. Representative student responses were chosen to provide some examples. There was very little difference between implementation and comparison groups, suggesting that the types of information requested have not changed, only their frequencies. For this reason, the analyses and examples presented below in this chapter are from the implementation students only.

This chapter addresses the qualitative procedures used to analyze student responses. The analyses are presented by aspect as described within the SciJourn Scientific Literacy Standards. This analysis aims to provide a snapshot of what constitutes scientific literacy for an average high school student.

Qualitative Analysis Procedures for Student Responses

The SLA is based on standards (Appendix D) developed as part of the SciJourn project and used as the theoretical framework for what constitutes scientific literacy. Quantitative analysis presented in Chapter 4 indicated participation in SciJourn activities increased student scientific literacy. Each of the five aspects provides some insight into how students view media and make connections to science and society. For this analysis implementation students' responses (*n*=673 pre, *n*=673 post) were analyzed as a whole, rather than on the individual student level. Using the standards framework questions emerged regarding how students responded in general and also the ways in which student responses changed over time. The following questions were analyzed:

- What types of additional factual information do students request when reading science news?
- How does the focus on factual accuracy vary depending on student role as a consumer or a producer (as framed in assessment questions)?
- What types of contextual connections do students make?
- When presented with a vague internet search, do students recognize the problem posed by such a search term and what suggestions do they make for refinement?
- What strategies do students use when conducting an internet search for additional information?
- What makes information relevant?
- What constitutes a need to know?
- What factors make a source credible to students?
- How does source choice change over time?

Using the framework developed in the expert/novice analysis as the basis for coding, each SLA question was coded for all student responses, focusing on the questions noted above. Coding categories were added as new types of responses were noted. Responses were coded multiple times if a response included several parts. Once all of the questions assessing a specific aspect were coded, coding categories were consolidated into common categories across all questions. This resulted in a numerical estimation of categorized student written responses. Each aspect was aligned to multiple questions resulting in a different number of responses for each aspect. Descriptions of coding frequency were determined by the overall number of phrases coded or by the number of students for each question and each coding category.

Factual accuracy.

Several factual accuracy questions required the student to suggest additional facts that would be needed to understand the science. Within the article and the graphic sections there are inaccuracies or inconsistencies incorporated into the text or graphic. The pre-test mean (X=0.96) suggests that students tend to request basic background information (i.e., definitions and explanations of concepts). The post-test mean (X=1.18) suggests that students began requesting information that should help them understand specific aspects of the science presented (i.e., content or process associated with the topic). Few students addressed inaccuracies (question 21, 4% and question 24, 8% n=673). In section one of the SLA students read an article and were asked to identify additional factual information that was needed to help them understand the article or to make it better. Slightly over half of all coded responses (n=1599) were requesting specific factual information (55%); the remaining responses were split between no suggestion (30%), and examples, witness accounts, other sources and opinions (9%), formatting changes (1%) and other (1%). In general the categories of information requested and frequency of request were fairly stable pre to post. However there were slight shifts (pre to post) in request frequency for specific information related to the science issue (e.g., *010-062*, *009-094*, and *021-037* in Table 5.1), requests for additional information from other sources (organizations, witnesses, and citizens) as in *019-019* and *025-019*, and increased specificity when asking for basic background information (e.g., *007-093* and *005-080*). This increase in specificity suggests students are analyzing the information provided more critically and are becoming better at articulating their information requests.

Table 5.1

Percentage of Responses to SLA Questions 4 And 5 Requesting Factual Information by Category for Implementation Group Students (N=673).

	Coded Responses (n=1599)		
Coding Category	Pre	Post	Examples (Post Assessment)
No requested information (or off topic)	32%	30%	*(025-006) No, I think this is enough information*.
General non-specific information	6%	4%	*(003-039) It could use some more citation, and as well as some more facts.* *(020-032) I think there should have been more detail on what happen.*
Specific requested background information	16%	14%	*(007-093) More effects after lead.* *(005-080) How the volcano got there*
Specific requested information directly related to science issue	23%	25%	*(010-062) How much lead was in the water before & after replacing part of the pipes.* *(009-094) Yes, the actual density of the volcanic ash and how dense it would actually have to start causing airplane engine problems.*

Table 5.1 Continued

Percentage of Responses to SLA Questions 4 And 5 Requesting Factual Information by Category for Implementation Group Students (N=673).

	Coded Responses (n=1599)		
Coding Category	Pre	Post	Examples (Post Assessment)
Specific requested information directly related to health issue	10%	11%	*(021-037) if there has been any occurences where lead from the water has affected the health of any children* *(025-066) There should be information about how the ash causes problems for people with allergies and asthma and if the ash is likely to come down to earth from high atmospheres.*
Specific requested information prevention or help	5%	5%	*(026-053) I think more information of the topic would be better, for instance information on how it could be fixed or even hoe to prevent it for happening in the future.*
Examples, witness accounts, quotes, other sources and opinions	5%	9%	*(019-019) The article might have been better if the author had wrote about a child having high levels of lead in their blood.* *(025-019) Not really, but I think that the article would have been better if they had interviewed someone to get their opinion on the matter*
Formatting changes	1%	1%	*(015-053) A chart of map to show what parts of Rhode Island are affected.*
Other	1%	1%	*(010-079) Info about specific airlines.*

Section four of the SLA has two questions addressing a specific factual inaccuracy. In Question 21 students look at a PowerPoint slide their friend has created for a presentation and make suggestions for improvements. This particular question places the student in the role of a consumer. Question 24 has students look again at the PowerPoint slide, but this time they will be presenting it, again asking the students to describe what improvements they would make. This second question places the student in the role of a producer. Although these two questions were essentially targeting the same idea (what needs to be changed), the two roles seem to have influenced their responses.

Table 5.2

Percentage of Responses by Coding Category Questions 21 and 24

	Responses by category (%)			
	Question 21 Consumer Role		Question 24 Producer Role	
Coding Categories	Pre (%)	Post (%)	Pre (%)	Post (%)
Numbers/Data	7	7	29	34
Formatting	32	36	3	3
Sources	6	7	8	11
No Suggestions	17	15	21	12
Specific data	2	2	4	5
General Facts	7	7	18	17
Everything	15	11	13	12
Addresses non-congruence	14	15	4	6

Students were much more likely to request additional numerical data when in the role of a producer. As a consumer, students primarily suggested changes to formatting, (see Table 5.3 for examples). Students were less likely to suggest changes to non-congruent information in question 24 than in question 21, which is likely due to the sequence of questions. Students who already suggested correcting the non-congruence in 21 generally did not repeat that suggestion for question 24. Suggestions by students changed in specificity between roles as well (Table 5.3). As a consumer students often hedged about what needed to be addressed by being vague (*007-093, Table 5.3*). While in the role of a producer they were generally more specific about what needed to be addressed (*015-063, Table 5.3*). Looking closer at specific student changes pre to post, was uninformative with regards to improvements since many students made reference to different types of changes such as formatting in the pre-assessment response and sources in the post-assessment. Overall however, students were more likely to suggest multiple changes in the producer role and had more specific suggestions.

Table 5.3.

Sample Student Responses Suggesting Changes Relating to Use of Numbers

Suggestion Category	Producer	Consumer
Numbers as Data	*(007-102) The statistics in the graph, they might be outdates, wrong or not what we need.* *(025-057) The stats to make sure there accurate. Because they could be completely different on another website.*	*(021-037)Check that statistics to make sure they were accurate* *(025-035) Use children statistics instead of adult*
Formatting	*(020-032) That we have facts, details, look nice and neat. I would also have my sources from sites.* *(035-006) Check the facts on the numbers/% with the year so that it is to scale. A wrong number means the entire presentation is infactual.*	*(025-088) There are too many numbers going on in the graph and it is a little hard to read. He could make it easier to read.* *(029-056) Title all the numbers correctly, and explain the meaning of the chart.*

Table 5.3. Continued

Sample Student Responses Suggesting Changes Relating to Use of Numbers

Suggestion Category	Producer	Consumer
Sources	*(006-083) Check more than one website for the information to be credible.* *(015-063) www.zfacts.com, I would want to make sure its credible*	*(003-087) give an expert siting that it's true* *(007-093) Looks perfect, make sure source is credible.*
Non-congruence	*(025-129) All of the percentages would have to be about children, and not adults. Right now the facts are about adults, and the Community Health Fair project is about childhood diabetes.* *(021-001) If diabetes is not related to obesity Because to me it looks like the two are related.*	*(006-068) Well he should rethink what he is showing in the chart b/c it looks like the higher one goes the higher the other does too.* *(007-073) You can't say the rise in obesity doesn't correlate when both graphs rise.*
General Facts	*(003-050) The rate at which children have diabetes, the year to year increase of children being diagnosed, what causes children to be diagnosed with diabetes at such an early age* *(005-093) How much CO2 is in parts per million. It sounds questionable & hard to find so I'd double check*	*(023-011) To find information on kids with diabetes.* *(019-031) Tell what the causes are.*

One area of science students found relevant, evident both in topic choice and in follow-through for articles, was health issues. Question 17 provides the student with informational text in the form of a health brochure on either H1N1 flu or High Blood Pressure (HBP). Students were asked to review the information and assess their health risk explaining how they came to that conclusion. Seventy-nine percent of students made a defined (yes or no) assessment of risk on the pre-assessment increasing to 86% of responses on the post-assessment (Table 5.4). The increase in defined risk assessment corresponded to a reduction in the number of students who did not make a risk assessment on the post assessment.

Table 5.4

Risk Assessment as a Percentage of Implementation Group (n=673)

Risk Assessment	Pre-Assessment (%)	Post-Assessment (%)
Yes	45	49
No	34	37
Maybe	2	2
I Don’t Know	1	1
No Risk Assessment	18	11

Each of the brochures provided risk factors to consider when assessing risk. Students generally used these factors when explaining their reasoning, occasionally suggesting other support. The average number of risk factors used as support increased when students felt they were not at risk for either H1N1 or HBP (Figure 5.1). Students could be considering one positive risk factor as evidence of overall risk, while a majority of negative risk factors may be needed to assume a lack of risk.

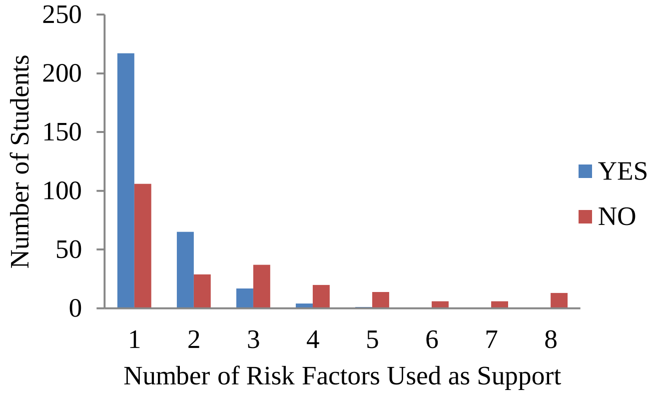

Figure 5.1. Number of risk factors used by students to support their personal risk assessment when making a defined risk assessment (yes or no).

SLA Form A contains a brochure on high blood pressure. The text included numerous risk factors for students to consider when assessing their personal risk. Students who stated they were at risk indicated that race, stress, and salt consumption were contributing factors (Figure 5.2). While students who stated they were not at risk indicated that being at a healthy weight, physically active and young reduced their risk. SLA Form B contained a brochure on H1N1 influenza. Again the text contained numerous risk factors for students to consider when assessing their personal risk. Students who stated they were not at risk attributed this primarily to being vaccinated or having contracted H1N1 previously. Having a healthy immune system and washing their hands were other factors frequently used to support their lack of risk. Students who stated they were at risk for contracting H1N1indicated that being in a school environment and transfer of germs via touching other objects, such as desks and door knobs, were the main factors. A few students suggested factors that were not listed on the brochure such as the vaccine no longer being effective and how easily the virus is spread.

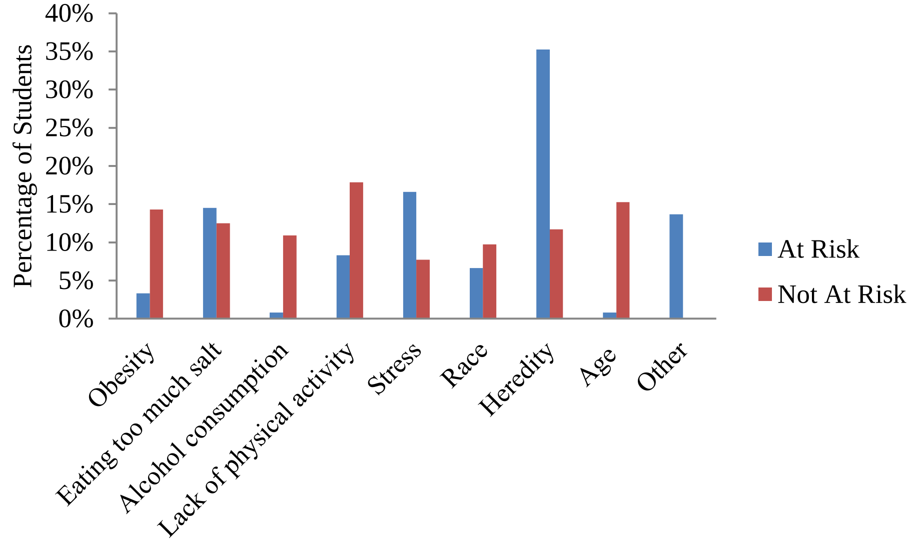

Figure 5.2. Frequency of risk factor use in supporting personal risk assessment for high blood pressure, implementation students only (*n*=673).

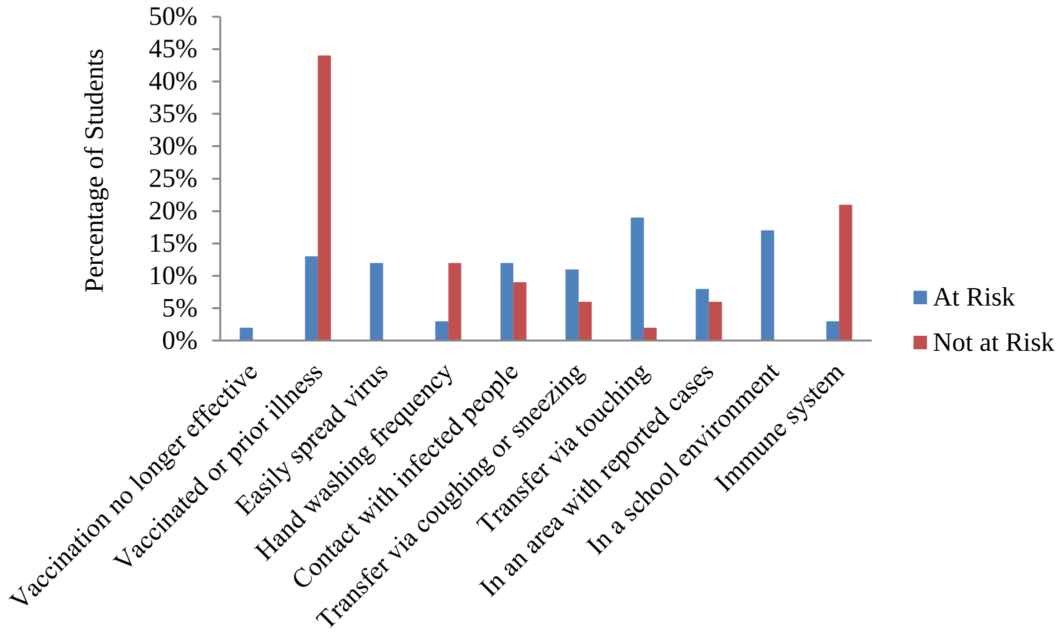

Figure 5.3. Frequency of risk factor use as supporting personal risk assessment for H1N1, implementation students only (*n*=673)

The factual accuracy questions requiring the students to make personal risk assessments indicate the difficulty in separating scientific fact from scientific and societal contexts. Transmission of germs by touching items infected individuals had or by being around infected individuals is both a scientific issue (how to minimize transmission using scientific means) and a societal issue (how to make the public knowledgeable regarding ways to prevent infection while in public spaces). Another example comes from the HBP question. Students suggested that their own personal intake of salt was due to fast food and snack foods. In the U.S. both fast foods and snack foods are easily accessible and advertisements enhance their appeal. The rise in obesity and subsequently HBP is both a scientific issue (how to treat HBP) and a societal issue (how to change personal and community habits). Such interconnectedness between science and society was also evidence in questions addressing context.

Context.

Both forms of the SLA included three questions asking the students to place information into context. Student responses were consistently split between science (approximately 80%) and society (approximately 20%) in post-assessment answers becoming much more specific when connecting science disasters to outcomes. For example, on the pre-assessment students might state that pollution is an issue following a hurricane. On the post-assessment students would go further stating that pollution in the water or air might cause health problems. This increased specificity suggests a strengthening of contextual connections.

Table 5.5.

Societal Connections Made in Relation to Natural Disasters

Coding Category	Percentage of Coded Responses (*n*=507)
Loss of adequate housing	15
Loss of resources for life (food shortage, lack of drinking water)	15
Loss of oil (increase in gas prices)	13
Economy (overall)	10
Jobs	7
Tourism and recreation	7
People leaving affected area and not returning	6
Business interests (loss of place of business, equipment etc)	5
Rebuilding	4
Prevention (future preparedness)	4
Way of life	4
Loss of personal income	3
Help	3
Products produced other than fishing	2
Infrastructure destroyed	2
Loss of personal property	1

Societal connections (Table 5.5) consisted of effects to individuals and effects to communities. Over half of the responses focused on a loss of adequate housing, loss resources necessary to sustain life, loss of oil, and the economy. These were often combined with other health or science concerns; combining the loss of a home with pollution in the ocean as in student *025-072*'s response and in student *007-085*'s response which combines the loss of housing with the loss of sanitary infrastructure and dangers in the air (mold and hazardous fumes) due to the disaster. In both of these responses students took isolated ideas and placed them in the perspective of a long-term impact on individuals and the community.

(025-072) The flooding would cause an environmental impact in that it probably pulled unwanted things back into the ocean. It also destroyed many houses that would need to be rebuilt which uses a lot of resources.

(007-085) Mold levels are probably super high, sanitary systems were totally wiped out, FEMA trailers were made w/ hazardous material to be breathing in. Pretty much people that lost their houses are screwed in all ways possible.

Similar to societal connections, students suggested a variety of science connections; mainly effects on the environment including loss of and damage to plants and animals, pollution, and effects on human health. Responses about health related issues, human death and mental health issues reflected immediate issues (death, illness and injury) and some that could develop as a result of the experience with actual physical harm. One response stated that "*the long term health impacts may include continuous danger for the fear of flooding when a storm comes through, resulting in anxiety & high stress levels of the citizens who survived the hurricane*" (015-086). Concerns about the long term mental health of survivors were evident in many of their responses. Other health issues, such as increased asthma and illness, were often attributed to pollution, mold, and contamination.

The aftermath of natural disasters often have a profound effect on the environment. Student suggestions regarding how science was connected (Table 5.6) to such a disaster included pollution of the environment, dead fauna, and alterations to the abiotic aspects of the environment such as a changed coastline. Often students made connections within their responses suggesting further understanding of the impact one event has on a biological community. Students identified issues with the food chain in which fish were a primary member as in *025-034*'s, *035-013*'s, and *031-014*'s responses below. However some students extended the effect beyond the disruption to the food chain to suggest ways it might also impact the economy and human food consumption (*025-125* below)

> *(025-034) It could kill the coral reefs, where many aquatic animals live and thrive. If all the reefs are covered in oil the fish will die causing a chain reaction that will make animals that eat those fish starve and so on and so on.*
>
> *(025-125) Lots of aquatic life will be killed because oil is very sticky and hard to remove. It can trap birds that try to land in it and lock their wings up so they can not fly. Fish can catch diseases, in return seafood restaurants that normally get their seafood from this area are at risk.*
>
> *(035-013) This will kill many marine animals, thus leading to less food for animals that eat the marine animals, etc. Ultimately, it will effect the food chain.*
>
> *(031-014) It is ruining the food chain because many animals, wildlife, sea creature's have died from the oil in the water they live in.*

These types of connections indicate that students have developed an understanding of the interdependence of life. Twenty four percent of students suggested that pollution was a long-term issue for both air and water (Table 5.6). Occasionally students made inaccurate connections; such as:

> *(025-114) Considering the gulf and mississippi river connect, oil could come up the river and kill all the fish.*
>
> *(025-041) … more heavy rainfall would happen.*
>
> *(005-052) They could cause random tsunamis, and also more tidal waves then normal.*

(015-071) Whatever hurricanes are in Louisiana, they could build up and get worse of the Gulf Coast.

While there were only a few student responses where the science was wrong, they indicate a misconception that one major natural disaster can cause an increase in frequency or devastation of future disasters and that pollution can travel upriver.

Table 5.6.
Science Connections Made in Relation to Natural Disasters

Coding Category	Percentage of Coded Responses (*n*=1582)
Pollution	24
Dead fauna	18
Medical health related, human death or mental health	13
Abiotic environment altered	10
Degraded fauna	6
Contamination by bacteria or oil (food sources, land or water) must say contamination	5
Increased environmental disruptions	5
Ecosystem issues	4
Dead flora	3
Food chain	3
Displaced animals	2
Pollution traveling wrong way	2
Mold growth	2
Degraded flora	1

Information Seeking.

While in schools we noticed students using a variety of strategies for finding information on the web. Phrases, key terms, questions, even image searches were common strategies. These searches were often so general that millions of corresponding results appeared. As a research team we began to consider how students could be fairly proficient at finding information on sites like *YouTube*, *Facebook*, and *Imagine Game Network (IGN)*. What practices were they using on such sites to find what they were seeking?

Watching my own teenagers access these sites it became clear that on YouTube they were comparing the image or sound to information they already knew like faces and logos. They also used the rating system on the site for individual videos. This process enabled them to weed out results that did not match what they were looking for. While on Facebook, they tended to search only for people they knew and verified the identity of the individual by looking at their photo. Similarly, my son searches for gaming information on *IGN*. He uses images from the game and walkthroughs to determine what he wants to pursue. All three of these examples (*YouTube, Facebook, and IGN*) indicate how students can use these and similar websites easily by combining their prior knowledge with results to find good matches. Such a reliance on prior knowledge to verify a search result becomes a challenge when searching for new information. While researching their topics students were searching for information that they lacked sufficient background knowledge about. The situation with new science information makes strategies they use every day on sites like YouTube less effective and begs the question, how are students approaching information seeking when unfamiliar with the topic?

There is an incredible amount of information on the web, causing simple searches using key terms to produce result lists that include some good information mixed in with other information such as off topic sites, advertisements, blogs, and sites with questionable credibility. Question 19 on the SLA asks students to explain why a key word search might not be the best choice for gathering information and asks them to suggest a change. Eighty-seven percent of students stated that the search was too broad (Appendix F). Only five percent suggested a phrase that could be used to refine the search and less than one percent suggested using a question. With the vast majority of students able to identify the need to narrow their search terms, but so few of them suggesting alternative search terms, it suggests that students can recognize a poor search strategy but may not know a better one.

Question 23 provides a search bar and asks the students to write in what they would type in order to find more information on either the connection between global warming and CO_2 emissions or the connection between diabetes and obesity in children. Students made 1,119 search suggestions for additional information (Figure 5.4). The suggestions mainly consisted of phrases that focused on only a single aspect of the research (e.g., *003-051, children with diabetes*). Very few combined requests (e.g., *023-054, Effects of CO2 on global warming*) were suggested, i.e., search requests that would provide information specific to either the relationship between CO_2 emissions and global climate change or the relationship between obesity and diabetes in children (Figure 5.5). Students were more likely to use a combined search when suggesting searches for global warming (Figure 5.5) than for the connection between childhood obesity and childhood diabetes; possibly due to their familiarity with global warming since it has been in the media more prominently. The search suggestions support the findings for question 19; students used more specific phrases but lacked the narrowing effect of using a combined search.

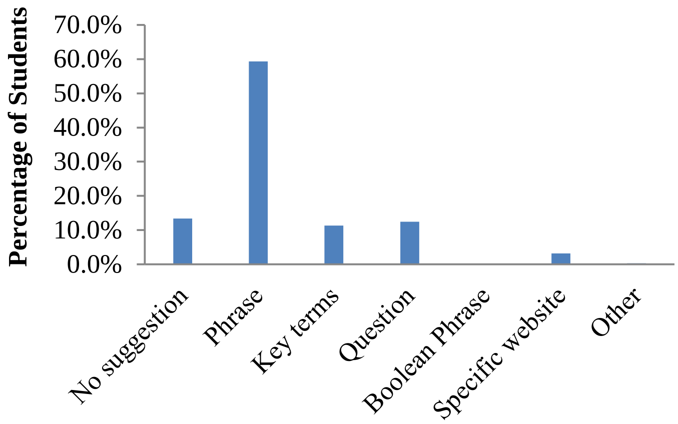

Figure 5.4. Student suggestions for internet searches. Each student had the opportunity to make two suggestions (*n*=1346). Illegible responses were excluded resulting in a final data set (n=1292). Website suggestions were assumed to be valid websites.

