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# Researching the Real: Transforming the Science Fair through Relevant and Authentic Research

Rosemary McBryan Davidson
*University of Missouri-St. Louis*, rosedavidson@sbcglobal.ne

Rosemary McBryan Davidson

M.Ed., Secondary Education, University of Missouri-St. Louis, 1980

B.A., Biology, St. Louis University, 1975

# Researching the Real:
# Transforming the Science Fair through Relevant and Authentic Research

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Dissertation Committee

Dr. Charles Granger, Ph.D.
Chairperson

Dr. E. Wendy Saul, Ph.D.

Dr. Alan Newman, Ph.D.

Dr. Angela Kohnen, Ph.D.

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## Abstract

This teacher research study documents the processes used to help students in an all-female, religious-based high school create science fair projects that are personally meaningful, scientifically sophisticated and up-to date in terms of science content. One-hundred sixteen young women in an honors chemistry class were introduced by their teacher to the methods used by science journalists when researching and crafting articles. The students then integrated these strategies into their science fair research through collaborative classroom activities designed by their teacher. Data collected during the process included audio and video tapes of classroom activities, student interviews, process work, finished projects, email conversations and the reflective journaling, annotated lesson plans, and memories of the lived experience by the teacher.

The pedagogical changes which resulted from this project included the use of Read Aloud-Think Alouds (RATA) to introduce content and provide relevance, a discussion based topic selection process, the encouragement of relevant topic choices, the increased use of technology for learning activities and for sharing research, and an experimental design process driven by the student's personally relevant, topic choice. Built in feedback loops, provided by the teacher, peer editors and an outside editor, resulted in multiple revisions and expanded opportunities for communicating results to the community-at-large.

Greater student engagement in science fair projects was evident: questioning for understanding, active involvement in decision making, collaboration within the classroom community, experience and expertise with reading, writing and the use of technology, sense of agency and interest in science related activities and careers all

increased. Students communicated their evolving practices within the school community and became leaders who promoted the increased use of technology in all of their classes.

Integrating journalistic practices into the research projects of these honors chemistry students also brought about positive changes in the attitude of the students toward science. The pedagogy implemented was successful at increasing the engagement of the participants in their own learning processes as well as increased interest in science. Moreover, the teacher researcher has expanded her skill set and is transitioning toward a more student-centered classroom. While this study focused on 116 honors chemistry students over the course of three years, it identified changes in practices that can be taken up and examined more broadly by science teachers who include science fairs as part of their curriculum.

## Note to Classroom Teachers

This dissertation is a success story. It describes my journey from an uncertain novice in a summer training session to that of an expert sharing her expertise through peer reviewed journal articles and presentations at international meetings. I have shared my developing practices at the National Science Teachers Association's national convention, the National Association of Research in Science Teaching's international conference and the National Research Dissemination Conference to name a few. My article on infographics, one aspect of my teaching strategies, was published in the March, 2014 issue of The Science Teacher. I plan to follow up this dissertation with additional articles on my use of journalism with my students' research projects.

My advice to classroom teachers is to focus in your reading of this dissertation on chapters four and five. Chapter four describes the classroom activities which I developed over the three years covered by this study to be most successful for merging journalism with the research projects of my students. Highlights include using content Read Aloud-Think Alouds (RATA) to capture student interest, strategies to improve the topics chosen by students for their research, adding stakeholder and expert interviews to the research process, and different methods for the students to use when communicating their findings. Chapter five presents anecdotal stories of how my students were affected by the emerging practices in my classroom, telling the story of their journey from novice to experts in their own right. I describe the increases in the engagement and motivation of my students which I witnessed along with the development of a community of learners, working together toward a common goal. Chapter five also discusses how the use of science journalism with student research projects develops their scientific practices.

## Dedication

This dissertation is dedicated to my mother, Mary Anne Hyla McBryan, whose brilliant mind was ravaged by two massive strokes in May of 2013. From early childhood my mother's emphasis on scientific study has been an impetus for me to improve my knowledge base. Visits with my mother to the local park to collect specimens of lichens, her guidance while I carried out research for my own science fair projects, and our eventual collaboration as teaching colleagues are some of the events which have shaped me into the science teacher and researcher that I am today. Abraham Lincoln's quote about his mother expresses quite eloquently the gratitude that I feel towards my own mother, "All that I am or ever hope to be, I owe to my mother."

## Acknowledgements

This research project could not have been completed without the willingness of my students to try new things and to give open and honest feedback on the process. For the three year period of 2010 to 2013 my students have opened their minds to trying something very different in science class; science journalism. They have accepted every challenge that I and the Science Literacy through Science Journalism, SciJourn, researchers have placed before them. They have crafted articles, peer edited, been pre-tested and post tested, observed, videotaped, and interviewed. Throughout the process they have remained open to new experiences and exuberant in adopting journalism activities into their chemistry coursework. I could not have succeeded with this research project without their willingness to collaborate and investigate along with me.

My principal during the time of this study, Sr. Pat Dunphy, was also supportive of the research going on in my classroom. She quickly saw the impact which journalism was having on our students and became an avid supporter of the program. She went out of her way to congratulate each student author upon their article's acceptance for publication. She attended in-service meetings and an advisory board dinner in order to share her perceptions of the benefits of the program with the SciJourn researchers. She has encouraged me in the writing of this dissertation so that my findings can be shared with the broader community of science practitioners. I am grateful for the support which she gave to me and my students.