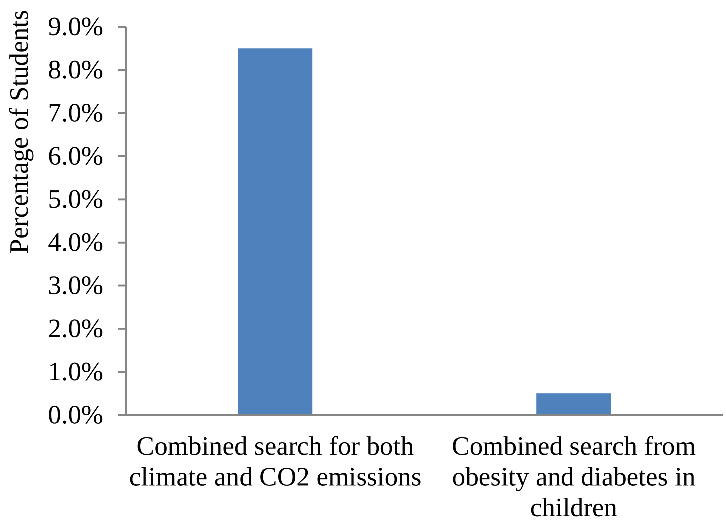

Figure 5.5. Percentage of students (*n*=673) who suggested a combined search.

Relevance.

Students are often heard asking "Why should I learn this?" or "What will I ever need this for?" Such statements can be viewed as students asking for their teachers to make the information relevant to their own lives. Understanding how students view relevance can help teachers make useful connections between students and new information by establishing a need to know and a temporal range for use of new information. Section one provides an article for students (*n*=673) to read followed by the open ended question "Who else should read this and why?" Very few students stated someone they knew personally (2.5%); generally a family member. Eighty-six and a half percent suggested people that were not personally known to them. Often these individuals were part of a group (e.g., travelers, homeowners, pilots, scientists, citizens, etc.). Students provided a wide variety of reasons for someone to read these articles. These reasons were grouped into four categories; immediate need to know (28.3%), future need or general knowledge (57.7%), or an interest (8.6%) and other (5.3%). When indicating an immediate need to know students focused on short term actions or health concerns. For example:

> *(029-029) This information is important to the public because it can affect the people who have allergies or asthma.*
>
> *(003-050) People with allergies, asthma or live in Iceland.*

All of these responses were directly related to information provided in the article about particulates in the volcanic plume. Student 029-029 essentially restated the article, while student 003-050 combined the need to know with a specific locality. Occasionally the need to know was a combination of both future and immediate needs, such as: *Because it effected the atmosphere which it polluted it and will or could harm the people living around the area (029-002) and I think an airplane pilot should read this article because they should be aware of why they cannot fly the plane and what to be aware of if they do fly their plane (025-128).* When referring to a future or general need to know students were vague in their description of both reader and need. For example:

(003-079) Everyone, because the article talks about the atmosphere so the world and everyone in it could be affected.

(009-090) A plumber or a person who lives in an older city, because this could happen to them.

In these two examples there is no specific impetus to take action although there is a general need to know indicated. Many of the students who participated in the project live in areas that have older homes and a near-by town with lead related issues. However there was only a single statement that connected a specific individual with a specific immediate need to know based on personal knowledge:

(020-034) I think mothers who may be concerned about there children should read this article. Quoting the article, they say "Children exposed to even very low levels of lead are likely to be less intelligent…" As a person with a child, I believe mothers would want to learn more about these kind of issues.

There were no direct links between students and the volcano in Iceland which may have influenced their response.

Section three of the SLA provides students a series of pictures and a short caption about natural disasters a little closer to home. Students were then asked to suggest why these pictures might be relevant to people today and in a separate question why it might be relevant in the future. Student response to both questions were analyzed together (n=1,346). Based on the previous analysis it would be expected that students would suggest reasons that reflected the three categories presented earlier (immediate need to know, future need to know, and an interest). However, students were more explicit in their responses to these questions allowing for further analysis of relevance (see Figure 5.8). When considering the category of immediate need to know examples could be found in comments about pollution, health, jobs, and environment. Often these ideas were combined as in the example below describing relevance for residents of the Gulf Coast.

> *(025-064) This is important information because the oil in the water can be hazardous to their health. The ecosystem on the Gulf will change from this oil spil causing the people's lives in the community to change. It is important to imform these people so they are aware of the changes that will occur around them such as fishing, the ocean (water supply), and many other factors of there life*.

The combination of factors implies that relevance can mean different things to different people. In the response above the student outlines issues that are both science related and societal. This same strategy was used when discussing relevance to people further removed from the area (Missouri residents).

> *(025-068) People living in Missouri should know this information in case there is anything we can do to help the cause, help manage the damage or contribute to cleaning efforts, as well as knowing what caused the explosion and if this could happen to an oil rig near us as well. If it was due, say, to a flaw in the oil rig design or its location, we should be made aware so that we can take any preventative.*

One of the main reasons (Figure 5.6) for people outside of the affected area to know about incidents such as the Gulf oil spill and Hurricane Katrina was to provide help. The example above describes help in both scientific terms (cause of explosion) and societal terms (helping to clean up). Occasionally when students felt there was little relevance, they still included societal and scientific aspects as in student *029-037*'s response below.

(029-037) It isn't. 200,000 barrels of oil aren't leaking into Missouri, and Barrack Obama doesn’t believe in getting out own oil, so as long as our friends in Asia an Africa are doing fine, so are we.

In this particular instance, the student is aware of the fact that the Missouri does not flow into the polluted area and his comment about where our friends are is a good indication that they are aware of other sources of oil. This combined with the comment about President Obama shows that this student has a fairly good understanding of some aspects of the science but ignores others in favor of a political point of view. Other students mentioned pollution as an immediate concern citing damage to fish, plants, beaches, and other sea life. However the two factors most often suggested as a reason for relevance were future oriented (Figure 5.6). Suggestions about preserving the history of the event or having a record of the experience to look back on imply a future use. Preparing for the future or understanding the risk of living along the coast was another example of a future need for the information provided in the photos and captions.

Overall, 22% of students suggested more than one reason for relevance (Figure 5.7). The analysis of each distinct response (n=1369) revealed that a small minority of students held onto several misconceptions such as the ability of oil and pollution to flow upriver and that as a result of Hurricane Katrina the Gulf Coast is at a greater risk for future hurricanes.

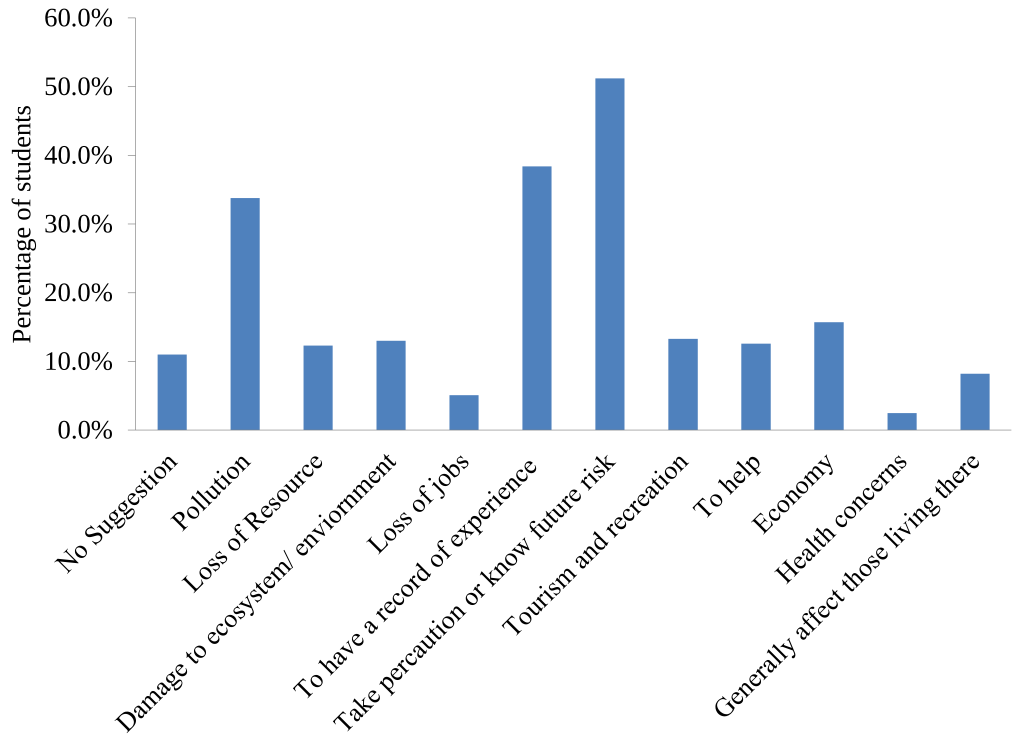

Figure 5.6. Percentage of students (*n*=673) suggesting reasons for relevance. Total number of student responses coded (*n*=1346) resulting in 1,735 factors being coded for.

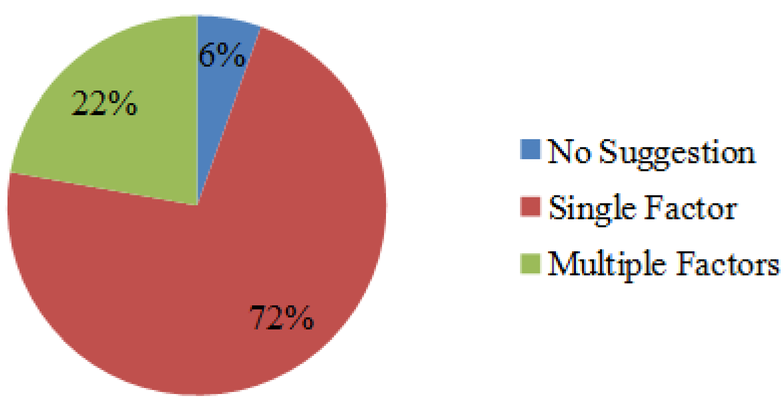

Figure 5.7. Percentage of students (*n*=673) suggesting relevance, broken down by number of factors cited to establish relevance (none, single factor, or multiple factors).

Multiple Credible Sources

One area many of the SciJourn teachers focused on was credibility. The SLA looks at credibility from the standpoint of students as both consumers and producers. Reading science news generally includes the introduction of individuals or organizations as experts. While the article may not explicitly identify these entities as experts there are cues within the text that help the reader in determining the source's credibility. These cues are referred to as attribution in journalism. In the first section of the SLA students read an article that includes several individuals and organizations with differing levels of attribution. Some of the organizations (EPA and WHO) should be well known to a scientifically literate individual. Other organizations cited (e.g., Lead Pipe Initiative and Earth Science Institute) were unknown or fictitious. Individuals differed in the degree of attributed expertise, including both real and fictitious experts. Students were asked to assign a credibility level (very credible, somewhat credible, unsure, not very credible or not credible) at three points in the article along with an explanation of what they based this assignment on.

Credibility of individuals and organizations.

One of the many bits of advice our Editor gave the students was that there was an organization for almost everything. Students gained familiarity with common organizations such as the EPA and Mayo Clinic through read aloud think alouds and research on their topic. These activities could have reinforced their early views (as documented on the pre-assessment) about organizations being credible. On the post-assessment there was a slight shift in credibility determinations for organizations (Figure 5.8). Results indicate students were more likely to consider organizations very credible after participation in SciJourn. Many of the teachers used lessons focused on what constitutes expertise and how expertise is situational. During read aloud think alouds, they would stop and evaluate individuals based on information in the article. This strategy may have led the students to become more critical of an individual's credibility after participating in SciJourn activities (Figure 5.9).

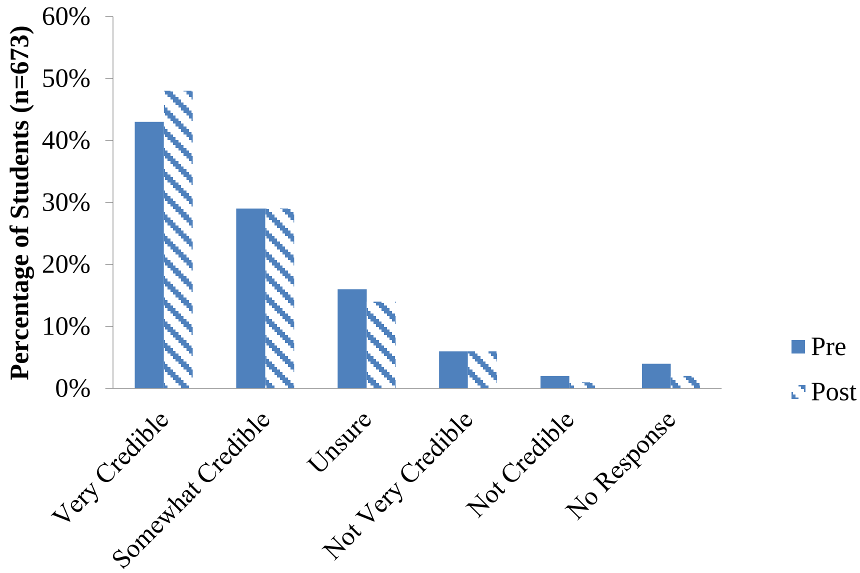

Figure 5.8. Forced choice credibility assessments (Q7) for organizations. Students (*n*=673) assigned credibility on a Likert scale (Very credible, somewhat credible, unsure, not very credible, not credible).

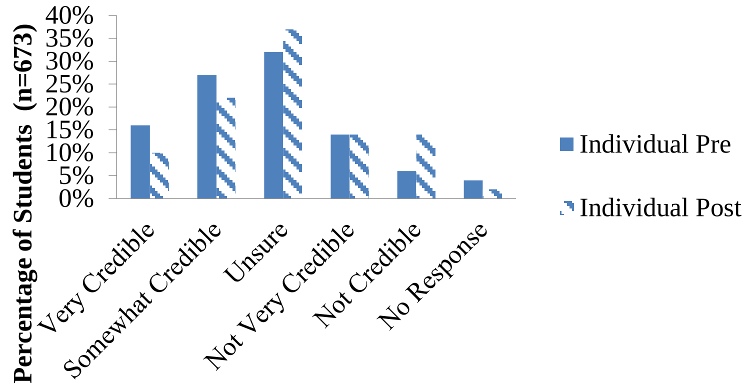

Figure 5.9. Forced choice credibility assessments (Q7) for individuals. Students (*n*=673) assigned credibility on a Likert scale (Very credible, somewhat credible, unsure, not very credible, not credible).

Credibility cues.

Through the expert novice comparison it was clear that experts and novices think differently about credibility. Experts were more apt to consider situational expertise and have a gradient view of credibility. Novices were more apt to have a stringent view of credibility i.e., either they are credible or they are not credible. One question that developed from this early analysis is what constitutes a credibility cue for students. Question seven's three parts (two organizations and an individual) provide a total of 4038 student responses. The analysis of these responses revealed several cues students used to base their evaluation on (Table 5.7). Students used a variety of cues some of which were in the text, while others were not. Overall students used a single cue to establish credibility (Figure 5.10). This was consistent between the pre-assessment and post-assessment.

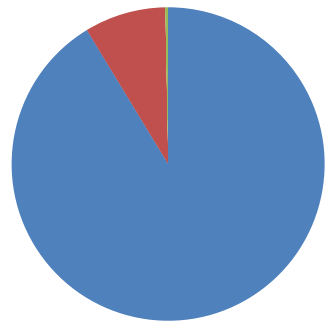

Figure 5.10. Credibility cue usage by students (*n*=673).

Single credibility cues such as those given by students (i.e. *019-021, 025-100, 031-014, 020-018* in Table 5.7) may suggest students consider a single cue contradicting or supporting credibility is sufficient. Other responses (i.e *005-079* and *021-020* in Table 5.7) show a more nuanced approach to credibility. Sample respones are a mix of individuals and organizations.

Similar cues were used as reasons for both high credibilty: *(010-097) government organization-regulates lead in homes-probably would not make things up* and for a lack of credibility; *(015-092) it's a government agency*. Post-assessment respones showed fewer students evaluated credibility on personal beliefs such as the government cannot be trusted.

Credibility in science is often related to scientific knowledge gained through education and research. Individuals and organizations that concentrate this knowledge and research in a particular field are considered experts. Student respones in this category (Academic, Research, or Expertise) suggest that being the person completing the research was an important factor in credibility. Knowledge was not limited to experts; students contended that research alone did not make someone an expert *(015-076, Table 5.7)*. A lack of expertise tended to focus on a lack of academic knowledge rather than research (*005-074, Table 5.7*). Research, in terms of measuring a volcanic plume, was used as support for very credible (*015-*

074), and not very credible (*021-005*). Individuals were scrutinized more than organizations when it came to research. This could be based on a collective having internal oversight (ie. *(025-019) this agency probably is made up of many people studying the topic so they have checked and double checked the information*); while individuals lack this oversight (*021-005*). Opinions being stated by either individuals or representatives of organizations in the article, made credibility questionable (somewhat credible, unsure, or not very credible).

Another cue that students used to question credibility questionable was their own lack of familiarity with the person or organization. Students often stated that they did not recognize the name of the individual or organization (*021-018*, *029-028*) making credibility questionable. However, when the students recognized the name of a relevant source they tended to consider the source either very credible or somewhat credible (*025-002*, *015-074*). Being a member of a group or organization, whether governmental or independent, led to greater credibility (Figure 5.11). Organizations associated with the government tended to have greater credibility than independent organizations (Figure 5.12). Government agencies were described as being fact based, or it being their job to protect us or the environment. Although students viewed the government as being generally more credible than independent organizaitons, it is unclear if that is because of a perception of truth or an expectation that governmental organizations aggregate data. Independent organizations were considered not quite as credible. Student respones provide a hint at what constitutes credibility for independent organizations; titles are important (*007-093*); being a member of an organization can imply expertise (*021-020*); membership in a group does not imply expertise (*035-006*) but may indicate some personal knowledge (*025-100*). Additionally, some of the statements made in the article by a variety of individuals were used as a credibility cue (*025-058*). This may not be an effective strategy; in this case the statement the student was referring to was blatanly inaccurate. Using facts or statements in the article to determine credibility could result in students taking what is said at face value without critical analysis of why the individual or organization is credible. Students pointed out that there was a lot of missing information (*023-061* and *009-094*) that made a credibility determination impossible (marked unsure). Many of these responses suggested needing to know more about the individual's job, title or location.

Table 5.7

Credibility Cues Used by Students with Examples

Coding Category	Sample Student Responses
Academic, Research, or Expertise	*(015-071) He took the measurements of the plume and was able to compare the size to help the people get a better hand on how serious the plume was.*
	(005-079) They have done their research and that is their job
	(020-018) They determine what is safe for the environment through tests and research.
Some Knowledge	*(010-104) She is a professional.*
	(015-076) They aren't going to be experts, but they will have done much research on their own.
Lack of Expertise	*(005-074) she doesn't have enough knowledge about it she is stating her opinion*
	(015-089) They are just a small group of people from a town who has lead pipes and they're working to get rid of them. The people have no scientific credibility.
Biased, Opinion, or a Single Viewpoint	*(019-021) It is somewhat credible because the back up their opinion with a emotional reason.*
	(021-005) This is one person so his measures and findings could have been misread or wrong.
	(003-073) This source is somewhat credible because it is a group of people with the same opinion about the lead pipes

Table 5.7 Continued

Credibility Cues Used by Students with Examples

Coding Category	Sample Student Responses
Governmental	*(025-125)* [re: EPA] *This is a government-sponsored agency, and their facts are extremely credible. They would be considered experts in this field, and should be taken as an authority on this topic.*
Group Membership	*(025-100) They are the people expierecing the problem.*
In Charge of / Responsible for	*(006-063) They are the ones that make sure the environment is as safe as possible for people*
	(031-014) It's their job to make sure that the environment is safe for the citizens.
Named in Article	*(029-013) They menshioned the EPA a few times in the article.*
	(019-004) Because in this article they give resources of where they got their information from.
Personal Name Recognition	*(025-002) I have heard of this group. I was under the impression that this was a nationwide agency.*
	(015-074) This is a very believable source because I have heard of it before and I have read articles from them.
No Name Recognition	*(020-018) I never heard of her.*
	(029-028) I haven't really heard of this organization
Agency, Organization, Group not affiliated with the government	*(007-093) agencies are credible*
	(021-020) It's a place where all they study is Earth Science. Plus, it's an institute; they're all experts.
	(025-020) This source is credible because it is an institute not a group.
	(035-006) They are citizens, not scientists or experts on the subject

Table 5.7 Continued

Credibility Cues Used by Students with Examples

Coding Category	Sample Student Responses
Cites support that is factually inaccurate in the article	*(025-058) Their is no background about her, and she doesn't think the problem is in the water where as the water company and EPA seem to think it is there. She may actually be right so that is why I didn't put not credible.*
Not enough information provided to know	*(023-061) I don’t know about her it doesn’t say she is any kind of expert. I think she is just stating her opinion.* *(009-094) Because they didn’t tell us what did for his Job and didn't give us enough info on him.*
Other	*(025-132) It gives you a different perspective.* *(029-024) Most people probably don't understand what it says.*

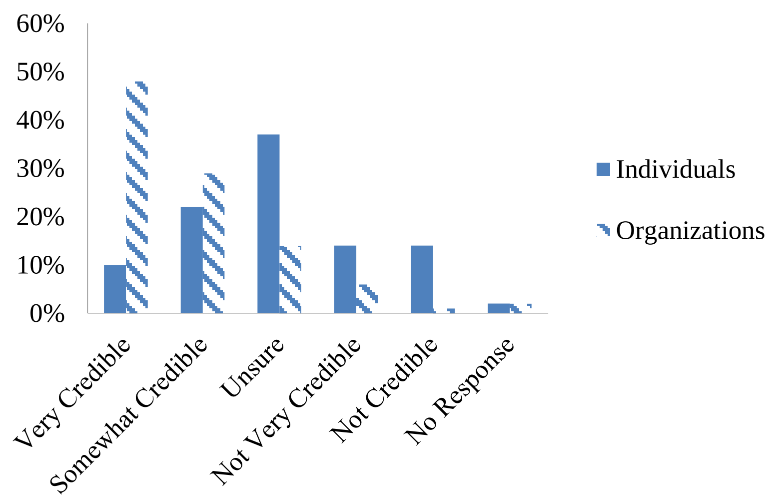

Figure 5.11. Comparison of credibility ratings by students (*n*=673) for organizations and individuals.

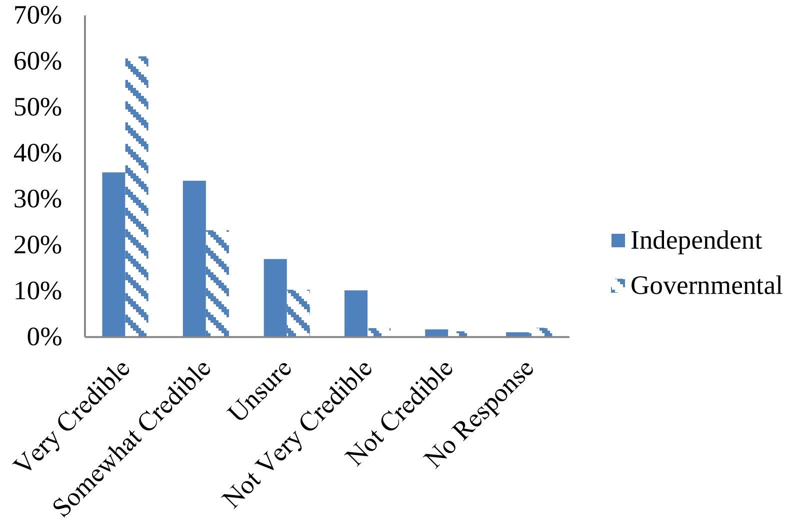

Figure 5.12. Comparison of student (*n*=673) credibility ratings for governmental and independent organizations.

Cue usage for individuals and organizations.

Credibility of individuals and organizations differed not only in their overall assessment of credibility but also in the types of cues used (Figure 5.13). Individual credibility was influenced by knowledge, lack of information provided in the text, having bias, an opinion, or representing a single viewpoint, student recognition of the name, being included in the article, and quoted information in the article. Organizational credibility was also influenced by knowledge and having bias, an opinion, or representing a single viewpoint, and their role or mission (in charge or responsible for), and their classification as an organization, agency, institute, or group. There was a difference between credibility cue usage among organizations (Figure 5.14), suggesting that students believed governmental organizations had more expertise, were less biased and tended to have a duty or responsibility regarding the issue. Statements such as- it is just an organization or they are not experts - were common when describing credibility for independent organizations.

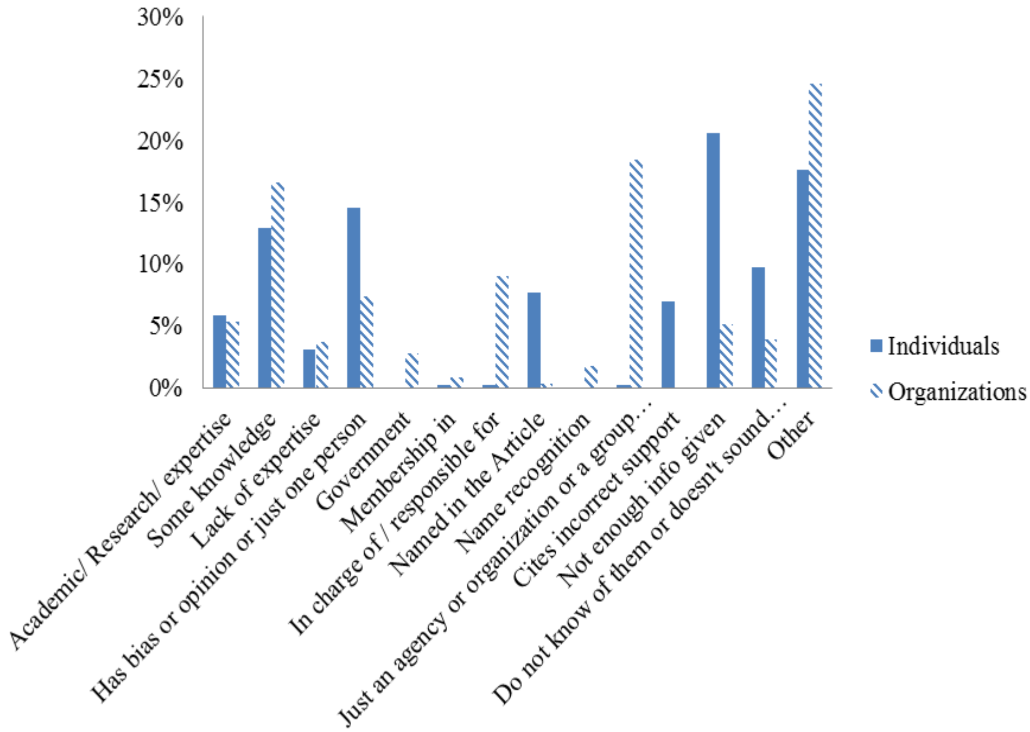

Figure 5.13. Implementation group credibility cue usage for individuals (*n*=544) and organizations (*n*=1136).

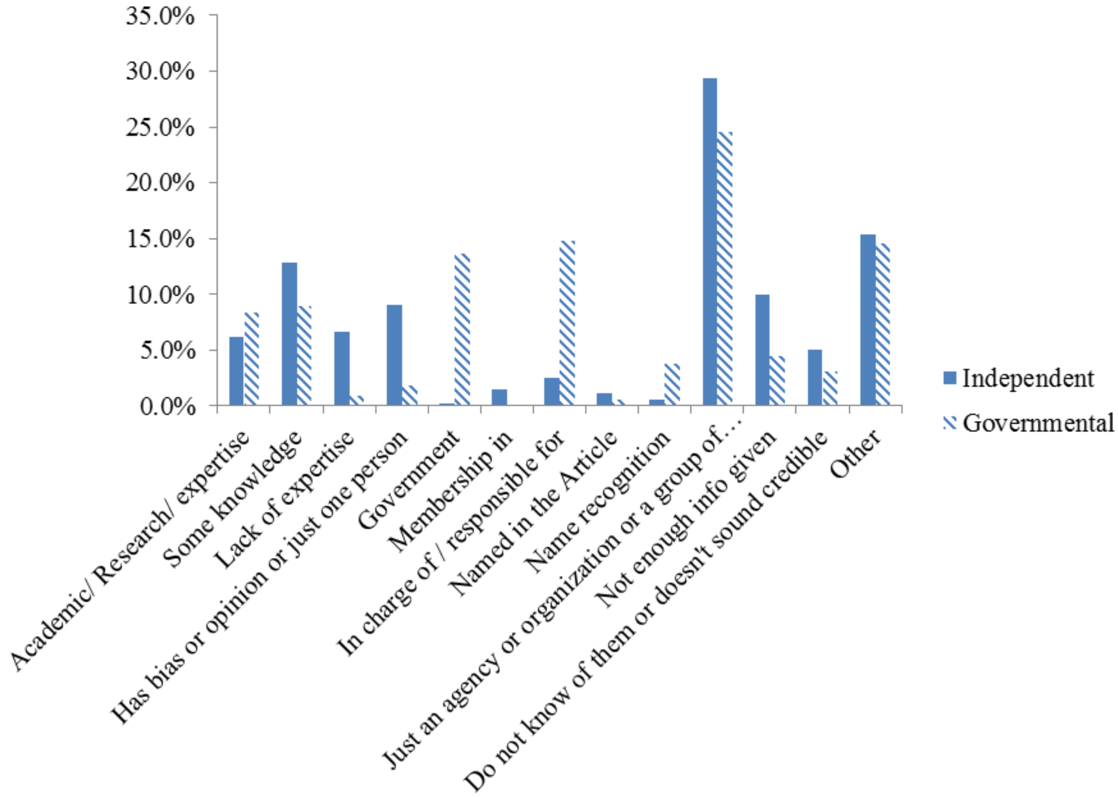

Figure 5.14. Credibility cues (n=562) used by the implementation group to evaluate independent and governmental organizations.

Looking at the overall picture of what makes a source of information more credible (very credible and somewhat credible) students have different criteria for individuals and organizations (Figure 5.15). High levels of credibility for individuals were dependent upon having some knowledge (academic or other) and being named in the article with bias or opinion and lack information making the individual slightly less credible.

Knowledge was also important for judging an organization's credibility. Other cues added credibility as well, such as being government-affiliated and having a role or duty relating to the issue. Just the titles: agency, organization, institute, group were often used to distinguish between very credible and somewhat credible. When a source was designated as not credible (Figure 5.16) the cues used were for organizations a lack of expertise, simply being an organization or group (i.e., Lead Pipe Initiative), and not enough information presented in the text. Individuals were determined to not be credible primarily by a lack of personal recognition and a lack of information in the text. From this analysis a broad definition of credible sources as seen by students can be drawn:

An individual or organization that has some knowledge related to the issue or topic, which has limited bias, preferably affiliated with the government, has a purpose or duty to study the issue, and has some name recognition.

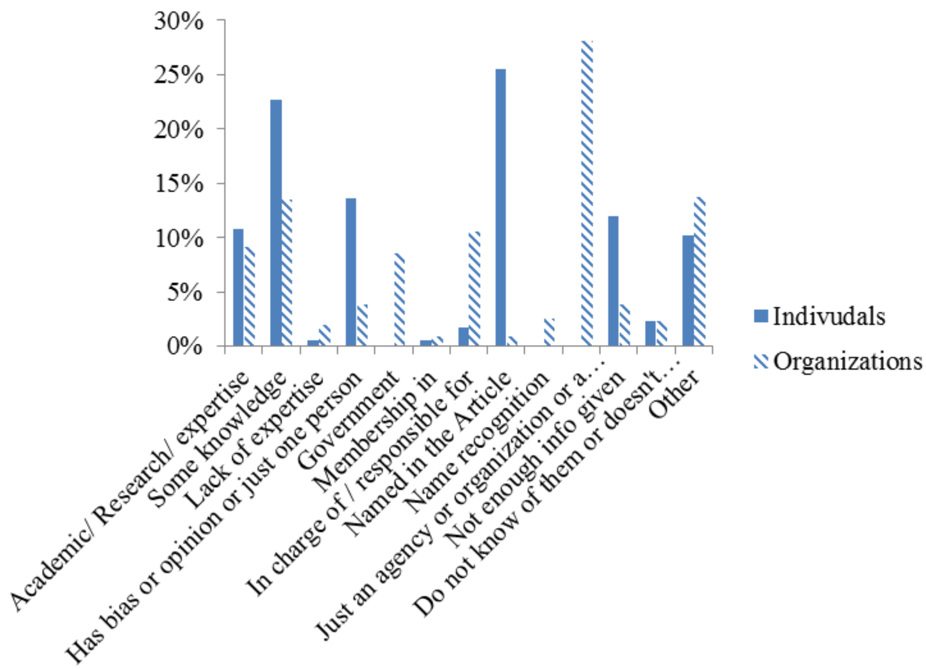

Figure 5.15. Credibility cue usage when very credible or somewhat credible was indicated for individuals (*n*=179) and organizations (*n*=899).

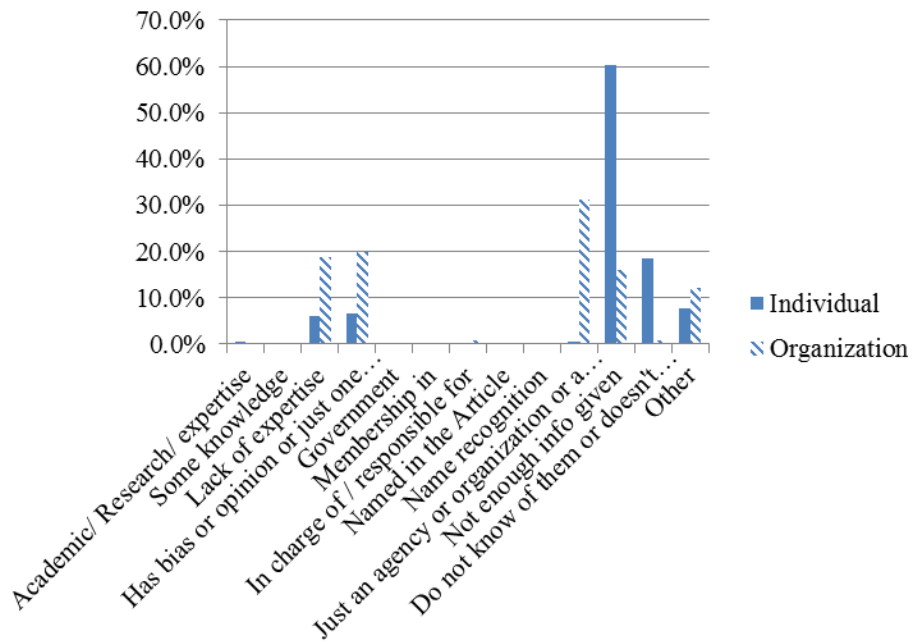

Figure 5.16. Credibility cue usage when not credible or not very credible was indicated for individuals (*n*=184) and organizations (*n*=106).

Suggesting multiple credible sources.

Many writing tasks in school ask the students to find and use multiple sources. SciJourn activities also focused on having credible sources. This was reinforced in comments by the editor on student article submissions, asking the students to find better sources. Questions 18 and 22 ask the students to suggest credible sources that could provide information about H1N1, high blood pressure, CO_2 and global warming, or childhood obesity and diabetes. Student suggestions fell into five categories: people, organizations, websites, media, and other (Figure 5.17 and 5.18) with slight changes between pre and post assessment (Figure 5.19). People and organizations were suggested more frequently on the post assessment.

Figure 5.17. Pre-assessment source suggestions (*n*=1709) by students: 225 media, 525 people, 289 organizations, 540 websites, 130 other.

Figure 5.18. Post-assessment source suggestions (*n*=2057) by students: 160 media, 731 people, 457 organizations, 590 websites, 119 other.

Not only did students provide more source suggestions on the post-assessment; there were shifts within each of these categories as well. On the pre-assessment, students suggested a variety of media as sources (for the purpose of analysis the library was considered a collection of media). Their post-assessment responses revealed a reduction in print media that is static (books, almanacs, and encyclopedias) and an increase in printed information from articles, scientific studies, newspapers, magazines, and journals. This shift suggests that students consider sources that are printed on a frequent basis as a better choice for information (Figure 5.20).

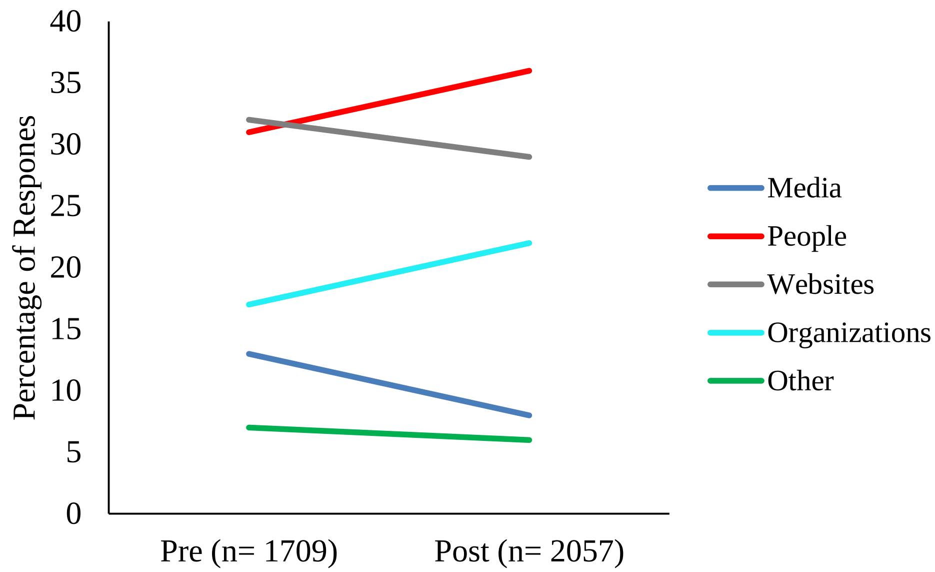

Figure 5.19. Changes to source suggestions reflected by percentage of responses.

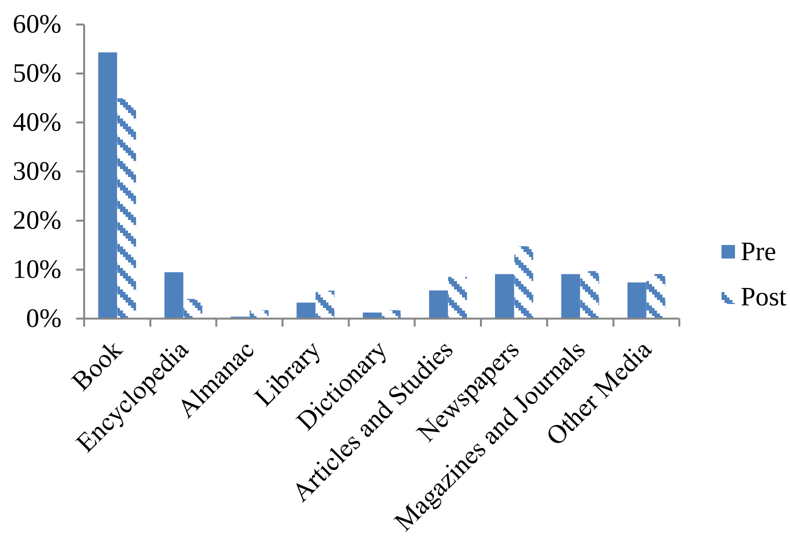

Figure 5.20. Types of media suggested as sources on the pre-assessment (*n*=243) and post-assessment (*n*=176) displayed by percentage of responses.

Individuals or groups of people were suggested as well. Over 60% of pre-assessment suggestions were for medical professionals (Figure 5.21). Post-assessment responses suggest that students are beginning to see credibility as more than just training or education. The increase in suggestions of someone who is affected by a disease or an issue suggests that the knowledge of stakeholders was more highly valued after participating in SciJourn activities.

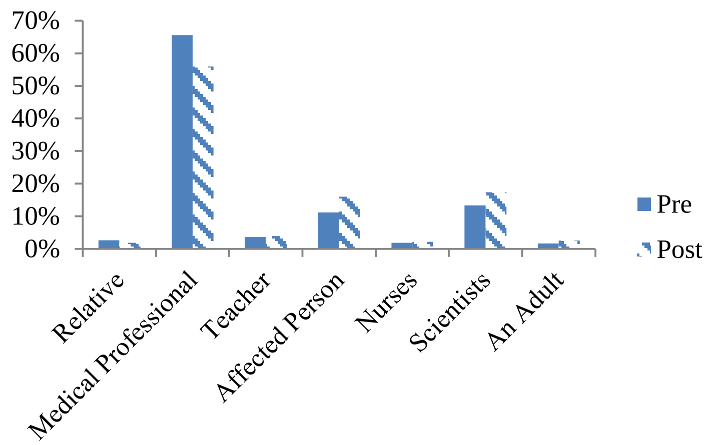

Figure 5.21. Types of individuals suggested on pre-assessment (*n*=525) and post-assessment (*n*=731) displayed by percentage of responses.

Suggestions about organizations changed as well (Figure 5.22). Students suggested more organizations with increased suggestions that were government affiliated (e.g., FDA, EPA, CDC, State health departments) and organizations related to a particular disease or a health issue (e.g., Juvenile Diabetes Association, American Red Cross, American Heart Association). These shifts suggest that students became more familiar with a variety of organizations and began to understand the role such organizations have in studying disease.

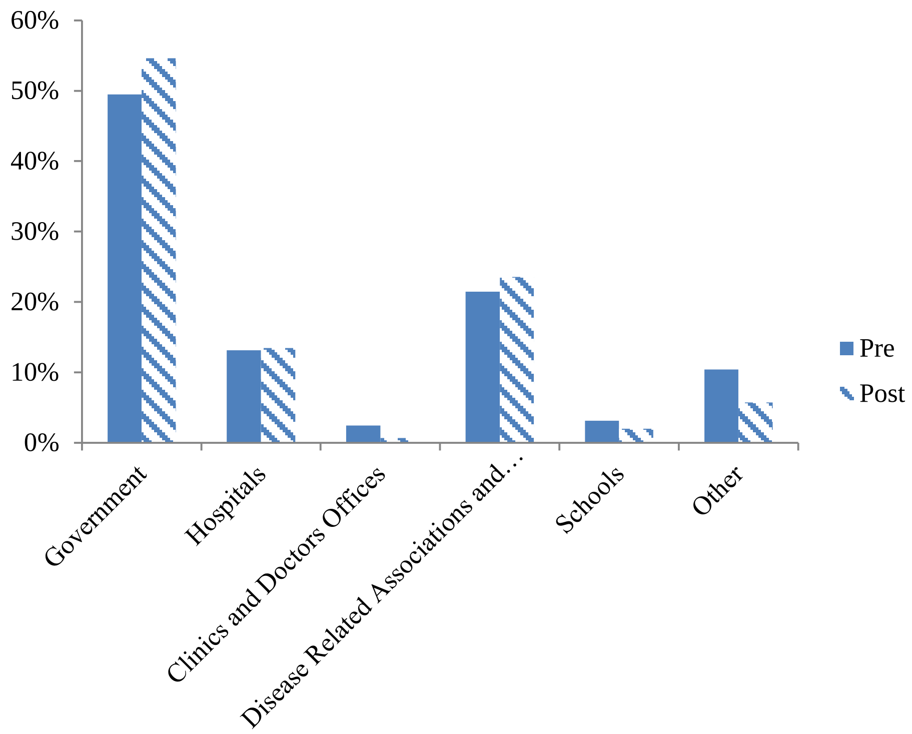

Figure 5.22. Types of organizations suggested on pre-assessment (*n*=289) and post-assessment (*n*=454) displayed by percentage of responses.

Students often use the internet to find information; as a result suggestions for sources that are related to the World Wide Web were very frequent (Figures 5.17 and 5.18) on both the pre-assessment and the post-assessment. However, suggestions changed significantly from pre-assessment to post-assessment (Figure 5.23). On the pre-assessment 51% of suggestions were Google, Yahoo, Bing, the “internet” or “websites”. The post-assessment indicated that students had more specific targets for information such as organizations, government websites, specific web-sites (e.g., WebMD.com, MayoClinic.com, KidsHealth.com), or made suggestions for a type of site. This increase in specificity resembles their suggestions for individuals and for organizations. It is interesting though that on Question 23 where students were asked to suggest search terms/phrases to find additional information they were less specific than when suggesting websites as a source in Questions 18 and 22.

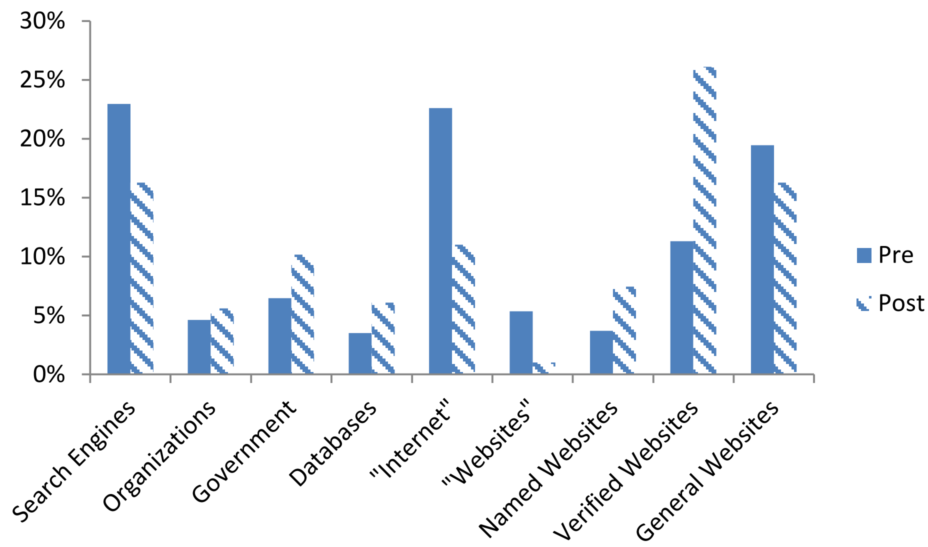

Figure 5.23. Types of websites suggested on pre-assessment (n=540) and post-assessment (n=590) displayed by percentage of responses.

Summary

At the beginning of the chapter several questions were posed about how students interact with scientific information in news articles, informational brochures, photos with captions, and PowerPoint presentations. The analysis of implementation student responses revealed that over time students became more specific when describing contextual connections, search terms and phrases, and sources. Student role as a producer or consumer impacted the types of suggestions for improvement yet did not alter the percentage of students identifying the factual inaccuracy within the presentation significantly. Credibility is situational. Student responses suggest that participation in SciJourn activities helped them understand this aspect of credibility. Finally, students think about relevance in two broad ways, immediate need to know and a future need to know. This temporal component to relevance impacted their suggestion as to who the information would be relevant to.

Chapter Six

Findings: Hierarchical Linear Modeling

Chapters four and five provide support for improving scientific literacy by incorporating science journalism. These analyses were limited in scope due to an assumption that improvement was based upon SciJourn activities that students participated in. In 1976, Cronbach pointed out that:

> The majority of studies of educational effects—whether classroom experiments or evaluations of programs or surveys—have collected and analyzed data in ways that conceal more than they reveal. The established methods have generated false conclusions in many studies. (p.1)

This view stems from the complicated hierarchy of education with school level variables, teacher level variables, and student level variables playing a role in the outcome of any intervention. Kohnen (Farrar, Kohnen, Hope, & Graville, 2011; Kohnen, 2011) described these variables as Spheres of Influence, acknowledging that a teacher's instructional decisions are influenced by a variety of variables. As Cronbach (1976) suggested, ignoring these influences can lead to false conclusions about educational interventions. Several researchers suggest that using hierarchical regression or hierarchical linear modeling to determine what variables have the biggest effect on the construct, in this case scientific literacy, and contend that this model will provide a better explanation of the intervention's impact (Bryk & Raudenbush,1992; Osborne, 2000; Raudenbush & Bryk, 1986).

Variables

One goal of the SciJourn program was to develop a wide range of activities that build scientific literacy. During the two week summer training, professional development provided during the school year, and classroom visits many of these activities were used. Teachers in the program were encouraged to choose what activities worked within their curriculum. As a result, no two teacher's implementations of SciJourn materials were alike even in a superficial sense. Variables that may have influenced their choices for implementation are described below:

School level variables.

All school level data was collected from the State Department of Elementary and Secondary Education unless noted.

- SES: determined by the percentage of students receiving free and reduced lunches.
- Scores on state assessments; English and Science scores were used.
- School location: rural, suburban, or urban distinctions were made based on a report prepared the Attorney General (US Department of Justice, 2008) using census data.
    - Rural – less than 500 inhabitants per square mile
    - Suburban- between 500-2000 inhabitants per square mile
    - Urban- over 2000 inhabitants per square mile
- Average attendance
- Average ACT scores
- School type: public or private
- Technology access was determined through teacher surveys.

    - High level of access includes classes that have a complete set of computers in the classroom or are part of a 1 to 1 computer initiative where students were issued a computer.
    - Medium level of access includes classes that have a computer lab available that has high speed internet.
    - Low level of access includes classes that have limited access to computer labs (generally shared with business classes) or intermittent or dial-up internet.

Teacher level variables.

On the application teachers provided demographic information. As teachers implemented the project implementation level and technology usage was noted in observations and discussions. These two sources provided some insight into the variables at the teacher level.

- Gender
- Length of teaching career
- Teaching Field: Science or other fields
- Teaching Area of Expertise: physical science, life science or other
- Education level
- Degree in Science, Education, or other
- Participation group: one year (Cadre I) or two years (Pilot group)
- Use of technology in classroom
    - High level of use included frequent use of computers in the classroom or at a computer lab throughout the year.
    - Medium level of use included visiting the computer lab a few times a year.

  - Low level of use included using technology in the classroom such as a Smartboard with very limited or no student use of computers.

- Implementation Level: teachers were not given a specific curriculum to follow instead they were provided a wide variety of activities they could use and were encouraged to develop their own lesson ideas. The main objective stated by SciJourn was to work towards students producing a science news article of their own, and regardless of lessons, all teachers were encouraged to target the learning goals represented in the scientific literacy standards. Implementation level was determined by the SciJourn team using classroom observations, teacher self-reporting of activities, and article submission.
  - High level implementation means teachers met the objective of production and submission of student-written articles and incorporated a wide variety of SciJourn activities.
  - Medium level implementation means teachers incorporated a wide variety of SciJourn activities but did not have their students submit completed articles.
  - Low level implementation means teachers incorporated a limited number of SciJourn activities focused mainly on reading strategies, such as the read aloud think aloud only.

Student level variables.

Information on student variables was provided on their IRB consent forms or through the teacher.

- Gender

- Grade level (freshmen, sophomore, junior, senior)
- Course: in all of the schools in the study, students select their courses
- Published an article (yes or no)
- Revised an article and resubmitted a second draft (yes or no)
- Multiple articles: students drafted multiple articles and submitted them

Generalized Linear Mixed Modeling (GLMM) Procedures

The variables described above were analyzed to determine their influence on student scientific literacy development, using a nesting order of student variables as first level, teacher variables as second level, and school variables as variables level. This analysis focused on overall SLA post-assessment scores for the implementation group only (*n*=673). Further analyses examined the role of these variables in SLA sub-scores.

Overall SLA score analysis.

Initial GLMM analysis revealed that school variables were not significant predictors of student achievement. This included standardized test scores and availability of technology within a school. Similar to the results in the RAND study (Buddin & Zamarro, 2009), teacher education level and licensure had no predictive value. Two student variables (course and revision) and two teacher level variables (implementation level and teaching focus area) contributed to the variance within student SLA post test scores. Increased implementation and revision of student writing had a positive influence (Table 6.1). The resulting Akaike corrected (594.829) model explains the variance within the overall post assessment scores using these four variables (Table 6.2). Additional models were created for the five aspects of scientific literacy (relevance, context, factual accuracy, multiple credible sources and information seeking); these models will be described in the section "Scientific Literacy Aspects" below.

Table 6.1

Fixed effects influencing implementation student SLA scores

	F	df1	df2	Sig.
Corrected Model	11.254	15	610	0.000
Teacher				
Implementation level	19.141	2	610	0.000
Area of focus for teaching	5.126	1	610	0.024
Student				
Course	3.775	7	610	0.001
Revision toward production	9.374	1	610	0.002

Probability distribution: Normal
Link function: Identity

This model suggests that of the variables that were examined implementation level, course enrolled in, revision toward production and area of teaching focus had significant ($p > 0.05$) influence on the student scores. Increased implementation provided a greater benefit when it incorporated writing (Figure 6.1). The area of teaching focus also had predictive value in the model. Teachers whose teaching assignment was primarily focused on the physical sciences had higher overall means than those whose teaching assignment focused on the life sciences or other fields (Figure 6.2). Course enrolled in was also predictive of SLA scores (Figure 6.3). The final predictive variable in the model was if the student revised for publication. This was determined if the student revised based upon the editor’s feedback and then resubmitted a second draft for editing (Figure 6.4). As noted by Kohnen (in press) teachers approached editing different from our science news editor; whereas teachers were considering grammar and format and the editor was more focused on the scientific basis of the article and the logical support provided within. This could explain why students who revised with the goal of publication correlated to higher SLA post assessment scores.

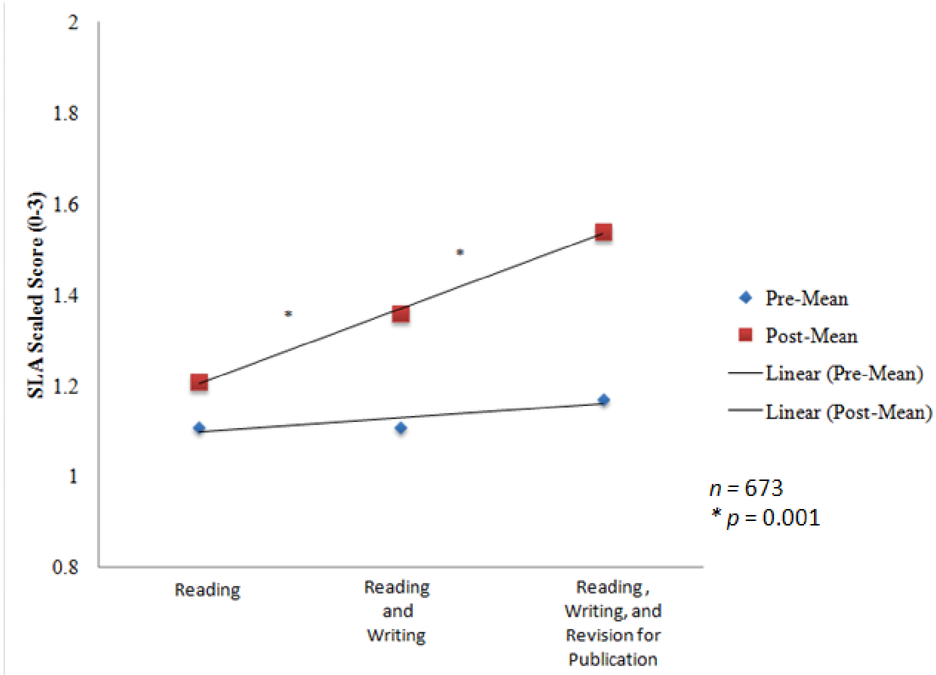

Figure 6.1. Implementation level means. Implementation level was a significant variable (p> 0.000) in the GLMM model based on student (*n*=673) post assessment SLA scores.

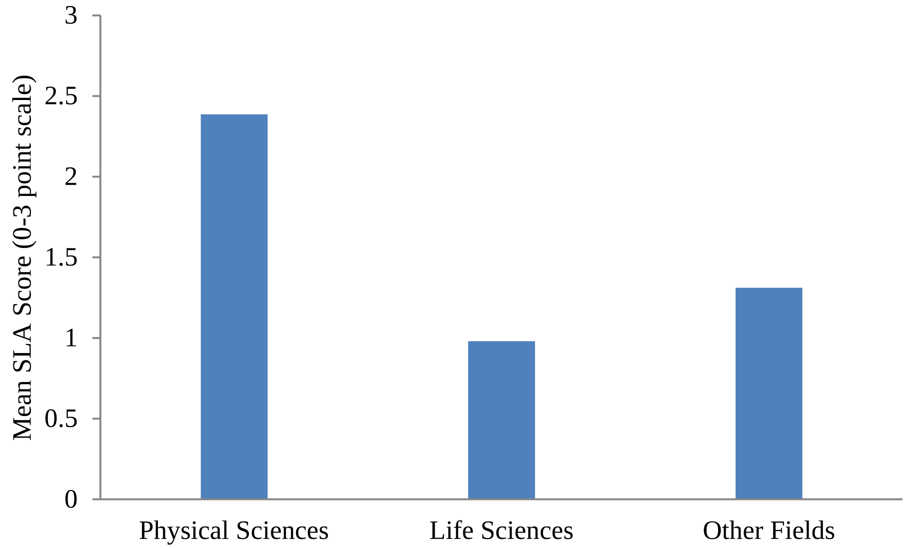

Figure 6.2. Teacher certificate focus area means. Focus area was a significant variable (p= 0.024) in the GLMM model based on student (*n*=673) post assessment SLA scores.

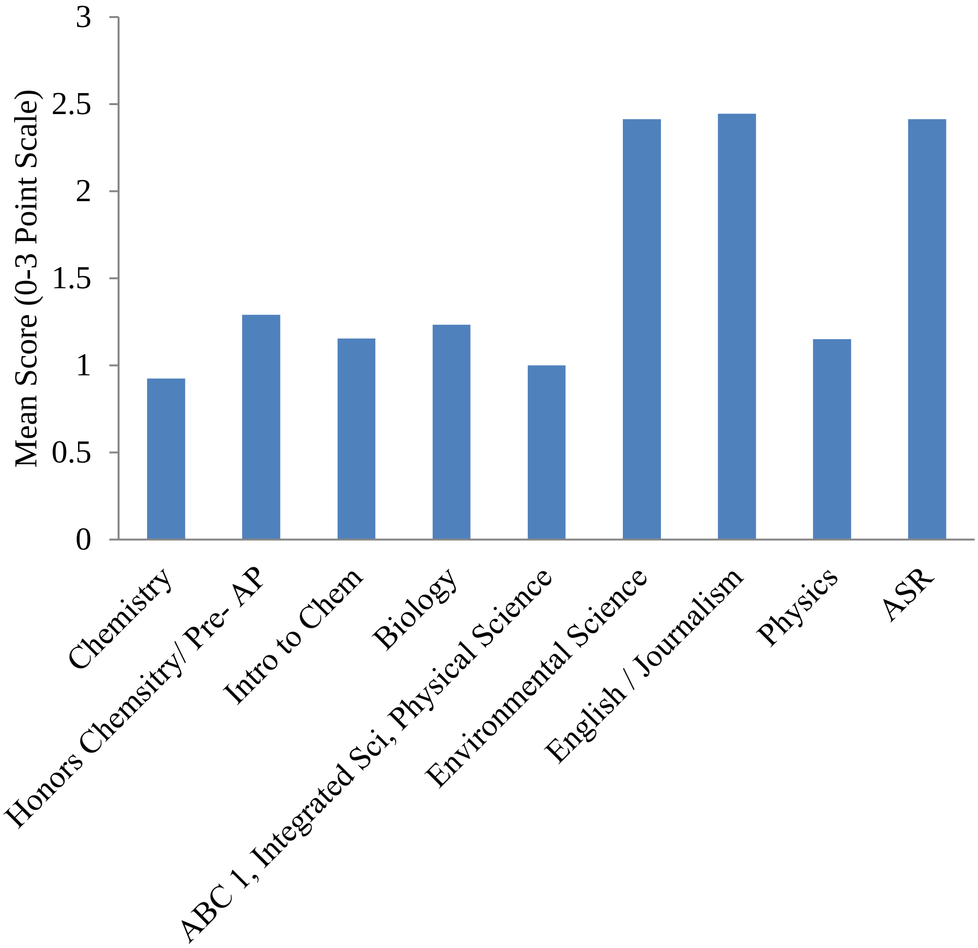

Figure 6.3. Means for courses. Course was a significant variable (p = 0.001) in the GLMM model based on student (*n*=673) post assessment SLA scores. Note: ASR (Authentic Science Research) is a four year progressive course aimed at students who plan on a future career in science.

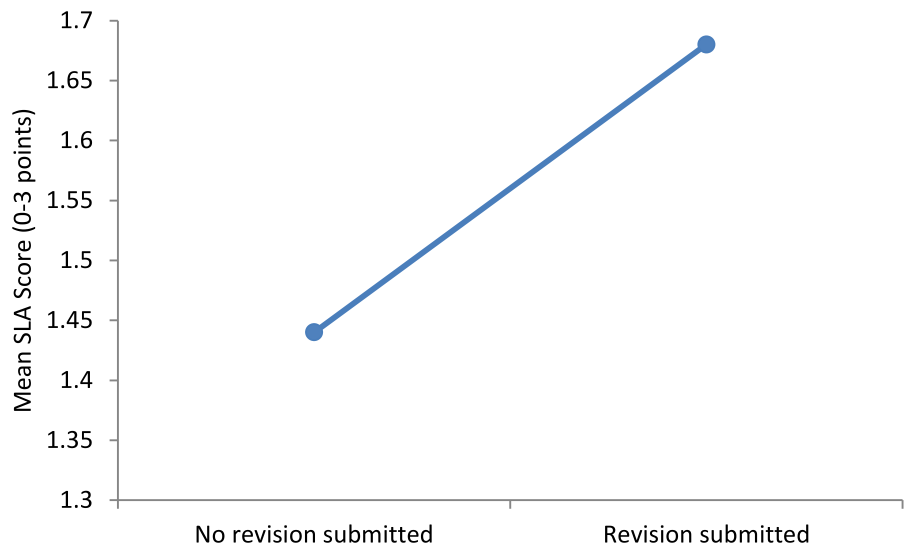

Figure 6.4. Means for revision. Revision was a significant variable (p = 0.002) in the GLMM model based on student (*n*=673) post assessment SLA scores.

Scientific literacy aspects.

Within the SciJourn Scientific Literacy standards are five aspects. Each of the aspects was analyzed within the nested framework described above. These analyses indicated that a variety of variables influenced each aspect. The GLMM model for the sub-scale relevance suggests that the single variable "revision" was a significant (p = 0.003) predictor of post assessment scores (Table 6.2) suggesting student views of relevance were generally unchanged without revision. Context sub-scale scores (Table 6.3) were also influenced by revision (p = 0.018) and course enrolled in (p = 0.011). Information was contextualized in class through read aloud think aloud activities and through the article writing process. This data suggests that using science news writing is a useful activity to contextualize new information, although it is unclear if other activities such as read aloud think aloud activities have an impact or simply contribute to the student's ability to contextualize when writing. Similar to context and relevance, factual accuracy sub-scale

scores (Table 6.4) were also influenced by revision (p= 0.018). In addition implementation level (p= 0.001) and course (p=0.031) also were significant predictors of sub-scale score. As mentioned in chapter five, teachers noticed early in their implementation that students struggled to find multiple credible sources. The teachers' effort to develop this aspect of student scientific literacy was evident in the quantitative analysis (chapter 4), although their efforts were shaped by their teaching environment as demonstrated by the GLMM model for multiple credible sources which included Implementation level (p= 0.000), area of teaching focus (p= 0.023), and course
(p = 0.015) as significant influences for sub-scale scores (Table 6.5).

Information seeking generally was accomplished using the internet in classrooms; this is reflected in the model for information seeking which included technology usages (p = 0.034), implementation level (p = 0.000), course (p = 0.016) and revision (p = 0.030). Coefficients for all variables categorized by sub-scale category are reported in Appendix G.

Table 6.2

GLMM results for relevance sub-scale post assessment scores

	F	df1	df2	Sig.
Corrected Model	2.075	15	610	0.010
Revised	8.805	1	610	0.003

Probability distribution: Normal
Link function: Identity
Information Criterion: Akaike Corrected 857.552

Table 6.3

GLMM results for context sub-scale post assessment scores

	F	df1	df2	Sig.
Corrected Model	8.748	15	610	0.000
Course	2.640	7	610	0.011
Revised	5.619	1	610	0.018

Probability distribution: Normal
Link function: Identity
Information Criterion: Akaike Corrected 1169.74

Table 6.4

GLMM results for factual accuracy sub-scale post assessment scores

	F	df1	df2	Sig.
Corrected Model	5.516	15	610	0.000
Implementation Level	7.045	2	610	0.001
Course	2.218	7	610	0.031
Revised	5.594	1	610	0.018

Probability distribution: Normal
Link function: Identity
Information Criterion: Akaike Corrected 941.902

Table 6.5

GLMM results for multiple credible sources sub-scale post assessment scores

	F	df1	df2	Sig.
Corrected Model	6.558	15	610	0.000
Implementation Level	15.900	2	610	0.000
Area	5.199	1	610	0.023
Course	2.508	7	610	0.015

Probability distribution: Normal
Link function: Identity
Information Criterion: Akaike Corrected 964.800

Table 6.6

GLMM results for information seeking sub-scale post assessment scores

	F	df1	df2	Sig.
Corrected Model	9.143	15	610	0.000
Technology Usage	4.522	1	610	0.034
Implementation Level	24.702	2	610	0.000
Course	2.496	7	610	0.016
Revised	4.737	1	610	0.030

Probability distribution: Normal
Link function: Identity
Information Criterion: Akaike Corrected 1023.096

Summary

Teachers repeatedly stated that they found the SciJourn summer institute and subsequent professional development very beneficial in part because there was no required method or way of implementing science journalism in their classrooms. This provided the teachers with the authority to make decisions based on what was best for their classes. The GLMM model for the overall post assessment scores supports this strategy for professional development—providing basic instruction combined with a wide variety of activities aimed at improving a set of practices; with support from other teachers who are working toward the same goal; and a team of people who encourage the teachers but are also available to answer questions and provide ideas. The autonomy of the teacher resulted in a wide variety of implementation styles. Interestingly, implementation level and revision were the significant predictors in the overall score and in the vast majority of sub-scale scores based on GLMM modeling, suggesting individual teachers' implementation styles had less influence than simply working toward the goal of creating a well-researched science news article. Other factors commonly considered influential in student success such as: SES, attendance, test scores and geographic location, teachers' years of experience, teachers' education level, student gender and grade level were not predictors of variance.

Chapter Seven

Discussion and Implications

The National Research Council released *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* in 2012, providing a new vision for science education in the United States. The need for science and engineering professionals was part of the impetus for this work; however, the report acknowledges the need of all American citizens to have knowledge and capabilities which would be useful to them in life, stating:

> By the end of the 12th grade, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives (p. 9).

To achieve this goal, the report outlines practices, crosscutting concepts, and core ideas in science that should be attended to in future drafts of science standards. Dimension 1 describes several practices that are important to science and engineering; and includes a section focused on the collection and communication of science information. Within Dimension 1, *Practice 8: Obtaining, Evaluating, and Communicating Information* begins with the following statement:

> Being literate in science and engineering requires the ability to read and understand their literatures. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics. Reading, interpreting, and producing text are

> fundamental practices of science in particular, and they constitute at least half of engineers' and scientists' total working time. (p. 74)

The section goes on to describe the difficulties with science text and how communication is an important practice for scientists, adding the following:

> Being a critical consumer of science and the products of engineering, whether as a lay citizen or a practicing scientist or engineer, also requires the ability to read or view reports about science in the press or on the Internet and to recognize the salient science, identify sources of error and methodological flaws, and distinguish observations from inferences, arguments from explanations, and claims from evidence. All of these are constructs learned from engaging in a critical discourse around text. (p. 75)

This new framework could represent a shift from the emphasis on laboratory experiments as a way of knowing to include other activities such as reading, writing, and critical thinking, in addition to making it clear that these practices are important for everyone. Although the above quote references the aim of preparing citizens to critically read reports in the press or on the internet, the more specific goals in the subsequent portions of the document mainly refer to reading primary science literature. This contradiction indicates there is only a slight shift in thought about what constitutes science education in relation to science-related communication. Engaging students in scientific discussions and decisions throughout their lives is one important influence on the framework goals. SciJourn holds a very similar view of engaged life-long learners, and developed standards and activities that can be used to help address the practices required for consumers of science information which may include primary literature but also a wide variety of other types of secondary media.

This chapter is presented in three sections. The first section focuses on the findings in relation to the research question; how does participating in science journalism activities impact student scientific literacy? The second section integrates these findings into the vision provided in the NRC Frameworks. The third section considers the implication this research has on developing the future science standards.

Findings in Relation to Research Question

Developing scientific literacy among students is by no means a new idea. Science education has long held this as a goal (DeBoer, 2000; Hurd, 1958; 1998; Jenkins, 1990; Yore, Pimm, & Tuan, 2007). Teachers have used a wide variety of instructional strategies to address some aspects of scientific literacy such as relevance and context. SciJourn built upon this by providing additional strategies that address the use of multiple credible sources, information seeking and evaluating factual accuracy. The quantitative analysis in this study revealed that all participating teachers (implementation and comparison groups) helped their students improve their scientific literacy, with those students who participated in SciJourn activities improving significantly more. There were many variables that could have contributed to these gains. Generalized linear mixed modeling (GLMM) identified three variables that influenced the variation in scores including both student and teacher variables; the model including these variables accounted for 14% of the variance in the scores. Two of the variables (implementation level and revision) were directly related to SciJourn practices. This suggests that incorporating reading and writing science news can improve scientific literacy practices for students.

Phillips and Norris suggest that reading is a form of inquiry within science education (2009). I contend that reading as a form of inquiry should be expanded to communication as a form of inquiry; including the role of writing and conversations. Once a student has a question they would like to pursue as in the first stages of article research, students spend a great deal of time reading. As students gain a better understanding of their topic, their questions shift and reading may no longer be sufficient, at which point students begin asking their family, teachers, and other adults questions. This question asking process is another form of communication that helps the student learn about their topic, its importance to others, and possible impacts. Once students collect this information from reading and talking, they transform it into a written description of their findings. The format of a science news article helps students focus on the most important aspects of their findings, and the norms of the genre demand they take into consideration the biases that might be present in their information and data. From reading, to interviewing, to writing, students continue to shape their questions and seek out additional information; in this manner their inquiry is neither linear nor truly recursive.

This meandering approach may be more similar to real inquiry than most of the lab experiments used by teachers. Communication as inquiry is only one part of the scientific literacy puzzle. Life experiences, basic understandings about the natural world, its interconnectedness, and the nature of science are a necessity as well. SciJourn provides an example of how integrating communication practices focused on relevant scientific and technological issues can facilitate the learning of science content and the nature of science.

Student Scientific Literacy

While there are many definitions of scientific literacy, Roberts (2007; 2010) contends that these can be divided into two visions. Vision I focuses on the “structure of science”, “scientific skill development”, “correct explanations”, and providing a “solid foundation” as the purpose for learning science. This vision is aligned to current curricular expectations, where as a student matriculates through school they learn how science is done, what is science and what is not, how to explain phenomena in terms of scientific principles and to prepare them for a future course or career in science.

Vision II provides another cluster of purposes for learning science including “everyday coping”, “self as explainer”, and “science, technology and decisions”. These two visions create a landscape for what constitutes a scientifically literate individual. Roberts goes on to provide examples of what it means to be scientifically literate within each vision using *Project 2061* as an example for Vision I and Nuffield Foundation’s *Twenty First Century Science* as an example of Vision II. *Project 2061* describes the scientifically literate individuals as one who:

> is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (AAAS, 1990, p. xvii)

As the example for Vision I, Project 2061 provides a framework for a scientifically literate individual as someone who knows science. Roberts uses the definition provided by the

Nuffield Foundation as part of a course of study for high school students, called Twenty First Century Science. In this view, a scientifically literate individual will:

> appreciate and understand the impact of science and technology on everyday life; make informed personal decisions about things that involve science, such as health, diet, use of energy resources; read and understand the essential points of media reports about matters that involve science; reflect critically on the information included in, and (often more important) omitted from, such reports; and take part confidently in discussions with others about issues involving science. (Nuffield Foundation, n.d.)

The current science education model in America is based on Vision I. This presents a challenge. *Project 2061's* definition is narrowly focused on science as a set of concepts and processes. This has led to an overemphasis of scientific literacy as knowing facts in most secondary education courses. Aikenhead, Orpwood, and Fensham (2011) suggest scientific literacy in today's knowledge-based economy is less about what you know and more about your capacity to learn. Twenty First Century Science's definition of a scientifically literate individual focuses on the utilization of science information. Nuffield Foundation distinguishes between these two general visions by describing individuals as producers of new scientific information and informed consumers. It is within the framework of the Visions outlined by Roberts (2010) that the SciJourn definition of scientific literacy, and the role of the individual as a producer or a consumer that the qualitative results are best described.

Vision I or Vision II? While the SciJourn project is more aligned to Roberts' Vision II (Polman et al., 2012), the GLMM analysis indicated that there are other variables that influence scientific literacy. Course and revision toward publication were two student variables that consistently influenced the student's scientific literacy as assessed in this study. This could be a reflection of greater content knowledge, more life experiences, or a combination of the two. Often students chose to write about topics that they may not have encountered during formal schooling such as hippotherapy or homeopathic medicine. Selection of such topics supports the view that experiences outside of the curriculum can powerfully impact a student's scientific knowledge. Helping students view this outside knowledge and classroom knowledge as equally valid and supporting one another was an obstacle participating teachers and the SciJourn editor felt needed to be addressed and overcome.

Other variables such as implementation level, teacher's area of specialization and technology usage also influenced the changes to student scientific literacy. Looking at these variables together, it can be surmised that in order for students to improve their scientific literacy both students and teachers must consider and bring to bear some basic science understandings and experiences that come from inside and outside of school.

The SciJourn standards describe the set of practices needed by students (and citizens) to be scientifically literate in a media infused society. The analysis of each of these aspects revealed more about the scientific literacy of an average high school student as evidenced by the responses from this heterogeneous group of students.

Relevance.

For teachers, relevance can be both a useful strategy for engaging students in the learning process and an obstacle to learning. One challenge is the limited amount of new science incorporated into classroom curriculum and textbooks; as a result, teachers struggle to explain why information that is sometimes hundreds of years old is still relevant today.

Teachers who incorporated reading (either as bellringer activities or read aloud think aloud discussions) used current science news to show how information from so long ago is still relevant today.

SLA responses indicated that students were aware of the temporal aspect of knowledge; suggesting that information may be of immediate use to some and future use to others. Many of the student responses suggested that information contained in the science news article was good to know regardless of usefulness, suggesting that information can also simply be interesting. The analysis reflected a view that general science knowledge has value. In addition, science knowledge associated with a necessary action made the information more relevant to students. A science news article can provide the impetus for action by someone who lives far from a natural disaster. Many students thought an article or photos about a natural disaster could solicit help from the public at large. From this it can be surmised that students do see connections between themselves and distant science issues such as hurricanes or oil spills.

Students also believed that the need to know was similar for scientists and the general public; stating scientists needed to know in order to prepare for a future event through scientific advances or to mitigate the damage done, while the general public needed to know in order to take proper precaution for a future event or to help out locally with clean up. Students tended to hold the view that science had a responsibility to learn from both natural and man-made disasters by developing solutions and improving current materials and systems to ensure it does not happen again. Another view held by students was that individuals needed to be informed and take action to protect themselves and others. Relevance outside of school was linked to both scientific needs and societal needs. With few students envisioning a future career as a scientist, using the societal angle may be a useful way of illuminating relevance.

Context.

Although teachers may tend to feel it is important for them to help their students see science information as relevant, it is equally important for students to place new information into context. Making connections to what they have already learned in science and what they know about the world around them can help anchor new ideas. The SLA contained three questions asking students to make connections between new information in a health brochure and a series of photos related to a natural disaster.

Students made connections to science (applied and pure science knowledge) and society. Most of the connections made within a science context related to the interdependency of biotic and abiotic variables within the environment. Their concern about the effect a disaster would have on animals and food webs was associated with disruptions in the environment both directly attributed and indirectly attributed to the event. Several aspects of their connections are similar to how they viewed relevance.

Context also had a temporal component. Immediately following the disaster, students suggested animals and plants would be directly affected, eventually impacting the food chain. When asked to state longer term impacts, students often suggested societal issues such as loss of income, loss of jobs, damaged or lost housing, a change to their way of life and inadequate resources. Students also felt mental health issues would increase as a result of surviving a natural disaster. Students also held the view that many of these societal issues can be addressed through advances in science. Similar to relevance, students stated scientists had a role in preventing future devastation by looking at what happened and learning from it, then using this information to avoid future disasters. The interplay between an immediate context and future contexts was evident in the student responses.

Generally impacts on the environment were at the macro-level (i.e., organism, population, community, or eco-system levels). This suggests that placing information into context for students begins by making connections at very broad categorical levels. Cross-categorical connections—such as the idea that pollution in the water could affect animals and plants that live in and around the water—were common although the underlying processes were rarely alluded to. Physical proximity to the disaster was one variable students recognized when placing information into context; students often made connections between people living in the immediate area and effects due to exposure to contaminants. Similar to relevance, students made contextual connections around helping with suggestions for helping restore the environment and with rescuing injured animals. The overlap between relevance and context in terms of the temporal and proximal aspects suggests that for students these two ideas are intertwined.

Factual Accuracy.

During the pilot phases of SLA development, it was noticed that students were not paying attention to fine factual details included in text and graphics. Blatant false information was often ignored. This could be due to the student feeling the information was irrelevant to the issue, as in the article about lead levels due to the corrosion of lead pipes. Within the article, a source suggests that older homes tend to have paint made of 100% lead and that could be the issue rather than the piping. Few students questioned this statement. Clearly there are several issues with the statement. No paint is 100% lead. Lead paint can be a problem but it is not in the water so it cannot contribute to the contamination. While this inaccuracy seemed fairly obvious, students rarely addressed it. When mentioning this statement, students implied more testing needed to be done to verify the water pollution was due to the piping rather than questioning the accuracy of the statement.

Another example is from the article about a volcano eruption, stating that the plume was only 3m high. For anyone familiar with metric measurement, this should be obviously incorrect, yet few students noticed or questioned this fact. Ignoring facts such as these while reading science information is an indication that students are not considering the detailed factual evidence presented in the article when evaluating the factual accuracy of the information as a whole.

In the last section of the SLA, this trend continued. Students were provided a graph and some text describing the graph in a simulated PowerPoint presentation slide. The text contradicted the graph. Fewer than 20% of the student responses were related to the incongruence. Some of these students specifically stated that the data in the text was an incorrect interpretation of the graph, while others suggested that the creator of the PowerPoint slide needed to verify the accuracy of their statement or the graph. With 80% of the students ignoring the inaccuracy, it is clear that students are not comparing the images and text to look for detailed factual consistency. Students instead looked at the presentation as a whole suggesting changes to appearance for the graph and providing citations for the textual information included. Inattention to factual details and incongruence between graphical data and its interpretation is an obstacle to becoming scientifically literate.

As scientific discoveries are being reviewed and published, the scientific community attempts to verify the accuracy of the discovery by replicating the study and related analyses. Through this process, some scientific discoveries are found to lack merit. Although citizens do not have a large direct role in this process, it is essential that questionable statements of fact are recognized and their simple presence in an article, brochure, or presentation should cause the consumer to be critical of the overall message as well. It is clear from the analysis that students are not as critical of scientific information as they should ideally be, nor as critical as the experts who completed the SLA.

Multiple Credible Sources.

One way to become more critical of science information is to pay attention to the source. Initially students referenced sources too broad to be useful (e.g., library, book, Google) often including sources that lacked credibility (e.g., Ask.com, Yahoo Answers, and Cha-Cha). Many students stated they did not know what it meant to be credible on their pre-assessments and understanding what it means to be credible is important for consumers of scientific communication.

Our experts, as consumers of scientific information in the media, are aware of possible biases, research or political agendas, and the business behind TV ratings and web advertisements, in addition to having familiarity with a wide variety of credible sources. Students lack life experience to help them consider these issues. Teachers recognized early on in their SciJourn implementation that students lacked a basic familiarity with well-known credible sources such as the EPA and the CDC. This was supported by pre-assessment responses suggesting that a source was credible if it sounded real or if the student had heard of the source before.

As students struggled with the concept of credibility, it became clear that students tended to view credibility as black or white and often related to expertise. Students used a string of assumptions to determine an individual's credibility. If a person had a title they were experts and experts are credible; therefore anyone with a title is credible. However, the usefulness of expertise is dependent upon the question being addressed or the issue being investigated. A member of a local herpetological society may be a credible source for questions about a Hellbender, but not about blue tailed skinks. One example teachers used from a lesson about experts is ice truck drivers (Saul, et.al, 2012). Students almost unanimously state that truck drivers are not experts; unless you wanted to know how to drive on ice.

As students researched for their articles, teachers pushed them to find better sources and try to arrange an interview. Through this process, the students' view of credibility became more sophisticated. Credibility cues such as affiliation with a university or government, organizations that are dedicated to issues, and written information from scientific journals were used. This shift in views about credibility was most apparent when students suggested websites. Pre-assessment responses tended to include Yahoo.com, Ask.com, and Bing. While some post-assessment responses still suggested these sites, others suggested WebMD.com, MayoClinic.com, and HHMI.org. Through participation in science journalism activities, students expanded their familiarity with credible sources and created a way to determine credibility of unfamiliar sources using credibility cues. Students made some of the largest gains within this strand.

Information Seeking.

Research for student science news articles in SciJourn was mainly completed using the internet. Teachers made use of classroom computers and computer labs during the research phase. Observations made by this researcher and members of the SciJourn team during this time indicate that students used a wide variety of strategies for finding information on the web. In general these strategies help students navigate the web for information, producing a large pool of websites, advertisements, and documents for students to choose from. However, many of these results were not credible or were unrelated to the purpose of the search. Often this was due to the vagueness of the search terms used. Students tended to use very broad terminology (e.g., global warming, high blood pressure, diabetes) that provided too many options for students to make sense of, resulting in their overdependence on the first few links suggested. As their familiarity with organizations increased, students used these sources by directly accessing them on the web and searching within the site. Their increased familiarity was evidenced by the number and variety of specific sites suggested instead of search terms on the post-test.

Increasing the number of credible sites students use on a frequent basis will help to prepare them for the future. If students visit the doctor 10 years from now and are told they have hypertension, it will be important that they begin researching at a credible site such as Mayo Clinic. This directed searching helps to eliminate some of the less than credible information available on the web.

Students often referred to corroborating or verifying the information on the web with other websites. Because students engage in this verification process, determining credibility of a website needs to go beyond simply knowing a few credible sites to visit. Similar to developing credibility cues for sources, website credibility cues (e.g., “about us” sections, copyright date, and affiliation) are needed to inform judgments about the accuracy of the information.

As students engaged in researching and writing activities, they improved their information seeking in two meaningful ways: first by building a collection of useful credible sites, and second by developing cues that can be applied to any website to help determine credibility. One area that needs improvement is the use of combined phrases to narrow a search. Very few students (less than 8%) used this strategy to focus their research although they overwhelmingly (87%) recognized the need to have a narrow search.

Students as scientifically literate citizens.

Scientific literacy is influenced by an individual's subject matter knowledge, their understanding of the nature of science, life experiences, and their use of communication as a mode of inquiry. The SciJourn project enables students to develop practices that facilitate using communication as inquiry for scientific issues. Reflecting on Nuffield Foundation's definition of what it means to be scientifically literate can contextualize the results from this study. Students' overall SLA mean suggests that the teens in this study earned between one third and one half of the points scientists, science educators and other scientifically literate individuals earned on the SLA. However, there are indications in their responses that they do see a relationship between science, technology and society. Science and scientists have a responsibility to the general public in terms of generating new discoveries and improvements to existing technology and understandings about the natural world. In return citizens need to take scientific and technological developments and make use of these advances to benefit society as a whole.

Using scientific information to make decisions is complicated by the need to be familiar with credible sources and have the ability to seek out and evaluate new sources of information. Students improved more at finding (i.e., information seeking) and using multiple credible sources than the other aspects. Teachers and students found that the read aloud think aloud strategy for science news generated discussion and questions that helped in understanding the information. However, students continue to skim over the factual details in the news story on the assessment in favor of the overall picture. As a result, students may draw inaccurate conclusions about the veracity of information.

Engaging in discussions and communications about science and technology can be scaffolded by building student confidence in their ability to make connections to science and technology in relation to themselves and others, contextualizing information with science and society, learning to pay close attention to the details presented within scientific communication for accuracy, and seeking out credible sources of information. While working with my own students prior to this study, I had suggested they contact a scientist for an interview. Many of those students responded with something akin to "… but what will I say?" By improving the students' practice with regards to using communication as a form of inquiry, students can gain enough knowledge and confidence that they arrive at a place where they have something to say or have meaningful questions to pose. It is at this point that students will begin to engage in the public discussion about science and technology as legitimate peripheral participants (Lave & Wenger, 1991).

SciJourn's Place within the Common Core Frameworks

The new frameworks for science education (NRC, 2012) state a goal of developing a more "scientifically based and coherent view of the natural sciences and engineering, as well as of the ways in which they are pursued and their results can be used" (p. 11). The report identifies a second goal of reducing the breadth of coverage in science to increase the time for in depth investigations and argumentation to increase student understanding. The final goal is to integrate content knowledge and "scientific practices needed to engage in scientific inquiry and engineering design" (p. 11). These goals are aligned with Vision I, developing scientific literacy by providing knowledge and experiences that approximate what scientists and engineers do. This is reflected in a diagram (p. 45) depicting the three spheres of activity for these fields:

1. *Investigation* which includes making observations about the real world, experimenting, collecting data, and testing solutions is considered
2. *developing explanations and solutions* focuses on theory and model building, hypothesis formulation, and proposal of solutions
3. *evaluating*- within this sphere that information for other spheres is analyzed and refined.

When considering the diagram as a whole, the overall message is about the nature of science; mainly how science is done and how rigorous testing of hypotheses against the real world can improve understanding of the natural world. However, science in the real world is both tricky and complicated by other factors such as politics, the economy, and religion to name a few. Carl Sagan (1997) explained this complexity:

> Science is far from a perfect instrument of knowledge. It's just the best we have. In this respect, as in many others, it's like democracy. Science by itself cannot advocate courses of human action, but it can certainly illuminate the possible consequences of alternative courses of action
> (pp. 29-30).

Sagan went on to explain that scientific habits of mind such as holding conflicted views about an outcome simultaneously, open-mindedness to the facts, and achieving a balance between open acceptance of all information and an over-reliance on existing knowledge without scrutiny are what strengthen scientific thought. Such habits of mind are an "essential tool for a democracy in an age of change" (p. 30). Creating critical consumers of scientific information is a step toward creating scientific habits of mind.

Science education has two main goals of educating all students and at the same time providing the necessary foundational knowledge needed for students to pursue science and engineering careers. This duality of purpose may cause students to be lost along the way. Contextualizing the content by taking into account student interests can bridge these two purposes. SciJourn is one way of building this bridge. Using the three spheres identified in the frameworks, I created a model of how science/engineering knowledge can be augmented by science journalism (Figure 7.1). As with the original model presented in the NRC report (2012), there are three spheres. The main differences are in the types of evidence that are acceptable, the goal of including all stakeholders and the lack of a conclusion. This investigation of a scientific issue by using both primary and secondary sources can help prepare future citizens.

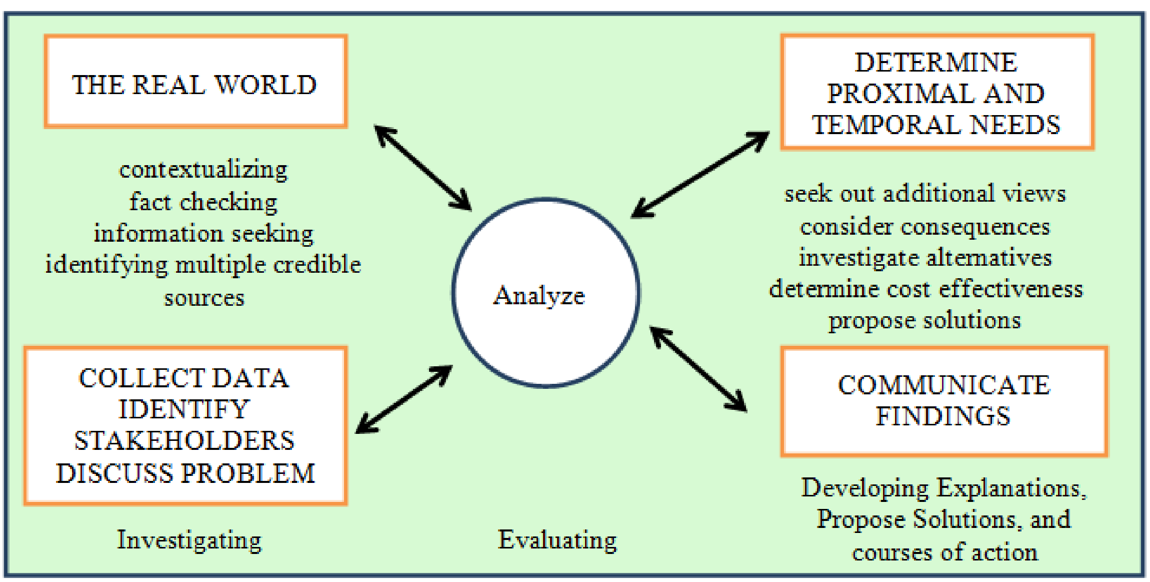

Figure 7.1. Spheres of activity related to science journalism built using the model provided in the NRC report *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*.

All students, those not interested in science as well as future scientists and engineers, need to understand how science works (practices and application of practices) and some basic principles (content knowledge). As adults however, they may be confronted by a situation where they need to know about a science or engineering issue of which they lack understanding. Since most adults do not engage in scientific investigations to answer these questions (Polman, et al., 2012), it is important to consider how their decisions are made. What kinds of science information can they access? What influences their interpretation of this information? How much data is needed to make an informed decision?

The notion that science can provide information but it is what people do with the information that makes the difference can be useful when considering how the frameworks can be interpreted. Consider the following scenario: a citizen noticed that the spacer material in the joints of their driveway is being squeezed out, leaving the concrete slabs pushing directly against each other and causing cracks. When mentioning this to a neighbor across the street, the neighbor states that it is the exact opposite in their driveway: there is a large gap forming between the end of their driveway and the street. Most citizens are not well versed in civil engineering or materials science to understand what is happening, which in this case is "street creep".

Later on at the subdivision meeting, others are also talking about this issue. One house actually had damage to their basement foundation due to this phenomenon. Clearly this issue needs to be addressed in the minds of the citizens. As a group they begin discussing who is having problems and they notice a pattern that has to do with where the street curves. Deciding what should be done about this is where it gets complicated. Is it an individual's responsibility to fix their driveway? Is it the builder's responsibility since they put in the roads? Or is it the city's responsibility since they approved the road design to begin with? Is there a solution that can satisfy all stakeholders? How much will it cost to fix their driveways? How long do they have to find a solution before additional houses are damaged? Questions such as these are not answered by systematic scientific inquiry; although, this is a good example of communication as inquiry in action.

Through observations and discussions within the context of their world, these citizens gained an understanding of the issue at hand, considered the cost of action and the consequences of inaction. Other important examples are health issues or purchases of new technology. A scientifically literate citizen should make decisions about these issues by applying some basic understanding of the science involved.

The use of secondary scientific literature to establish a foundation of knowledge that can then be used to make informed decisions is inherent in science journalism practices. The scientific literacy aspects of relevance, context, factual accuracy, multiple credible sources, and information seeking are implicit in the use of communication as inquiry. Situating new ideas and issues within the context of the real world, identifying stakeholders, collecting additional information, determining priorities in terms of need, investigating alternative ideas and views, and communicating information are part of science journalism.

Using Figure 7.1 as a link between the three spheres described in the NRC frameworks and how it relates to science journalism, each of the eight practices outlined in the NRC framework were evaluated.

Practice 1: Asking questions and defining problems.

The first practice (NRC, 2012, pp. 54-56) focuses on questions about the natural world; determining which questions are rooted in science and which are not, refining the line of questioning to clarify information or provide additional details, questioning patterns and contra indicators of established patterns and ideas, and determining stakeholders' proximal and temporal needs through questioning within the context of science and engineering.

Within the spheres of activity for scientists and engineers, this is the process of asking a testable question and developing a hypothesis or defining the problem. Science journalism activities are closely aligned to this framework. Scientists and citizens ask many questions about the natural world; some of the questions have personal implications such as "why are my nails splitting lengthwise?" or "why do I get a headache every time I eat this food?" Sometimes the questions are in relation to an observation about the world around them like the trees budding earlier or the increase in the number of armadillos in Missouri.

The usefulness of questioning is understood in journalistic practices, yet in science it is not explicitly taught in relation to what the students read. One strategy many of the SciJourn teachers adopted was the read aloud think aloud. While reading a science news article from sources such as the *New York Times* science section or *Science News for Kids* online, teachers model questioning the science information within the story. This type of modeling can help students learn how to become critical consumers of science information in the media.

Another way teachers helped students develop questioning practice was by aligning the questions with expertise. The alignment of expertise and questions ensures that quality information is sought out and identified. Early on in the project, teachers incorporated an activity where students pitched their topics and other students asked "where is the science?."

This helped the students understand what constituted a science question. Interviewing was another opportunity for students to develop questioning practice.

The translation of questioning practice to search terms for online research was confounded by the students' existing search strategies. However, by the end of the project many of the students had transitioned from using generic questions as a search strategy to using specific terms. Questioning can be viewed as the gatekeeper to information. As many of the students found, refinement of their question opened the door to information that was more aligned to their needs and the information came from higher quality sources.

Asking questions and defining problems in the context of questioning is equally important to scientists and non-scientists. However, a focus on experimental science may not prepare the students to navigate the plethora of secondary literature on science topics once they are out of school; whereas science journalism activities can provide a way of navigating this territory for scientists and non-scientists alike.

Practice 2: Developing and using models.

Scientists and engineers use a variety of models to help articulate relationships and issues as well as solutions. Computers and simulations have constraints and limitations but provide ways of investigating systems that otherwise cannot be directly assessed. Representing phenomena with diagrams, drawings, and other types of models help others understand the ideas being described (NRC, 2012, pp. 56-58).

A benefit of allowing participating teachers to find their own way while implementing the project was that teachers often generated unexpected possibilities during implementation. One teacher in particular wanted to focus on student interpretation of models, in the form of infographics. Infographics are ways of visually presenting information that would be difficult to convey in text. This type of graphic would be considered a model as described by the framework: "diagrams representing forces on a particular object in a system, diagrams, maps and other abstract models as tools that enable them to elaborate on their own ideas or findings and present them to others" (NRC, 2012, p. 58).

The teacher's initial strategy was to provide students with the opportunity to critically analyze the graphics in order to understand the overall message, but also to pull out specific pieces of information that were interesting or contradicted student expectations. As the students' practice at interpreting infographics improved, students were challenged to create their own; as a result one student created an infographic that explained the physics behind a ballerina's moves, another researched fast foods and compared the amount of fat in popular fast food entrees.

The strategy of incorporating infographics was picked up by another teacher whose students were doing experimental research. Instead of presenting their findings in a traditional report the students created an infographic with topics such as the accumulation of CO_2 in classrooms and the correlation to sleepiness in students and the relationship between caffeine consumption and school attendance.

Using infographics as a way to model data can contextualize the information as well. For example in the fast food infographic, the student used a simple bar graph and incorporated logos for the fast food companies. The combination of the data in an easy to read graph and recognizable logos enables readers to connect with and make sense of the data. Another way students contextualized the data was surveying their peers, focusing on issues students were both familiar with and had questions about.

As the analysis of questions 21 and 24 showed, students are not proficient at interpreting graphics; by incorporating infographics for analysis and creating their own, students have to pay closer attention to the overall message as well as the finer details.

Practice 3: Planning and carrying out investigations.

Investigations in science classrooms are generally limited by the available materials, time, and space. Yet many science teachers feel this hands-on approach is the best way for students to learn about how science is done. While the NRC frameworks do not provide a step by step approach to such investigations, they do describe several important considerations: framing testable questions and hypotheses, determining appropriate data to collect and tools needed to do so, reliability of measurements, variables to be tested or measured, and controlling for confounding effects (NRC, 2012, pp. 59-61).

A traditional science class approach to this might be a science fair project or a laboratory exercise. After graduation, students will no longer need to compete in a science fair or complete a laboratory exercise as an assignment. Yet, they need to understand how science is done, but more importantly they need to apply this knowledge to science information presented in the media. One teacher gave a great example of how their students do not apply what they know to information they read. Using an article about Acai berries with a flawed experimental design, the teacher asked the students what was wrong with the article and the students found many little things they felt needed to be changed (sources, citations, smaller words, etc.) but did not address the issues with the experimental design. Had the students applied what they know about the way science is done, they would have known that the article's claims were suspicious.

Experimentation is one way to help students understand how science is done; in order for them to make good decisions about the information found in the media, they also need to be able to critique experimental designs and claims. Science journalism provides an avenue to the critical consumption of information, but the student needs to learn first what good scientific inquiry practices are.

Practice 4: Analyzing and interpreting data.

Systematic data analysis and drawing conclusions from the dataset is an extension of practice three. The interpretation of data is facilitated by creating charts, tables, and graphs. Looking for patterns within these depictions can help the student to draw well supported conclusions. Ideally students would be able to distinguish between causation and correlation within the data (NRC, 2012, pp. 61-63). On the SLA, students were more likely to state two variables were in a causative relationship when it was a medical issue. However, most of the students were not focused on the data at all, suggesting changes to format, adding a legend or color to improve the data presentation.

Students graph and analyze various types of data in science. So it may seem to make little sense as to why they were so focused on the appearance of the graph. This could be explained by the scoring guide for the state science test; which has four points (title, axes labeled, appropriate axes scales, data plotted correctly with a key) (DESE, 2005). The focus is on construction of the surface features of the representation, not usefulness or interpretation.

If a learning progression is incorporated into the common core science standards as suggested by the NRC framework, by secondary school the focus needs to shift from construction of surface features to interpretation. Use of infographics and graphs that are included in articles can help students learn to interpret the data for themselves and draw their own conclusions.

Practice 5: Using mathematics, information and computer technology, and computational thinking.

Mathematics is sometimes referred to as the language of science. Practice five provides guidance as to how this is envisioned. Students should have an understanding of "dimensional quantities and use appropriate units", be able to use these in graphs and charts as well as investigations, and use mathematical tests to analyze data (NRC, 2012, pp. 64-66). When I have asked my own high school students what their least favorite subjects are, math and science are often mentioned. This could be due to their lack of understanding, an ineffective teacher or lack of context for these subjects. Regardless of the reason, once graduated, students who did not particularly like these subjects may avoid them as adults. Non-avoidance of difficult concepts such as science and math is crucial to developing a scientifically literate citizenry.

Science journalists do not generally conduct their own experiments; yet they have to become masters at interpreting the data given in terms of units, statistics, and mathematical models used as support for a claim. Using this understanding, science journalists provide the numbers but may also provide a translation of the number such as 1 in 100,000 people instead of saying your risk is 0.001%. Such a translation requires the journalist to understand the dimensional relationship and be able to convey the information in a meaningful way.

Although it is important for people to be able to make sense of the data provided in science information, it is unclear how best to achieve this. One strategy is for students to consider the numbers in the context of the information and ask themselves if it makes sense.

For example, on the SLA one article mentions that paint is made of 100% lead, the other article claims the plume from a volcano was only 3m high; in both instances the students should have questioned the data, but rarely did. Teachers may not ask their students to question the textbook and, if this is the only print source used, such a practice models accepting published information as truth. In my own experience, when a student runs an experiment and gets numbers that are way out of line, they often want to change their hypothesis rather than question the data.

Students need to question the data and be able to determine if the data falls within the realm of plausibility, in order to develop into effective scientists and scientifically literate citizens. Simply running experiments or only reading science information will not achieve this. Combining the two activities of investigating and questioning the data could improve scientific literacy.

Practice 6: Constructing explanations and designing solutions.

According to discussions with participating teachers many of the students in SciJourn found writing an article to be frustrating due to their lack of understanding about the topic. However, when students began with a topic that they knew a little about or knew someone that had some knowledge on the topic, it was less daunting. Constructing an explanation in science is often bound by the types of data available.

The Frameworks identify several goals for students in relation to constructing explanations and designing solutions: students should be placing the information from the investigation into the context of scientific theory, supporting it with evidence which could consist of both primary and secondary evidence; and they should be able to offer causal explanations and to acknowledge weaknesses in their understandings and explanations (NRC, 2012, pp. 67-71).

Many classroom based first hand investigations do not require the student to place the information into context to understand the process or the results. However, science in the public sphere is not straightforward and is impacted by both scientific contexts and societal contexts. In order to really understand a situation, students need to be able to see connections between science and society.

Science journalists have a responsibility to their audience to present the most encompassing version of the facts. This means they consult all stakeholders (scientists and non-scientists), evaluate the credibility of the information provided by both sides, look for strengths and weaknesses in the arguments provided by both sides and decide which facts are credible and important within the context of the issue at hand. On the SLA students were provided a series of photos and asked to make connections in terms of relevance and context. Students generally felt that science and society were entangled in these photos. The photos themselves provided a narrative of the event for survivors, but also provided scientific evidence that could be used to avoid the disaster in the future. The outcomes identified by the students included damage to the ecosystem and other more scientific connections alongside societal issues such as job loss and changes to the economy of the region.

This attention to the interaction between science and society is not explicitly targeted by the framework. However, as an adult it will be important to evaluate issues with both the science context and the societal context. Incorporating science journalism practices that force students to investigate stakeholder views, evaluate the strength of their claims based upon the scientific data used, and communicate the relationship between science and society can improve the students' ability to use information to construct explanations and make decisions.

Practice 7: Engaging in argument from evidence.

Scientific understandings are based on evidence. Using a variety of evidence can strengthen the argument or claim. Recognizing flaws in others' arguments and claims as well as their own is a stated goal of the framework (NRC, 2012, pp. 71-74). The accumulative nature of science, where scientific information is constantly scrutinized using all of the available tools and as it stands up to peer review and independent replication, results in widely accepted scientific laws, ideas, and theories.

Recently there have been a couple of science stories that teachers could use to help students understand the nature of science in terms of existing ideas and new discoveries. The discussion of removing the title of "planet" from Pluto included many articles explaining why this change should be made and why not. There was not a consensus within the scientific community. The lack of consensus required the scientists who were proposing the change to provide evidence to support their claim that Pluto was not a planet. Another example is a journal article released in late 2010 about arsenic eating bacteria. Shortly after the article was published a slew of reports came out questioning the methodology used in the study and its findings. Both of these articles provide real world examples of science as a human endeavor in action.

Often early drafts of student articles lacked the facts to back up claims or arguments students included in their article. When revising articles, students were directed to pay closer attention to the science on the topic. This resulted in a stronger presentation of the arguments and at times a reversal in the students thinking. The understanding of how science works in the bigger picture (beyond a single experiment) is hard to achieve in a classroom. Use of media reports to illustrate the process by which new scientific discoveries are vetted and old ideas change based on new evidence can help students evaluate future science information.

It appears that students make assumptions about the strength of an argument based on the number of supporting facts. As demonstrated on the SLA, the number of facts required for adequate support depended on if the support was for or against a particular issue; in the case of the SLA it was a health risk. Another example of students considering an accumulation of facts as support for the overall argument was provided by a teacher who used a read aloud think aloud activity about an article on “Dihydrogen monoxide.” While reading the article, the teacher commented on the facts presented (which are all essentially true). The students became very concerned when they heard that this compound is in their school. These chemistry students had learned how to interpret chemical names and use them to write formulas. However, they were so focused on the facts they neglected to apply their understanding of the chemical naming system to realize the article was about water.

While there was not a specific flaw in design of the “Dihydrogen monoxide” article or even any inaccuracies, it demonstrates that facts in isolation or an accumulation of facts can seem to be something that they are not. Students need to learn how to evaluate evidence, understanding that some types of evidence may hold more weight than others and an accumulation of facts is not the only criteria by which to judge a scientific argument.

Practice 8: Obtaining, evaluating, and communicating information.

Scientists and engineers spend a good portion of their time reading (e.g., O'Neill and Polman, 2004; Phillips and Norris, 2009) as such reading should be a focus of science instruction as well. The framework (NRC, 2012, p. 74) describes the role of the text in communicating ideas in terms of both creating and understanding graphical representations of data, features and structure of scientific and engineering text and written and oral presentations. This occurs while engaging in critical analysis of primary literature that is adapted for classroom use (Phillips and Norris, 2009) and media reports of science with regards to "validity and reliability of the data, hypotheses, and conclusions" (NRC, 2011, p.76).

At first glance, this section of the framework gave me hope that it would target the goal of teaching all students, using science reports in the media as a way to engage even the struggling students. However, the emphasis on critically assessing reports by focusing on data, hypotheses, and conclusions indicates that this set of goals is really aimed at students in the pipeline toward science careers.

Science journalism does not include hypotheses nor does it include conclusions. As a matter of fact, science journalism takes pride in the fact that they provide credible information from reliable sources so readers can draw their own conclusions. Science text, even in textbooks but especially in primary science literature, is lexically dense. The difficulty of reading and comprehending information that assumes some background knowledge could cause lower performing readers to disengage from the topic or activity. In addition, the strict use of textbooks and primary literature is likely to perpetuate the student view that if it is in a book or magazine, it is fact.

What this standard is asking students to do is to become critical consumers of science information. By starting with popular media reports, which are written at a lower reading level and do not require the same depth of background knowledge, can remove the obstacles associated with reading; this may allow the teacher and the student to focus on the data, questions, and other aspects of the article for analysis. Additionally, science journalism requires the students to assess credibility of sources and expertise of stakeholders. This added layer can help students learn strategies to determine if the source is trustworthy.

Combining adapted primary literature and media reports, describing the different purposes and audiences, as well as being critical consumers of the information contained in each will better prepare students for the future than ignoring these distinctions.

Implications for Future Science Standards

The Science Literacy through Science Journalism (SciJourn) project started with my desire to improve my students' ability to write about science so they could be more competitive when it came to college essays and scholarship competitions. The idea morphed into a goal of developing scientific literacy through science journalism, resulting in a collection of activities focused on science journalism that requires students to become both critical consumers of science information in the media but also producers of science news.

The overriding view of what it takes for a student to be scientifically literate included some basic understandings about science content and the nature of science and the ability to make sense of science information that goes beyond the student's current content understandings. SciJourn and some previous projects (e.g., Jarman & McClune, 2007; Korpan, et al., 1994; Korpan, 2009; Polman, Newman, Farrar & Saul, 2012) use science news and media reports to develop scientific literacy focused on the critical analysis of articles and science text. The inclusion of the production aspect sets this project apart from other endeavors with the exception of David Williamson Shaffer and colleagues' (Hatfield & Shaffer, 2006; Shaffer, 2006) Science.net game; unlike Science.net, SciJourn involves students writing science news aimed at authentic publication with a rigorous editorial process.

Practices that are needed by students in relation to scientific literacy that could have lifelong benefits were identified and became the backbone of the SciJourn standards (relevance, context, factual accuracy, multiple credible sources and information seeking). From these standards many ideas were formulated about what kinds of activities and strategies would be most beneficial in terms of improving student scientific literacy. Based on teacher utilization, the read aloud think aloud was a strategy that provided a lot of "bang for the buck." It could be done in either a very small portion of a class period or extended, and teachers could focus on various issues, such as the facts, the sources, the overall message or even how to make sense of the data within the article.

The transition from consumer to producer of science news required the students to apply the strategies modeled in the read aloud think aloud activities to their own research. The first draft articles were edited by their teacher and later a science news editor. This initial editing revealed areas for improvement that focused on the science content rather than the grammar or structure (Kohnen, in press). Some students revised simply to satisfy the requirements of the assignment, while others revised with the goal to be published in *Scijourner*.

The quantitative analysis suggests that incorporating something as simple as a read aloud think aloud activity to model critical reading strategies for science information can improve scientific literacy scores. Translating critical reading practice into producing a well researched science news article had a greater impact on student scientific literacy gains. Working toward publication by revising their writing with a focus on the science content provided the greatest gains.

Student scientific literacy scores were about half of the experts scores. Even though we expected students to be less scientifically literate, it is important to describe the level of scientific literacy of a high school student. Need was an important factor in both relevance and context. This need can be described as proximal (i.e., how will this impact me?) and temporal (i.e., when do I need to know this?). Students tend to ignore specific facts when encountering an argument presented within scientific information in text or on the web such as the issues with airplane engines and volcanic ash found in the SLA. Student focus on the surface features of data representation such as legends and labeling units was influenced by what the state test assigns points to rather than in the interpretation of the data. Students have limited experience in terms of recognizing credible sources and using the internet to locate credible information about science.

With that said, students improved their scores in the sub-scale categories for context, factual accuracy, multiple credible sources, and information seeking. This suggests incorporating science journalism activities can augment current science instruction in a way that prepares students for a future after school where they garner information about science topics from the media.

The new science frameworks begin with a call to action due to the need for better educated citizens to help solve many of the issues that face the United States and the rest of the world today and in the future. It includes a series of practices that should provide the backbone to constructing standards. While the stated call to action is to increase the number of people with strong science backgrounds, it also states that non-scientists need to increase their understanding of science concepts and the nature of science.

Many of the practices focus on how science is done, beginning with asking questions, then developing models or hypotheses, followed by carrying out a firsthand investigation that includes data collection, then the subsequent analysis of the data collected, using the data to draw a conclusion that is supported by evidence, and finally communicating those results. For science educators, this is very reminiscent of the scientific method as has been approached in traditional instruction, and more recently in science inquiry.

If scientists and engineers spend roughly half of their time engaged in the process of science and the rest of the time immersed in the literature, why is the framework tied only to these firsthand investigations? Much of the science included in textbooks is hundreds of years old. Considering the students' concept of relevance and context, textbooks are likely to be seen as largely irrelevant. They perceive no immediate need for this information, nor do they feel that it impacts them. Science news can be a bridge between the old and the new, providing the proximal and temporal components necessary for students to become engaged with science content. Additionally, many of the schools that participated in the study have reduced funding and introduced new technology initiatives that have depleted funds for science laboratory experiments in the classroom. The lack of funding combined with the focus on facts and concepts in order to assess student understandings on state tests has reduced the number of experiments conducted.

Many of the classroom experiments suggested in the curricula of teachers participating in this study are cookbook type activities where there are guaranteed outcomes that have right or wrong "answers". Such activities do not simulate the practices of scientists and engineers as envisioned by the frameworks. With the lack of relevance to students and the obstacles to having true inquiry in many classrooms, other strategies should be considered.

In addition, the “learning progression” view of the frameworks should be extended into adulthood. What practices does an adult who does not hold a degree in science or engineering and whose career does not require basic science understandings need to make good decisions about scientific issues? They will need some basic understanding of how science works and an understanding of the overarching laws, theories, and principles of science and engineering. However, they need practices that include communication as inquiry as well. The overemphasis on practices that many students find irrelevant to their future could alienate students.

Integrating activities similar to those used by participating teachers in the SciJourn project can engage students in the content by providing relevance and contextualization. Critical analysis of text, where students actually have to apply their understanding of scientific content and practices and there is an opportunity for the student to be right and the text to have flaws can provide a sense of self sufficiency that they will need later on in life. Finally, through the production of science news, students learn how to communicate ideas and concepts that could be outside of the content taught in the classroom. Opportunities to research new ideas and communicate their findings can help prepare students to tackle the questions that arise in the unpredictable future.

Implications for Research

Most of the research about scientific literacy focuses on student understanding of science concepts and the nature of science. Based on the goal of helping all students develop scientific literacy, investigations into alternative methods such as SciJourn should be undertaken. I believe that in order to assess student scientific literacy, further studies are needed to determine the impact each of the following has on developing scientific literacy: how scientific literacy changes over time for individuals, how educators can facilitate the integration of current science and textbook science, and how to extend science beyond the walls of the classroom. Some potential future studies follow:

1) A similar study to the one conducted could be completed using a longitudinal approach. Such a study would use the SLA to assess scientific literacy in 7^{th} or 8^{th} grade, again in high school, and finally a few years post high school. A combined analysis such as the one undertaken in this study could provide a snapshot of what scientific literacy looks like as a young teenager, a young adult, and as an adult. This type of study could provide some understanding of what impacts scientific literacy over time, and how to design pathways for development.
2) A second study could attempt to assess life experience and compare this information to SLA scores. Such an analysis could provide information about the kinds of experiences that benefit scientific literacy. Identifying those experiences can influence the types of activities and experiences that are incorporated into K-12 education.
3) A third study would look at adult scientific literacy using the same tool. The experts chosen to take part in the project were generally considered to have high

levels of scientific literacy. Understanding more about the level of scientific literacy in the general public is essential and could provide some information to develop initiatives focused on improving adult scientific literacy.

4) Another study could investigate the integration of course content and science journalism practices to determine the affordances and constraints different content areas have for developing scientific literacy.
5) Finally, a study looking more closely at the article production process and its effects on students' scientific literacy. Revision was one of the statistically significant variables identified by Generalized Linear Mixed Modeling. A closer look at how student scientific literacy changes throughout the process could help illuminate the cognitive changes that are occurring.

Implications for Teaching Science

This study provides a baseline for student scientific literacy in regards to the consumption of scientific information found in the media and the production of science news reports. The study indicates that infusing a curriculum with science news media reports and activities that engage students in the critical consumption and production of science news improves student scientific literacy. Based on my findings, in conjunction with the new frameworks for K-12 science education, I would recommend the following ideas in order to ensure all students increase their scientific literacy while in K-12 educational settings:

1) Teachers should model how to make sense of scientific information. Incorporated into the modeling should be a focus on both the scientific connections and the societal connections. Teachers should include in the discussions evaluations of expertise, the

kinds of sources, the kinds of stakeholders and the more traditional science issues associated with content and the nature of science.

2) By the time students are in high school there needs to be a transition from graph construction to graphics interpretation. Students often engage in construction of graphs without analyzing the results. A shift in focus from construction to analysis should include other types of graphics such as infographics and images.

3) The incorporation of digital technologies in a classroom needs to be accompanied with explicit training for the student in how best to use the technology. In this study students benefited from discussions about how best to search the web for credible information.

4) Make critical consumption of science information central to learning science. Incorporate media accounts of scientific discoveries and controversies into the curriculum to help students see the need for learning the information. Encourage discussions about what is going on in science outside of the classroom.

5) Develop alternative ways of communicating understanding in science classrooms, other than science lab reports. All students will benefit from translating technical science information into a consumer friendly version. Incorporate science lab report writing into courses geared toward preparing students for a science major in college or a career in a science field, while using other methods such as science news reporting in other courses.

At the end of the day, education is about what works best for students. Not all students are destined to be future scientists. Creating standards that perpetuate the little scientists approach (O'Neill and Polman, 2004; Osborne, 2007) will not promote the goal of the new frameworks of developing scientifically literate citizens. Clearly, a new twist on developing scientific literacy is needed, and science journalism is a promising twist as demonstrated by results in the SLA.

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APPENDIX A: SciJourn Scientific Literacy Standards

SciJourn Standards for Scientific Literacy

The following standards were generated by the SciJourn Research Group and are a work in progress. They arise from discussions with science journalists and editors and our work with high school students. The standards focus primarily on content and are designed to help teachers and students assess their own and professional journalists' science writing, particularly science-related news articles. They grow specifically from our group's understanding of scientific literacy.

Standard	**Elaboration of Standard**
I: Students are able to **search effectively** for and recognize relevant, credible information sources, especially on the Internet.	The Internet is an efficient way to search all of this worldwide.
I.A: Knows how to use search engines and search terms	I.A.: Choosing the right terms makes a search more efficient. For example, “astrobiology” as a search term returns more credible sites than “life on other other planets” because it is the word used by scientists.
I.B.: Privileges data from credible government and nonprofit sites (e.g.; nih.gov and cancer.org) and can ascertain the credibility of “other” websites, using the About Us for clues.	I.B.: Reporters understand the value of citing primary sources of data. The Internet is filled with sites that pro- vide recycled content surrounded with ads. A challenge for teens is to identify those sites that keep their information up-to-date and maintain quality control on their material. As a rule this is typically government and nonprofit websites.
I.C: Reporters are expected to research their subject before writing a story, collecting background information, identifying credible sources and exploring the issues and controversies surrounding the topic.	

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0822354

Standard	Elaboration of Standard
II: Student articles are based on **multiple, credible, attributed sources**	
II.A multiple sources	II.A: The goal of this standard is to recognize that science is an ongoing discussion and that various opinions or views help inform the research process. A more sophisticated analysis would lead a student to realize that even credible sources have certain biases or leanings, which is another reason to favor multiple sources
II.B credible sources	II.B: It is important for students to understand and assess the limitations of sources of information.
II.B.1: Sources are relevant and reliable.	II.B.1: Relevance is context specific. For example, quoting U.S. data from the Centers for Disease Control and Prevention for a story on AIDS in Africa may not be as relevant or reliable as information from the World Health Organization.
II.B.2: Some science stories naturally lead to questions of how “other” communities and society as a whole are affected. For example, a story on a new medical treatment could quote someone affected by the disease. A new technology to eliminate mercury	II.B.2: Some science stories naturally lead to questions of how “other” communities and society as a whole are affected. For example, a story on a new medical treatment could quote someone affected by the disease. A new technology to eliminate mercury from coal might include a comment from an industry representative. This underscores the connection between science and society.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0822354

Standard	Elaboration of Standard
II.C.: Attributed sources	II.C: Attribution recognizes that information has a source (who/which may have a certain agenda), provides a pathway for the reader to verify and expand on something in the story (just as science journal articles must provide sufficient information to replicate the experiments), and establishes a historical record for where an opinion or concept started. Less formal than a reference, attribution includes individual names or organizations, websites, news-papers/TV shows, reports, and press releases. Attribution is particularly important because of the “talk radio” or the “high school social network” model of repeating “facts” that are never sourced. Learning to read journalistic and academic conventions is key to the understanding and use of attribution.
II.C.1: Except for accepted facts, ideas and theories, all assertions, numbers, details and opinions are attributed	II.C.1: For students used to textbooks and teacher lectures, this may be the greatest challenge. Any information that could be seen as new, not widely known, opinion, or controversial should be attributed in some way. Attribution prevents the author from making blanket or false statements, especially by quoting credible sources.
II.C.2: The names of the experts/organizations are given and their area of expertise/qualification is identified. Any biases or potential conflicts of interest are noted.	II.C.2: These details help the reader form an opinion on whether or not the information is trustworthy. In some cases, it may mean understanding who supports the work of a researcher or organization. It also imposes a discipline on the student; they pay attention to details such as who supports or funds certain types of work

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0822354

Standard	Elaboration of Standard
II.C.3: Copyright rules are followed and relevant URLs are given.	II.C.3: Following copyright rules protects the publisher and author from unwanted fees or legal action; URLs provide the reader with a source for more information
III. Scientific information, discoveries and technologies are **contextualized**; broader implications as well as reflections on past and future understandings are noted.	III. Context puts the story in perspective and helps the author and readers understand why they should care about the discovery or technology and why researchers are interested in the topic. It underscores the inter-connections between science and society and the cumulative nature of scientific research. Students are asked to understand the nature, limits and risks of a discovery, emerging concept or technology.
III. A: The import of the information for society is understood and sufficiently detailed.	III.A: Detailed information helps the reader determine the implications and importance for society. Social, ethical, economic, and political effects are important to consider.
III.B: The article indicates which data/ideas are widely accepted in the scientific community and which are preliminary. The article sensibly weights the import of findings and, where appropriate, uses qualified rather than declarative language.	III.B: Does the new knowledge change how experts view the topic or does it confirm what is known and believed? Preliminary knowledge carries the risk of being wrong or unsuccessful in the long run. Researchers typically qualify their findings; reporters should do the same. Good science writers understand which ideas carry more scientific weight and are therefore less likely to be drawn into social, political, or ideological debates, such as whether global warming is real or intelligent design is a theory.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0822354

Standard	Elaboration of Standard
IV. Scientific information is **relevant** to readers.	IV: Reporters have a duty to address the interests of their audience.
IV.A: Reported findings are linked to local or personal concerns and new applications are considered.	IV.A: They build on the fact that science and technology affect each of us personally.
IV.B: Readers' implied questions are anticipated and addressed.	IV.B: Reporters' questions should be critical and reflect those of the readers.
V: Information is **factually accurate** and important information is fore-fronted.	V: Reporters pay attention to details, including ensuring that the facts are checked for accuracy, spelling and attribution. Who, what, where, when and why – the 5 W's of journalism—are typically present in the first few paragraphs.
V.A: The story structure indicates what is more and less important from a reader's and writer's perspective. The science connection is noted.	V.A: The writer determines the gist of the story, what details are most important (these come next) and which details come later down to help flesh out the story.
V.B: The article shows an understanding of the content and is able to explain concepts and information, including methods of scientific inquiry.	V.B: The writer understands the scientific inquiry methods and scientific processes she or he reports. In the long run, the new discovery or technology may be incorrect or fail (e.g., cold fusion), but the initial reporting should be as accurate as possible. Depending on the story's audience, the student author should provide sufficient information so that the reader understands the finding and how scientists arrived at it. This requires the student to understand and digest the technical elements of the research.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0822354

Standard	Elaboration of Standard
V.C: Precise language is employed and scientific terms are used appropriately.	V.C: The author's challenge is to explain scientific ideas simply, without changing the science. Consider the problem of astronauts "floating" in space vs. living in a low gravity environment. Or not differentiating between type I and type II diabetes.
V.D: Quantitative measures are given in correct and comparable units.	V.D: Nearly every story has a number—a percentage, cost, patients tested, etc. Citing those numbers is an important element of science practice. Quantitative measures can be given as analogies.
V.E: The latest/up-to-date information is presented.	V.E: Reporters strive to "break a story" or to be the first to analyze events. Students may lack the resources to be first, but they should determine that their information and the issues are up-to-date. No one, for instance, wants to promote a medical treatment that has been discredited. An interest in timeliness encourages students to look at publication/announcement dates as a means to determine whether it is up-to-date.
V.F.: The headline and photo caption accurately reflect the content of the story.	V.F.: The headline should capture the gist of the story; the photo caption should briefly summarize a key aspect of the story as reflected in the image.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0822354

APPENDIX B: Scientific Literacy Assessment Form A

YOUR NAME: ____________________

TEACHER'S NAME: ____________________

Scientific Literacy Assessment

Instructions for Completing these Exercises.

The exercises that appear on the following pages are a very important part of the research being conducted at your high school this year by the Scientific Literacy through Science Journalism (SciJourn) project. Thanks so much for your participation; you are helping students and teachers around the US learn more about what makes sense to teach in schools.

Directions:

- If you have a question regarding the directions, the question, or a portion of the text, you can ask your teacher for clarification.
- **Budget your time**. You will be asked to complete the entire assessment in about 45 minutes. All we want you to do is provide the best answer you can in the time allotted.
- **Be brief**, but make your meaning clear.

Here are a few important things to know about these exercises:

- All answers are confidential. When we record your answers, your name is removed and replaced with a number.
- **This is not a test.** There is no one right answer. You will not be graded on these exercises.
- Your answers on these exercises will not affect your grade in this class, or any other class.

Again, if you have any questions about any part of these exercises, please ask.

(This area for SciJourn Use Only)
Control Number:
FORM A

SECTION 1

Read the following news article. Use this information to answer questions 1-12. You may refer back to the article. Underlined words represent hyperlinks.

Citizens block lead pipe replacement

Last month protesting neighbors in Providence, Rhode Island stopped the local water company from taking out their lead water pipes. The citizens, known as the Lead Pipe Initiative, have no love for lead, but they fear the work will make the lead contamination in their drinking water worse. It is the first time that citizens have protested partial lead water pipe replacement on public health grounds.

Lead is a very potent neurotoxin that disrupts brain development. Children exposed to even very low levels of lead are likely to be less intelligent and to have more trouble paying attention at school, according to SmartKid.com.

Marcus Mitchell, speaking for the Lead Pipe Initiative, says that residents want the water company to completely replace the lead pipes in the city's system. Lead pipes are still found in the plumbing of many older cities.

Since 2006, the Environmental Protection Agency has required the Providence water company to replace publicly owned lead pipes because lead in the city's drinking water exceeds EPA standards. This "partial" replacement does not remove privately owned lead pipe. EPA defends the law and says that removing part of the pipe is a good way to reduce lead levels in the water, according to spokesperson Ernesta Jones.

But in January of this year, the U.S. Centers for Disease Control and Prevention (CDC) warned that partial replacement can elevate lead levels in children's blood. CDC found that children in Washington, D.C. who live in houses with partially replaced lead pipes are more likely to have high levels of lead in their blood (Journal of Exposure Episodes, 2010. v10, p213-227).

Recent laboratory studies by Virginia Tech environmental engineer Marc Edwards suggest that replacing part of an old lead pipe with a new copper pipe causes the lead pipe still in the ground to corrode. This "galvanic corrosion" is similar to what happens in a car battery. "Galvanic corrosion doesn't happen in all cases, but when it does it can release large amounts of lead," Edwards says.

Many public health experts doubt that partial replacement is a problem. "This is a classic case of conflipation," says Mary Columbus. "The houses with partial replacement are old houses with lead paint. The paint contains 100% lead. It's the paint that's the problem, not the water," she adds.

But water company general manager Pamela Marchand also believes that partial replacements do not work well. "We're not seeing enough lead reduction," she says.

The Lead Pipe Initiative is trying to find a way to fund total lead pipe replacement that costs an additional \$2500 to \$6000 for each home. EPA is currently re-evaluating its policy about partial service line replacement.

1. Is there anyone who you think should read this article? Why?

2. Why is this information important to the general public?

3. What connections can you make between the article and what you have learned in school?

4. If you were presenting this information to a community group, what information about ***lead*** would you check with other sources? Why should this fact be checked?

5. Is there any additional factual information missing from this article that would improve it?

6. If the author was asked to write a follow-up article on this topic, who else might she interview? Why would this person be a good choice?

7. There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. These sources are also highlighted within the article

Lead Pipe Initiative				
○ not credible	○ not very credible	○ unsure	○ somewhat credible	○ very credible
Explain why:				
Environmental Protection Agency (EPA)				
○ not credible	○ not very credible	○ unsure	○ somewhat credible	○ very credible
Explain why:				
Mary Columbus				
○ not credible	○ not very credible	○ unsure	○ somewhat credible	○ very credible
Explain why:				

8. What other information about SmartKid.com would you like to have to determine the credibility of the source?

9. Often articles include hyperlinks as resources within the article. In this article there are several choices. If you wanted to learn more, which hyperlinks would you choose? Explain why you chose this link what you hope to find once you click on it.

Useful link:	Why would you use this link?	What information do you hope this link will provide?

10. Which of the hyperlinks would help you to find background information on water quality standards? (choose ONE)

○ Lead Pipe Initiative ○ lead water pipe ○ EPA standards ○ U.S. Centers for Disease Control and Prevention

○ galvanic corrosion ○ water company ○ Virginia Tech ○ Washington , D.C.

11. Which of the hyperlinks would help you locate an expert on lead levels in children? (choose ONE)

○ Lead Pipe Initiative ○ lead water pipe ○ EPA standards ○ U.S. Centers for Disease Control and Prevention

○ galvanic corrosion ○ water company ○ Virginia Tech ○ Washington , D.C.

12. Which of the hyperlinks would help you locate information on how to actively participate in the debate as a concerned citizen? (choose ONE)

○ Lead Pipe Initiative ○ lead water pipe ○ EPA standards ○ U.S. Centers for Disease Control and Prevention

○ galvanic corrosion ○ water company ○ Virginia Tech ○ Washington , D.C.

SECTION 2

Use this information below (text and photos) to answer questions 13-16.

On April 20, 2010 Deepwater Horizon (an offshore oil rig) exploded. Since the explosion over 200,000 barrels of oil have leaked into the Gulf of Mexico every day.

Photo courtesy of the US Coast Guard.
Source: www.incidentnews.gov/incident/8220

Photo courtesy of NASA, source:
http://www.nasa.gov/topics/earth/features/oil-creep.html

13. Why is this information important to people who live on the Gulf Coast?

14. Why is this information important to people who live in Missouri?

15. What kind of environmental impact could this leak have on the Gulf Coast?

16. What kind of environmental impact could this leak have on Missouri?

SECTION 3: *Use the information below to answer questions 17-20.*

American Heart Association

High Blood Pressure

©Xopher Smith

According to recent estimates, about one in three U.S. adults has high blood pressure, but because there are no symptoms, nearly one-third of these people don't know they have it. In fact, many people have high blood pressure for years without knowing it. Uncontrolled high blood pressure can lead to stroke, heart attack, heart failure or kidney failure. This is why high blood pressure is often called the "silent killer." The only way to tell if you have high blood pressure is to have your blood pressure checked.

Get the facts on high blood pressure and how to live a heart-healthier life. Find out how you can reduce your risks for heart attack and stroke with proper monitoring by a healthcare provider and simple lifestyle changes, even if you have high blood pressure.

©Anthony V. Khairov

Medical science doesn't understand why most cases of high blood pressure occur, so it's hard to say how to prevent it. However, we do know that several factors may contribute to high blood pressure and raise your risk for heart attack and stroke.

Controllable risk factors

- **Obesity** — People with a body mass index (BMI) of 30.0 or higher are more likely to develop high blood pressure.
- **Eating too much salt** — A high sodium intake increases blood pressure in some people.
- **Drinking too much alcohol** — Heavy and regular use of alcohol can increase blood pressure dramatically.
- **Lack of physical activity** — An inactive lifestyle makes it easier to become overweight and increases the chance of high blood pressure.
- **Stress** — This is often mentioned as a risk factor, but stress levels are hard to measure, and responses to stress vary from person to person.

©Oscalito

Uncontrollable risk factors

- **Race** — Blacks develop high blood pressure more often than whites, and it tends to occur earlier and be more severe.
- **Heredity** — If your parents or other close blood relatives have high blood pressure, you're more likely to develop it.
- **Age** — In general, the older you get, the greater your chance of developing high blood pressure. It occurs most often in people over age 35. Men seem to develop it most often between age 35 and 55. Women are more likely to develop it after menopause.

17. Are you at risk for high blood pressure? Explain.

18. Complete the following chart

What other credible sources could you use to find out more about high blood pressure (HBP) in teens?	Why do you trust this source?	What question(s) would you want this source to answer?

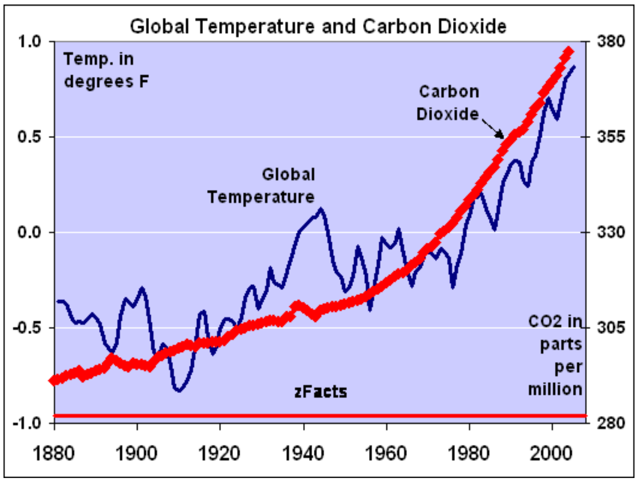
19. You want to find out more about why females tend to have higher blood pressure after menopause. Entering the search term ***menopause*** into a search engine might not be the best choice. Explain why not.

20. Why might high blood pressure be more common in teens today than 100 years ago?

SECTION 4: ***Use the information in the image below to answer questions 21-24***

Your friend Bill has asked you to *peer edit* his PowerPoint presentation on climate change. He wants you to make sure that he is presenting the facts correctly.

Changing Global Climate



- Carbon Dioxide (CO_2) emissions data from ice cores was compared to temperature records, confirming that Global temperature and carbon dioxide levels are not related

www.zfacts.com

21. What recommendations (if any) would you make to Bill?

22. Complete the chart below:

Suggest other sources that Bill can use.	Why should Bill trust that source?	What question(s) would you hope that source answers?

23. If you were to search for more information on the web in order to help Bill, what search terms or phrases would you use? Please write or type the search terms in the box exactly as you would type them into a search engine.

[ ] SEARCH

A. What information do you expect to get from this search?

[ ] SEARCH

B. What information do you expect to get from this search?

---

24. Your class is presenting at the Midwest Environmental Conference for High School students. You will be working with Bill to present the information on Global Climate Change. With a $10,000 cash prize for the best presentation, what information would you double check so that you are sure your information is of prize-winning quality? Why check those facts?

APPENDIX C: Scientific Literacy Assessment Form B

YOUR NAME: [ ]

TEACHER'S NAME: [ ]

Scientific Literacy Assessment

Instructions for Completing these Exercises.

The exercises that appear on the following pages are a very important part of the research being conducted by the Scientific Literacy through Science Journalism (SciJourn) project at your high school this year. We would like to take this opportunity to thank you again for your participation in this project. Without your assistance, none of this would be possible.

Directions:

- While working on these exercises, if you have a question regarding the directions, the question, or a portion of the text, you can ask your teacher for clarification.

- **Budget your time**. You will be asked to complete the entire assessment in about 45 minutes. All we want you to do is provide the best answer you can in the time allotted.

- **Be brief**, but make your meaning clear.

Here are a few important things to know about these exercises:

- All answers are confidential. When we record your answers, your name is removed. We attach only a number to your responses.
- **This is not a test.** There is no one right answer. You will not be graded on these exercises.
- Your answers on these exercises will not affect your grade in this class, or any other class.

If you have any questions about any part of these exercises, please ask your teacher or the person who is administering them. Thanks again for your participation.

(This area for SciJourn Use Only)
Control Number:

FORM B

SECTION 1

Read the following news article. Use this information to answer questions 1-12. You may refer back to the article. Underlined words represent hyperlinks.

"The volcano that stopped the world"

The volcano in Iceland that halted air travel across Europe last month started to erupt again on May 2, stranding more air passengers in Ireland and elsewhere.

The volcano, called Eyjafjallajökull, ramped up activity over the next few days, and was shaken by tiny earthquake tremors. Between 5:30 am and 8 am on May 6, it sent a plume of material into the air up to 30 feet (or 9 meters), according to reports by the Institute for Earth Science.

The material in the plume includes tiny shards of volcanic glass and ochtholotomeic rocks. Samples taken from the first eruption's volcanic plume on April 15, collected 9-35 m away from the volcano, showed a size distribution from 300 micrometers to less than 10 micrometers, thinner than the thickness of some human hair.

These preliminary measurements, made by **Th**röstur Thorsteinsson, show that the smallest pieces of the volcanic ash are equivalent to pollution known as particulate matter that is regulated by the U.S. Environmental Protection Agency. The so-called particulate matter raises health concerns for people in the area, according to the World Health Organization. The UN agency issued warnings for people with asthma and allergies, should the ash ever come down to earth from the high atmosphere.

The plume is traveling through the atmosphere, shutting down flights to Spain and Portugal, even as http://www.eurocontrol.int/ reopened air space in the UK. People remain stranded in New York City and elsewhere, trying to get to those places. The volcanic ash particles in a high enough density could create trouble for airplane engines.

"How can you get a volcano in Iceland?" asked Rick Sanchez, anchor at the news channel CNN on April 15 when the volcano first blew its top. "You think of Hawaii, but you don't think of Iceland. It's too cold to have a volcano there. But no."

1. Is there anyone who you think should read this article? Why?

2. Why is this information important to the general public?

3. What connections can you make between the article and what you have learned in school?

4. If you were presenting this information to a community group, what information about **volcanic ash and airplane engines** would you check with other sources? Why should this fact be checked?

5. Is there any additional factual information missing from this article that would improve it?

6. If the author was asked to write a follow-up article on this topic, who else might she interview? Why would this person be a good choice?

7. There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. These sources are also highlighted within the article.

Institute for Earth Science				
○ not credible	○ not very credible	○ unsure	○ somewhat credible	○ very credible
Explain:				
Thröstur Thorsteinsson				
○ not credible	○ not very credible	○ unsure	○ somewhat credible	○ very credible
Explain:				
World Health Organization				
○ not credible	○ not very credible	○ unsure	○ somewhat credible	○ very credible
Explain:				

8. What other information about http://www.eurocontrol.int/ would you like to have in order to determine the credibility of the source?

9. Often articles include hyperlinks as resources within the article. In this article there are several choices. If you wanted to learn more, which hyperlinks would you choose? Explain why you chose this link and what you hope to find once you click on it?

Useful link:	Why would you use this link?	What information do you hope this link will provide?

10. Which of the hyperlinks would help you to find background information on the eruption? (choose ONE)

○ Eyiafjallajökull ○ Thröstur Thorsteinsson ○ particulate matter ○ World Health Organization

○ plume ○ volcanic ash ○ Rick Sanchez ○ Institute for Earth Science

11. Which of the hyperlinks would help you to locate an expert on volcanoes in Iceland? (choose ONE)

○ Eyiafjallajökull ○ Thröstur Thorsteinsson ○ particulate matter ○ World Health Organization

○ plume ○ volcanic ash ○ Rick Sanchez ○ Institute for Earth Science

12. Which of the hyperlinks would help you locate more information on the health hazards of breathing particulates? (choose ONE)

○ Eyiafjallajökull ○ Thröstur Thorsteinsson ○ particulate matter ○ World Health Organization

○ plume ○ volcanic ash ○ Rick Sanchez ○ Institute for Earth Science

SECTION 2

Use this information below (text and photos) to answer questions 13-16.

In August of 2005, Hurricane Katrina made landfall in Louisiana, resulting in widespread flooding after landfall, combined with winds more than 125mph.

Photo courtesy of NOAA http://www.katrina.noaa.gov/satellite/satellite.html

United States Navy with the ID 050902-N-5328N-228

Photo courtesy of FEMA Photo Library

United States Navy with the ID 091116-N-1825E-004

13. Why is the information in the text and photos important to people who live in Louisiana today?

14. Why is this information important to people who move to New Orleans?

15. What kind of continuing environmental impact could this have on the Gulf Coast?

16. What might the long term health impacts be for residents of the Gulf Coast?

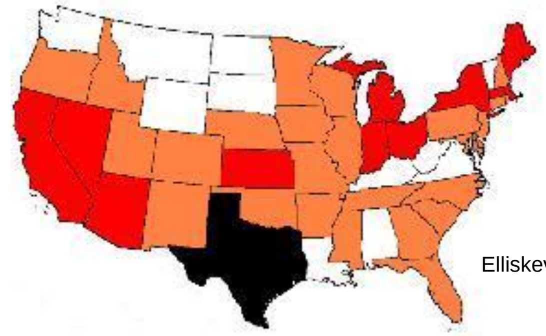
SECTION 3: ***Use the information below to answer questions 17-20.***

H1N1 - Influenza

U.S. Centers for Disease Control and Prevention

Human infections with 2009 H1N1 are ongoing in the United States. Most people who have become ill with this new virus have recovered without requiring medical treatment. The 2009 H1N1 virus is contagious and is spreading from human to human.

Spread of 2009 H1N1 virus is thought to occur in the same way that seasonal flu spreads. Flu viruses are spread mainly from person to person through coughing or sneezing by people with influenza. Sometimes people may become infected by touching something – such as a surface or object – with flu viruses on it and then touching their mouth or nose.



Elliskev

Getting infected with any influenza virus, including 2009 H1N1, should cause your body to develop immune resistance to that virus so it's not likely that a person would be infected with the identical influenza virus more than once. People infected with seasonal and 2009 H1N1 flu shed virus and may be able to infect others from 1 day before getting sick to 5 to 7 days after. This can be longer in some people, especially children and people with weakened immune systems and in people infected with the new H1N1 virus.

What are "emergency warning signs" that should signal anyone to seek medical care urgently?

.

In adults:

- Difficulty breathing or shortness of breath
- Pain or pressure in the chest or abdomen
- Sudden dizziness or confusion
- Severe or persistent vomiting

In children:

- Fast breathing or trouble breathing
- Bluish skin color
- Not drinking enough fluids
- Not waking up or not interacting
- Being so irritable that the child does not want to be held
- Flu-like symptoms improve but then retur with fever and worse cough
- Fever with a rash

Take these everyday steps to protect your health:

- Cover your nose and mouth with a tissue when you cough or sneeze. Throw the tissue in the trash after you use it.
- Wash your hands often with soap and water. If soap and water are not available, use an alcohol-based hand rub.
- Avoid touching your eyes, nose or mouth. Germs spread this way.
- Try to avoid close contact with sick people.

Alcibiades

17. Are you at risk for H1N1? Explain why you think so.

18. Complete the following chart

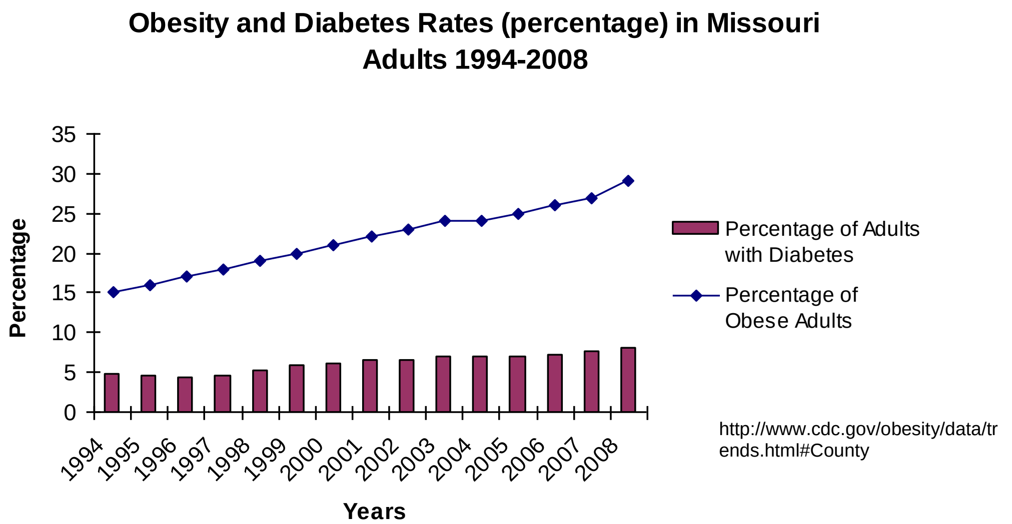
What other credible sources could you use to find out more about H1N1 Influenza?	Why do you trust this source?	What question(s) would you want this source to answer?

19. You want to find out more about why children tend to have more symptoms after becoming infected. Entering the search term **<u>H1N1</u>** into a search engine might not be the best choice. Explain why not.

20. Why might infections such as Influenza H1N1 spread faster today than 100 years ago?

SECTION 4: ***Use the information in the image below to answer questions 21-24***

Your friend Julie has asked you to peer edit her PowerPoint presentation on childhood diabetes. She wants you to make sure that she is presenting the facts correctly.



As this chart indicates, the rise in obesity during the period 1994-2008 is not correlated to the increase in diabetes.

21. What recommendations (if any) would you make to Julie?

22. Complete the chart below:

Suggest other sources that Julie can use.	Why should Julie trust this source?	What question(s) would you want this source to answer?

23. If you wanted to search for more information on the web in order to help Julie, what search terms or phrases would you use? Please write the search terms in the box exactly as you would type them into a search engine.

[ ] SEARCH

A. What information do you expect to get from this search?

____

[ ] SEARCH

B. What information do you expect to get from this search?

____

24. Your class is presenting at the Community Health Fair. You will be working with Julie to present this information on childhood diabetes. With a $10,000 cash prize for the best presentation, what information would you double check so that you have the best presentation? Why check those facts?

APPENDIX D: SLA Scoring Guide

SLA Scoring Guide

Revised

5/31/2011

Question 1

Rationale: Establish relevance for a specific audience with a focus on the underlying science issue as a basis for the need to know.

Form A Question: Is there anyone who you think should read this article? Why?

Form B Question: Is there anyone who you think should read this article? Why?

3 points- Includes a specific target audience and indicates why this might be of interest and includes an explanation of the specific science issue that would be of interest. *Example:*

> *People who live with small children, especially people in Washington, DC; Providence, RI; or any other city where lead levels exceed EPA standards. Because people living in those homes are most likely to be affected, and children are especially sensitive to the effects of lead.*
>
> *People who travel or live in the volcano region should be aware of the possibility that the volcanic particulates may aggravate their allergies, asthma, or other respiratory problems because this awareness would enable a degree of prevention and facilitate diagnosis and treatment. The awareness would also mitigate the risk and inconvenience of attempting air travel in the volcano region.*

2 points- Identifies a specific science issue without a specific audience or includes a specific target audience and why they might be interested without stating specific science issue. *Example:*

> *people living in the area to understand health concerns and people traveling*
>
> *The people in Providence RI, and people living in other places (Washington DC) who are getting their pipes replaced*
>
> *My cousins in Chicago, they have a very old house*

1 point- identifies a broad audience without establishing the specific science issue that would be of concern. Or establishes a broad audience that could be almost anyone and a specific science issue of concern.

Earth Scientist, Meteorologists- to keep informed of current events about the eruption

people wanting to travel to this area, could be dangerous to fly

0 points- Does not establish a specific audience (eg. Everyone or anyone) or does not suggest an audience at all and does not make a science connection.

Question 2

Rationale: Connect science issues to society as a whole. (Relevance)

Form A Question: Why is this information important to the general public?

Form B Question: Why is this information important to the general public?

3 points- Implies a broader audience recognizing that people outside of the immediate area or being directly affected could be impacted as well, importance is rooted in the science issue and its possible impact.

> *Those who potentially travel through the volcano region could come from anywhere around the globe. Therefore, informing the general public is a means of reaching the fraction of the public for whom the circumstances have a direct impact.*
>
> *Because our society benefits from ensuring that children aren't exposed to toxics that can impair their health. In fact, our society and our government should ensure that such problems are remediated effectively.*

2 points- Implies a broader audience that is directly impacted or is in a similar situation and importance is rooted in the science issue and its possible impact.

> *Because many people throughout the US could be living in areas where the lead levels exceed EPA standards*
>
> *The eruption caused travel issues and raised health and safety concerns about the level of pollution and hazards created.*

1 point- Includes a broad general connection to the science issue.

> *health concerns and disruption to traveling activities*
>
> *Lead can affect brain development in children.*

0 points- Does not connect science issue to the welfare of the general public or establish a specific need to know.

> *It is affecting everyone*
>
> *So they can know about current events*

Question 4

Rationale: Within each article are ambiguous, misleading or incorrect facts with regards to the science. (Identifying factual inaccuracies)

Form A Question: If you were presenting this information to a community group, what information about ***lead*** would you check with other sources? Why should this fact be checked?

Form B Question: If you had to present this information to a community group, what information would you check with other sources regarding **volcanic**

ash and airplane engines before including in the presentation and why?

3 points- Identifies a specific science fact or issue that needs to be checked and the explanation as to why it should be checked alludes to a concern about its
accuracy.

> *I would perform an online search to attempt to find records of jet engine failures and prop-driven airplane failures caused by volcanic ash. My search would target both failures during non-testing use of jets and airplanes as well as tests that explored the relationship between volcanic ash load and engine failure.*
>
> *Is it really the case that the houses in the area have 100% full lead in their paint? That's weird.*

2 points- Identifies a specific science fact or issue that needs to be checked and the explanation as to why it should be checked does not allude to a concern about its accuracy or lacks an explanation about why this should be checked.

> *levels of lead pollution in my area*
>
> *how much ash is a problem for the engine, can the engine be designed in a way to avoid this?*

1 point- Identifies other fact(s) that should be checked not specific to the science presented in the article or limited to background information on the science.

The most important thing to check is what Mary Columbus says

What does lead damage in the human body.

0 points- Does not identify a specific fact or answer is unrelated to the article (it could work for any article)

I would look up the pros and cons.

I would mostly get the facts and the main problems and solutions

Question 5

Rationale: Making decisions and being informed requires the use of multiple credible sources that examines science and technology in the context of both the broader world of science and technology but also societal implications. (Contextualization)

Form A Question: Is there any additional information that you think might make this article better?

Form B Question: Is there any additional information that you think might make this article better?

3 points- Identifies specific additional information that will help the reader to understand the science issue or confirms/corrects specific statements within the article.

There is an error in the news atricle about the height of the ash plume. 30 feet is an error.

Elaborate on the probability and frequency of recurrent activity that is expected of a volcano subsequent to its initial activity following a long period of dormancy.

I'd explain more about lead paint and how that might be confounding the results. The galvanic corrosion and the car battery comparison is a little confusing if you don't know how a battery works.

2 points- Identifies information tangential to the science, yet will help reader understand the issue. (Societal implication) or addresses credibility of sources within article.

I would like to know the extent of lead piping found in cities. Perhaps the author could have given an example of how much lead piping is still in a city like New York or Chicago.

It would be nice to know how many partial replacements are done in this country annually and how much they cost.

How many planes were held up, passengers stranded?

How much does the damage to the engine cost to repair?

Identifying who Mary Columbus is and why she is speaking on this topic, so that we know whether she is a credible source.

1 point- Information sought only provides very broad general background knowledge, not specific to the article or sources within. Additional information seeks to incorporate other non-scientific points of view (eg citizens or passengers)

I think that some additional information that should be added to this article should probably be some links to other websites and sources that tell about this lead problem.

I think that this article should contain opinions and points of view from the general public.

0 points- Does not request additional information or answer is broad enough to include all information on the topic.

No, I think its fine just the way it is.
the exact amout and the right
things

Question 6

Rationale: Identification of other credible sources and explains why the source is credible

Form A Question: If the author was asked to write a follow-up article on this topic, who might she interview next? Why would this person be a good choice?

Form B Question: If the author was asked to write a follow-up article on this topic, who might she interview next? Why would this person be a good choice?

3 points- suggests a source that would clarify some aspect of science within the story and has the expertise, experience, training, or first hand knowledge to establish credibility.

The authors of the CDC report, because this is a result that goes against conventional wisdom now. It would be good to know how certain they are of the results.

a plane engineer, they could explain the problems with the engine

A health professional who is broadly connected with caregivers in the region of the volcano. This person would provide insight on whether or not the potential health risks of volcanic particulates were realized. Such dialogue may improve current treatment of affected individuals and aid prevention of adverse effects during similar events in the future.

2 points- Suggests a source that would personalize the article increasing its relevance to the public or would elaborate on a non-science aspect of the article. (First hand experience or knowledge)

What happened with the protest? That is what I want to know. They are "on the ground" so to speak, and could tell the reporter the exact situation.

Airline and airport authorities and travelers who were stranded. They all suffered as a result of the eruption

Local residents on personal experiences from the volcanic eruption.

1 point- Suggests a source already included in the article to clarify information or another expert without stating the purpose. Or simply adds opinion or other view point. Suggests a source that is too far removed to be informed.

> *Pamela Marchand - I'd like to learn why they think partial pipe replacement isn't working and what they propose to do about it.*
>
> *If the author was asked to write a follow-up article on this topic, she might interview the EPA next.*
>
> *an expert on lead*
> *pipes a doctor*
> *The president*

0 points- Does not suggest a source or the source is not credible or so broad it could include anyone.

> *the government and the companies*

Question 7a (Form A)

Rationale: Determine credibility of a source

Question: There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. *These sources are also highlighted within the article- Lead Pipe Initiative*

3 points- Selects Somewhat credible and states credibility is affected by possible bias, financial support, lack of expertise and/or experience.

> *Somewhat credible- They're an interest group who are the ones affected but might not be impartial.*
>
> *Somewhat credible- As a group of concerned citizens, they are credible, and their viewpoint is important. But their position could be informed more by emotion than by facts.*
>
> *Somewhat credible- A nonprofit made up of citizens with an interest in this issue for some reason. Do they have medical backgrounds or chemistry backgrounds? What makes them so convinced? That makes me trust them less -- but they must have some reason to be concerned!*

2 points- Selects Very Credible or Unsure or Not Very Credible . If Very Credible is chosen – credibility should be limited to the experiences and viewpoints of a citizen group (no science expertise was noted in the article). If Unsure was chosen should indicate not enough information available to determine and suggest additional information to make a credibility determination. If Not Very Credible was chosen should indicate credibility is reduced by bias or lack of explicit expertise.

> *Very credible -This source is an activist group with an agenda that is intended to improve public health.*
>
> *Very credible- These are people who are worried about their water and are very well informed.*
>
> *Unsure- We don't know what credentials the citizens have or whom they have employed to help them; but, the initiative is, by definition, a group of concerned citizens, so they may not need any more credentials than that.*

1 point- Selects Somewhat credible or very credible or not very credible without explanation or uses statements directly from article as justification.

0 points- Selects unsure, not very credible or not credible.

Question 7b (Form A)

Rationale: Determine credibility of a source

Question: There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. *These sources are also highlighted within the article- EPA*

3 points- Selects Very credible or Somewhat credible and states credibility is based on government affiliation, expertise and/or experience and could include reservations on credibility due to political agenda

> *Somewhat credible- It's a government agency that needs to marshall evidence to support their regulations, but they could also have a political agenda.*
>
> *Somewhat credible- The EPA is a well-known government agency with responsible for oversight of issues like this one. However, not all citizens will be confident that EPA is acting in their best interest.*
>
> *Very credible- An agency with a track record -- of course, they screw up sometimes, but they are obliged to make their results public and those are reviewed by outside scientists.*

2 points- Selects Very Credible and credibility is based solely on government affiliation.

> *Very credible –US government agency.*

1 point- Selects Somewhat credible or very credible without explanation or uses statements directly from article as justification.

0 points- Selects unsure, not very credible or not credible.

Question 7c (Form A)

Rationale: Determine credibility of a source

Question: There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. *These sources are also highlighted within the article- Mary Columbus*

3 points- Selects Not credible or Unsure and states lack of credibility is based on lack of information provided in the text, specifically what expertise she has and/or affiliation.

> *Not Credible- She is not identified, in terms of what role she plays in this drama. I assume she's a citizen, but in order to be a credible source for statements such as the one attributed to her, she'd need to have her credentials established.*
>
> *Unsure- She's supposedly a public health expert, but her credentials and affiliation are not mentioned.*
>
> *Not Credible- At this point, she is not credible because she is not identified at all (where does she work? what does she do?). She also uses a made- up word, which makes me wonder if everything she says is made up.*

2 points- Selects Not Credible or Unsure and does not indicate that credibility is based is based on lack of information provided in the text, specifically what expertise she has and/or affiliation- or simply states not enough information.

> *Not Credible- Conflipation is not a word!*
>
> *Not Credible- not information included in the article to determine credibility*

1 point- Selects Not credible without explanation or uses statements directly from article as justification.

0 points- Selects unsure, not very credible or somewhat credible or very credible.

Question 7a (Form B)

Rationale: Determine credibility of a source

Question: There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. *These sources are also highlighted within the article- Institute for Earth Science*

3 points- Selects unsure and states credibility cannot be determined although possibly credible based on expertise suggests specific additional information needed to make credibility determination.

> *Unsure – although volcanoes are part of Earth Science, this institute may not specialize in volcanoes, not enough information to claim a degree of credibility.*

2 points- Selects Unsure, somewhat or not very credible - should indicate not enough information available to determine.

> *Unsure- It sounds credible, but there is not enough info to say for sure. Unsure- I have no knowledge of this source.*

1 point- Selects somewhat credible or very credible relying on title (Institute to establish credibility) or the study of the Earth, or that they made the measurements.

> *Very credible- They make measurements firsthand.*

0 points- Selects any answer without explanation or uses faulty science logic as support.

> *Somewhat credible- You can't measure exactly How high the plume of smoke/ash went so it could be wrong*

Question 7b (Form B)

Rationale: Determine credibility of a source

Question: There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. *These sources are also highlighted within the article- **Th**röstur Thorsteinsson*

3 points- Selects Not credible or unsure and states determination of credibility is due to lack of specific information needed to make that determination.

Not credible- Who is he? There is no information about him in the article

Unsure- There is no information about him in the article.

2 points- Selects Somewhat Credible and credibility is based on credibility gleaned from the article. (putting 1 and 2 together)

Somewhat credible- Being a scientist from the country, he should have first-hand knowledge about this particular volcano.

1 point- Selects Somewhat credible or not credible or not very credible without explanation or uses statements directly from article as justification.

0 points- Selects unsure or very credible.

Question 7c (Form B

Rationale: Determine credibility of a source

Question: There were many sources included in this article. In the table below, indicate the credibility of the sources and explain your reasoning. *These sources are also highlighted within the article- WHO*

3 points- Selects Very credible or somewhat credible and states credibility is based on government affiliation, expertise and/or experience and could include reservations on credibility due to political agenda

> *Very credible- WHO is a longstanding (since 1948), global organization. It is comprised of many medical doctors, public health specialists, scientists, and epidemiologists from around the world. The collective thinking of a large number of technically trained people maximizes the probability that the guidance of the organization is dependable.*

2 points- Selects Very Credible and credibility is based solely on government affiliation.

> *Very credible –a governmental organization*
>
> *Very credible- UN agency, organization of worldwide importance*

1 point- Selects Somewhat credible or very credible without explanation or uses statements directly from article as justification.

0 points- Selects unsure, not very credible or not credible.

Question 8

Form A Question: What other information about SmartKid.com would you like to have to determine its credibility?

Form B Question: *What other information about http://www.eurocontrol.int/*

would you like to have in order to determine the credibility of the source?

3 points- Requests additional information (at least 2 cues) with one of the cues targeting "who they are" such as membership, authorship, sponsor, organization affiliation.

2 points- Requests additional information (at least 2 cues) that establishes funding source, source or quality of information, how up to date, purpose, or type of organization, etc.

1 point- Requests additional information (only 1 cue) that establishes who they are, funding source, source or quality of information, how up to date, purpose, or type of organization, etc.

0 points- Does not request additional information for credibility.

Question 9

Form A Question and Form B Question: Often articles include hyperlinks as resources within the article. In this article there are several choices. If you wanted to learn more, which hyperlinks would you choose?

Explain why you chose this link what you hope to find there.

3 points- Names a hyperlink from the article and uses this link to establish credibility or elaborate on specific science facts in the article.

2 points- Names a hyperlink from the article and uses the link to establish background knowledge necessary to understand the science (ie galvanic corrosion)

1 point- Names a hyperlink from the article, uses the link to learn more about non-science specific aspects or a simple definition or expectations are incongruent with hyperlink. Suggests their own hyperlink to address related aspects that were not hyperlinked (eg. lead paint or Boeing)

0 points- Does not suggest a hyperlink or does not explain why they chose a hyperlink.

Question 10

Rationale: Utilize relevant embedded links to improve understanding.

Form A Question: Which of the hyperlinks would help you to find background information on water quality standards? (choose ONE)

Form B Question: *Which of the hyperlinks would help you to find background information on the eruption? (choose ONE)*

3 points-
Form A: selects EPA
Form B: Selects Eyiafjallajokull

2 points-
Form A: Selects water company
Form B: Selects Institute for Earth Science

1 point-
Form A: selects Lead Pipe Initiative
Form B: selects Throstur Thorsteinsson

0 points-
All other responses

Question 11

Rationale: Utilize relevant embedded links to improve understanding.

Form A Question: Which of the hyperlinks would help you locate an expert on lead levels in children? (choose ONE)

Form B Question: *Which of the hyperlinks would help you to locate an expert on volcanoes in Iceland? (choose ONE)*

3 points-
Form A:
CDC
Form B: Throstur Thorsteinsson

2 points-
Form A: Virginia Tech
Form B: Institute for Earth Science

1 point-
Form A: Lead Pipe Initiative
Form B: WHO

0 points-
All other answers

Question 12

Rationale: Utilize relevant embedded links to improve understanding.

Form A Question: Which of the hyperlinks would help you locate information on how to actively participate in the debate as a concerned citizen? (choose ONE)

Form B Question: *Which of the hyperlinks would help you locate more information on the health hazards of breathing particulates? (choose ONE)*

3 points-
Form A: Lead Pipe Initiative
Form B: World Health Organization

2 points-
Form A: n/a
Form B: Particulate Matter

1 point-
Form A: n/a
Form B: Volcanic Ash

0 points-
All other answers

Question 13

Rationale: Establish relevance for people directly affected

Form A Question: Why is the information in the text and photos important to people who live on the Gulf Coast?

Form B Question: Why is the information in the text and photos important to people who live in Louisiana?
3 points-
Answer incorporates both specific scientific and specific societal implications.

- ☐ *Because oil spills can harm underwater ecosystems, kill or injure birds (and I think fish, too), and foul public beaches. It can hurt the livelihood of fishermen and people involved in the Gulf Coast's tourism industry.*

2 points-
Answer is limited to broad scientific and broad societal implications or
Specific scientific and broad societal implications or
Broad scientific and specific societal implications or
Only specific scientific or specific societal implications but not both

- ☐ *Residents should be mindful of the possibility that a similar event could occur in the future. Such mindfulness would influence land use and other public policy decisions in a way that would mitigate the detrimental effects of a future event. The photos provide useful shock value to increase the degree of appreciation for the potential consequences of such an event.*

- ☐ *their food supply, jobs, and health are all affected by this.*

1 point-
Answer is limited to either broad scientific or broad societal implications

- ☐ *Could affect the local economy for a long time.*
- ☐ *They need to know how the oil spill might affect the environmental health of the coast.*

0 points-
Answer does not include either specific or broad scientific or societal implications.

Question 14

Rationale: Establish relevance for people who are indirectly affected

Form A Question: Why is this information important to people who live in Missouri?

Form B Question: Why is this information important to people who move to New Orleans?

3 points-
Answer incorporates both specific scientific and specific societal implications.

- ☐ *People moving to New Orleans may have come from a region where hurricane-magnitude high winds and flooding did not occur. Being informed of the possibility of such an event would enable the newcomers to formulate a prevention/mitigation plan to cope with a hurricane.*
- ☐ *contaminated food supply, or limited supply of some kinds of food*
- ☐ *Citizens should always be aware of news happening in their country. In this case, they could put pressure on lawmakers to hold the right people accountable. Also, no matter where environmental disasters occur, they affect everyone. The oil (or things that come in contact with the oil) will not stay in the Gulf.*

2 points-
Answer is limited to broad scientific and broad societal implications or
Specific scientific and broad societal implications or
Broad scientific and specific societal implications or
Only specific scientific or specific societal implications but not both

- ☐ *Because the Gulf Coast is part of the U.S. and therefore national news. The fact that Missouri citizens use oil also makes the story relevant to them.*

1 point-
Answer is limited to either broad scientific or broad societal implications

- *Important as a reminder of the dangers associated with living at or below sea level along the Gulf Coast*
- *We all use oil and gas we should be aware of the costs*.

0 points-
Answer does not include either specific or broad scientific or societal implications.

Question 15

Rationale: Place new information into the broader field of science

Form A Question: What kind of environmental impact could this leak have on the Gulf Coast?

Form B Question: What kind of continuing environmental impact could this have on the Gulf Coast?

3 points-
Answer incorporates at least two specific environmental effects.

- ☐ *Flooding may have flushed toxic material, including sewage, from storage points and networks and broadcast it into the local waters and lands.*
  Erosion of wetlands may have compromised the buffering effects that wetlands are known to have on the erosive force of coastal wave activity, thereby exacerbating ongoing decay of tidal marshes. Wetlands are rich sources of marine life, mammals, and water

- ☐ *Oil slicks on beaches, death of marine life (increase in seafood price, decrease of tourism), health impacts on citizens (breathing fumes, coming in contact with oil, eating tainted seafood).*

2 points-
Answer includes one specific environmental effect (could also include other broad effects)

- ☐ *Pollution from the debris, changed shorelines*
- ☐ *On animals, on the water column and dead zones, etc.*

1 point-
Answer includes only broad environmental effects.

- ☐ *Restoration on wildlife and agricultural activities.*
- ☐ *It could affect wildlife, fisheries, tourism.*

0 points-
Does not address environmental impact.

Question 16

Rationale: Place new information into the broader field of science.

Form A Question: What kind of environmental impact could this leak have on Missouri?

Form B Question: What might the long term health impacts be for residents of the Gulf Coast?

3 points- Answer incorporates at least two specific environmental effects or health issues.

- ☐ *Threaten charismatic creatures like sea turtles and manatees, threaten fishing stock, impact sites that migrating birds use.*
- ☐ *Eating tainted seafood, reduced health of marine life (the accumulation of which will mean that the oceans cannot support as much fishing, recreation, etc. and could impact the oceans' ability to hold onto carbon dioxide, which contributes to climate change), we don't know where the oil will travel, etc. If the right people are not held accountable and if tougher regulations are not put*
- ☐ *Increased allergies and problems with air quality (mold and chemicals from building materials)*
- ☐ *Microbial infections may be more abundant in the near-term. If non-living toxins were flushed into local waters and lands during flooding, there might be health effects such as cancer that would be hard to associate with a particular toxin or trace to the points of exposure.*

2 points- Answer includes one specific environmental effect (could also include other broad effects) or one specific health issue (could also include other broad effects)

- *If the Gulf is having problems, I wonder if Missouri farmers will have to control their runoff even more?*
- *Infection from contaminated water, respiratory conditions.*

1 point- Answer includes only broad environmental effects or a broad health issue.

- *spread of contamination by fish in the Mississippi*
- *toxins from the spills*

0 points-
Does not address environmental impact or health related impacts

Question 17

Rationale: Evaluating personal risk for health related issue using informational text.

Form A Question: Are you at risk for high blood pressure? Explain why you think so.

Form B Question: Are you at risk for H1N1? Explain why you think so.

3 points- States risk using at least 3 factors identified in the text and a factor not identified in the text to support this determination (specific family history, personal vaccination)

- ☐ *Yes. I have not had symptoms of flu since the 2009 H1N1 outbreak, which suggests that I have not been a carrier. Since I have not been a carrier, I probably do not have antibodies specific to the H1N1 virus.*
- ☐ *I am not currently at risk. I do not know anyone who has it and I take vitamins*
- ☐ *Yes. My mom has it, I'm over 35, and I do experience stress*

2 points- States risk using at least two factors identified in the text to support this determination.

- ☐ *Yes because you can become infected by a number of ways and from people who appear to be healthy*
- ☐ *Yes, overweight and age*

1 point- States risk without using facts from the text to support instead uses other information as support or limits assessment of risk to a single factor.

- ☐ *I think everyone is at risk but young adults seem to contract H1N1 virus at a higher incidence.*

0 points- States risk without support of any kind or does not state risk at all.

Question 18

Rationale: Need to be able to identify credible sources of health information.

Form A Question: What other credible sources could you use to find out more about high blood pressure in teens?

Form B Question: What other credible sources could you use to find out more about H1N1

3 points- Suggests multiple sources that have expertise, specialized experience or training in the field.

- ☐ Centers for Disease Control and Prevention and the World Health Organization (well –established organization with technically competent people.
- ☐ Local health agency or my doctor and Center for Disease Control
- ☐ American Heart Association and my doctor
- ☐ CDC, NIH, and Mayo Clinic

2 points- Suggests at least one source that has expertise, experience or training in the field.

- ☐ My dad, he has high blood pressure.
- ☐ My doctor, he sees people with the flu.
- ☐ Missouri Health Department
- ☐ Webmd.com

1 point- Suggests sources (one or more) that has very limited expertise, experience or training in the field.

- ☐ My mom

0 points-
Does not suggest an additional source or suggests a source so broad as to include anything (eg. Google, Yahoo, Internet)

Question 18 – part c is for qualitative coding purposes only

Question 19

Rationale: Recognizes possible reason for ineffective search results and suggests more effective searching strategy.

Form A Question: You want to find out more about why females tend to have higher blood pressure after menopause. Entering the search term menopause into a search engine might not be the best choice. Explain why not.

Form B Question: You want to find out more about why children tend to have more symptoms after becoming infected. Entering the search term H1N1 into a search engine might not be the best choice. Explain why not.

3 points- Answer suggests ineffective search strategy is related to search terms and identifies the need for a combined search term to narrow the search results (ie. H1N1 and children or Menopause and High Blood Pressure), providing specific suggestions for a future search.

- ☐ *It is not sufficiently specific. Including supplemental keywords, such as "symptoms" and "children" would help to filter out some of the less relevant hits.*

- ☐ *it's too general. i think you'd want to narrow it more by also typing "blood pressure" or "high blood pressure" as search terms.*

2 points- Answer suggests ineffective search strategy is related to search terms and identifies the need for a combined search term to narrow the search results (ie. H1N1 and children or Menopause and High Blood Pressure)

- ☐ *may not be specific enough about children's symptoms.*
- ☐ *Simply typing "menopause" will bring up lots of links that deal with menopause but not necessarily high blood pressure. You need more search terms.*

1 point- Answer suggests ineffective search strategy is related to search terms and does not make a specific suggestion for improvement.

- ☐ *H1N1 is a fairly general search for specific information*
- ☐ *this does not focus the search*

0 points-
Does not suggest a reason this search is ineffective.

Question 20

Rationale: Place new information into the broader field of science (historical changes)

Form A Question: Why might high blood pressure be more common in teens today than 100 years ago?

Form B Question: Why might infections such as Influenza H1N1 spread faster today than 100 years ago?

3 points- Answer includes at least one specific science connection and one specific societal connection.

- ☐ *Increased population densities increase the extent of interactions that effectively transfer the virus from host to host. Increased mobility increases the frequency and speed of transmission from hosts traveling from populations in which the virus is present to populations in which the virus is not yet present.*

- ☐ *people have more contact with each other, mass transportation spreads illnesses quicker to more parts of the world*

- ☐ *Because teens are more likely to be obese and they probably consume more salt. they may also feel more stressed. some teens may drink more than teens did 100 years ago*

2 points- Answer includes both broad science and societal connections

- ☐ People travel farther and faster today than they did 100 years ago.
- ☐ diet and exercise is different

1 point- Answer includes only broad societal connection.

- ☐ *travel (air, cars etc.)*
- ☐ *Diet*

0 points-
Does not make connections (scientific or societal)

Question 21

Rationale: Utilizes both text and graphs for gathering new information, recognizing when inconsistencies occur between text and an associated graph.

Form A Question: What recommendations (if any) would you make to Bill?

Form B Question: What recommendations (if any) would you make to Julie?

3 points- Identifies that there is an inconsistency between the data and the claim Form A) graph and text contradict; claim is causation instead of correlation Form B) graph depicts wrong data (adults instead of children); claim is causation instead of correlation and makes **more than one** suggestion for improvement.

- ☐ *The most glaring error is Bill's interpretation of the graph. Obviously, the two lines are correlated, which suggests global temperature and carbon dioxide are correlated. (For a scientific audience, additional statistical measures should be presented.) I would take "zFacts" off of the x-axis and write "Year" instead. I would tell him to change the y-axis on the left to ..."*

- ☐ *I would suggest that the overall trend is that global temperature and carbon dioxide levels appear to be related. In fact, zfacts.com says, "Local and global weather has always fluctuated and always will, so global warming cannot be expected to be a smooth process. But what can be seen above is that half of all man-made CO2 has been put into the air since 1975, and that matches the one-degree*

- ☐ *Eliminate the claim, "As this...in diabetes." The data does not support the claim. Both obesity and diabetes trend upward over the time period.*
  The causal relationship between the two conditions is unknown, but one possibility is that the two conditions are correlated. Replace or supplement the shown data (which is for adults) with data from children if it is available.

2 points- Identifies that there is an inconsistency between the data and the claim Form A) graph and text contradict; claim is causation instead of correlation
Form B) graph depicts wrong data (adults instead of children); claim is causation
instead of correlation and makes **one** suggestion for improvement.

- *Bill, if these data are correct, your conclusion is wrong because the CO_2 emissions data from ice cores and the Global temperature info are in pretty good agreement*.

- *Julie needs to present the data on childhood diabetes and obesity, NOT adult correlations.*

1 point- Provides a suggestion for change that addresses the inconsistency but does not address the causation/ correlation issue.

- Use data about children not adults

0 points- Does not identify factual inconsistency.

Question 22

Rationale: Need to be able to identify credible sources for additional information.

Form A Question: Suggest other sources that Bill can use.

Form B Question: Suggest other sources that Julie can use.

3 points- Suggests multiple sources that have expertise, experience or training in the field.

- ☐ American Diabetes Association and American Medical Association
- ☐ American Diabetes Association and an endocrinologist
- ☐ EPA and National Science Foundation
- ☐ International Panel on Climate Change and NOAA
- ☐ Respected science journals such as Nature and Science

2 points- Suggests a single source that has expertise, experience or training in the field.

- ☐ Diabetes Foundation
- ☐ A doctor
- ☐ EPA
- ☐ Al Gore

1 point- Suggests a source that has very limited expertise, experience or training in the field.

- ☐ My grandma who has diabetes

0 points-
Does not suggest an additional source

Question 22 – part c is for qualitative coding purposes only

Question 23

Rationale: Search effectively for information on the web.

Form A Question: If you wanted to search for more information on the web in order to help Bill, what search terms or phrases would you use? Please write the search terms in the box exactly as you would type them into a search engine.

Form B Question: If you wanted to search for more information on the web in order to help Julie, what search terms or phrases would you use? Please write the search terms in the box exactly as you would type them into a search engine.

3 points- Search terms are in the form of a string, Boolean phrase and/or includes specific scientific terms that help to narrow the search. Expected results are specific and commiserate with the suggested search terms. Suggests multiple searches.

- ☐ *Children + Type II diabetes + statistics - Statistics about children and Type II diabetes*

and

- ☐ *American Diabetes Association- general information on the disease, available resources for help*

- ☐ *“global temperature, carbon dioxide, climate change, consensus, scientists” - websitesoperated by groups that have analyzed the scientific data on climate change*

and

- ☐ *clean skies act- What legislation was passed to address this*

2 points- Search terms are broad (can be in the form of a string or Boolean phrase) providing a large variety of related information directly related to the topic and may not produce the desired information. Suggests at least one additional search.

- ☐ *"childhood diabetes"- Statistics about children and Type II diabetes*
- ☐ *"climate change" research- Which institutions are doing (or compiling) scientific research on climate change.*

- ☐ *Diabetes and obesity- relationship between childhood diabetes and obesity*

1 point- Suggests one additional search and the search terms are very general, resulting in a search that returns information directly applicable to the topic and
information unrelated. Or relies on terms from the graph or the text only.

- *"climate change" - Anything that mentions climate change.*
- *Juvenile diabetes – causes of diabetes in children*

0 points-
Does not suggest an additional search

Question 24

Rationale: Identifies additional information needed to improve factual accuracy

Form A Question: Your class is presenting at the Midwest Environmental Conference for High School students. You will be working with Bill to present the information on Global Climate Change. With a $10,000 cash prize for the best presentation, what information would you double check so that you are sure your information is of prize-winning quality?

Form B Question: Your class is presenting at the Community Health Fair. You will be working with Julie to present this information on Childhood diabetes. With a $10,000 cash prize for the best presentation, what information would you double check so that you have the best presentation?

3 points- Makes a suggestion for improving the factual accuracy of the presentation (Form A- correlation between CO2 and global climate and Form B- correction to use childhood statistics) and suggests using additional sources to verify the information being presented. Includes specific suggestions.

- ☐ Check with American Diabetes Association or Missouri statistics on childhood diabetes and obesity.

- ☐ Is it a fact that CO2 and temperature are unrelated, Bill? Exactly WHY carbon dioxide and temperature are unrelated is not described by this graphic. I would want to add some information to support that. And I think it's not true, so that could be a problem. I would have to persuade Bill to read some more research that shows they are related.

2 points- Makes a suggestion for improving the factual accuracy of the presentation (Form A- correlation between CO2 and global climate and Form B- correction to use childhood statistics) **or** suggests locating additional sources to verify information.

- ☐ *You want to be certain that all of the information you present is factual, and a good way to do that is by going to several sources to ensure that they all present the same data and interpret in the same way. You might also ask established climate scientists to look over the presentation.*

- ☐ *The CO2 levels, the global temperature, whether his conclusion makes sense*

- *the causes of childhood diabetes the causes of childhood obesity the causal relationship between diabetes and obesity, those facts are key to mitigating the frequency and degree of diabetes (and obesity depending on the causal relationship). Therefore, they are vital to the impact of the presentation.*

1 point- Suggests using additional sources to verify the information being presented but does not address factual inaccuracies in the current presentation or makes general suggestions without specifically addressing the factual inaccuracy.

- *I would check the source of the graph -- where did the data come from? Because we want to know whether the data came from a source that has an interest is promoting a particular conclusion about global warming.*

0 points- makes suggestions that do not address factual inaccuracy or credibility of sources of data

- Make a bar graph
- All of it.

APPENDIX E: Expert Novice Analysis *ANOVA* Table

ANOVA Expert Novice Comparison

		Sum of Squares	df	Mean Square	*F*	Sig.
Relevance	Between Groups	26.230	1	26.230	154.483	.000
	Within Groups	127.174	749	.170		
	Total	153.403	750			
Context	Between Groups	47.952	1	47.952	125.974	.000
	Within Groups	285.106	749	.381		
	Total	333.058	750			
Information Seeking	Between Groups	61.578	1	61.578	394.912	.000
	Within Groups	116.790	749	.156		
	Total	178.368	750			
Multiple Credible Sources	Between Groups	27.360	1	27.360	94.254	.000
	Within Groups	217.418	749	.290		
	Total	244.777	750			
Factual Accuracy	Between Groups	49.209	1	49.209	210.558	.000
	Within Groups	175.047	749	.234		
	Total	224.256	750			

APPENDIX F: Information Seeking Search Term Data

Explanations for Ineffective Search Term Usage by Percentage (n=673)

Category	Percentage
No Suggestion	11.0
Narrow the search	87.4
Suggests using questions	0.6
Suggests a text phrase	5.2
Other suggestions	2.1

APPENDIX G: GLMM Coefficient Table for Fixed Effects

Fixed Effects	Coefficient	Sig.
Overall		
Implementation Level	-0.357	0.000
Course	-0.149	0.001
Revised	-0.238	0.002
Relevance		
Revised	-0.344	0.003
Context		
Course	-1.243	0.011
Revised	-0.295	0.018
Factual Accuracy		
Implementation Level	-0.377	0.001
Course	-1.271	0.031
Revised	-0.267	0.018
Multiple Credible Sources		
Implementation Level	-0.436	0.000
Area	1.467	0.023
Course	-1.794	0.015
Information Seeking		
Implementation Level	-0.563	0.000
Course	-1.775	0.016
Revised	-0.240	0.030
Technology Usage	0.463	0.034

Note: First level within each effect was described by the coefficients