The other members of the cadre of SciJourn teachers to which I belonged shared their developing ideas and pedagogy with me during our in-service meetings. Their insights into the triumphs and struggles with adopting the journalistic process into their

classrooms provided guidance for the entire cadre. Our brainstorming sessions helped all of us to move forward in the process together.

The SciJourn research team also provided me with guidance and encouragement on this journey. The Principal Investigators for the project were Dr. E. Wendy Saul, an Endowed Professor at University of Missouri in St. Louis, Dr. Alan Newman, research professor at the University of Missouri in St. Louis, and Dr. Joseph Polman. Other research team members who became involved with my practices included Laura Pearce, Dr. Cathy Farrar, Dr. Jenifer Hope, Dr. Angela Kohnen and Cynthia Granville. Each of these team members shared their expertise with me during the two week summer training session, the in-services held quarterly during the school years, and during observational visits to my classroom. Their help was invaluable to me as I found my way through the process of adopting the journalism process into my courses.

Dr. Granger, Curators Distinguished Teaching Professor at the University of Missouri in St. Louis, my doctoral advisor, has been a constant support to me as I navigated the requirements of the doctoral program. He has listened to me and given constructive advice at every turn. He has provided insights that have assisted me in the process of writing this dissertation as a record of my journey into science journalism. My committee members have also aided in the completion of this research project. Dr. Wendy Saul has been a source of ideas and facets to explore. Dr. Alan Newman has helped me to merge my budding classroom pedagogy with the practices carried out by scientists in the real world. Dr. Angela Kohnen has helped me to focus my research finding. I believe that the dissertation which I have crafted with their help accurately

represents the changes which occurred in my classroom during the three years of the study.

My husband and children have been patient and understanding of the additional work load created by undertaking a doctoral program. They have helped to keep our household functioning, allowing me the freedom to pursue the goal of completing this dissertation. Without their understanding and support, I could not have managed the task or sustained my efforts.

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# Chapter One

## Introduction

The instructional landscape in the science classroom has undergone dramatic changes in recent years. The Next Generation Science Standards (Achieve, Inc., 2013) and Common Core Standards (2013) require science teachers to creatively adapt to these changes. The focus in science education has shifted to the preparation of all students to be college ready or career ready. Innovation in the way that teachers teach and the way that student learning is approached is a must if we want our students to be able to meet the challenges of the future.

Science teachers are criticized for the apparent ineffectiveness of the current science pedagogy. According to the ACT (2011), the current science education system in the United States is not producing students who are prepared for college-level science. In 2011 less than 30% of students taking the ACT met its College Readiness Benchmark in Science. ACT defines this college readiness as having the skills and knowledge needed to be successful in a first-year college science course (p. 1). Using this indicator, it can be posited that less than one third of our students are being prepared effectively for science coursework in college by the methods currently being used in science classrooms. The current science education system in the United States is viewed as not producing students who are as academically prepared as those from other countries. The 2011 testing by TIMSS, the Trends in International Mathematics and Science Study placed United States' students as 11$^{th}$ in science performance when compared to students from other countries (National Center for Education Statistics, 2012). The 2009 testing by PISA, the Programme for International Student Assessment, placed students from the United States as 23rd in science performance when compared to students from other countries (Organisation for Economic Co-operation and Development, 2010). According to the 2012 Science and Engineering Indicators created through the National Science Foundation, the current science education system in the United States is not producing the number of students who are choosing science related career paths that are needed to replace the current STEM, (Science, Technology, Engineering and Math) workers when they retire (National Science Foundation, 2012). In addition, females are not equally represented among those students who are choosing STEM careers. Only one in four individuals in STEM careers is female (Economics and Statistics Administration, 2011).

For current high school science educators the problem is clear: there is a need to change what we are doing in our classrooms if we want to be effective. Students will need to be competitive with their international counterparts in tests of science reasoning if they are to be successful in future. Students must be encouraged to develop their interest and abilities to pursue STEM careers. While much can be debated as to whether the ACT science reasoning test actually measures science readiness for college or whether classroom pedagogy can effectively increase the percentage of students entering STEM careers, the fact remains that science classroom pedagogy is in a state of crises (President's Council of Advisors on Science and Technology (PCAST), 2012). Something else needs to be tried; a change needs to be made to move our students forward, towards success with science and interest in science and more specifically towards literacy in science.

**Science Literacy**

When I think in terms of preparing my science students to be scientifically literate and prepared for their future, I do not think in terms of a test score, such as the ACT. Instead I defer to experts in my field and the National Science Education standards which they have created. The 1996 National Science Education Standards, developed by members of the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine, were based on the understanding that science education should have as its main goal that all students develop literacy in science.

Scientific literacy as described by the National Science Education Standards is the ability to use scientific understanding to make informed decisions in areas such as local, national and global policies which have economic and environmental impacts. Scientifically literate individuals are able to use science information in the choices which they make in their everyday lives. They are able to be informed citizens who understand the environmental and health issues that confront them. An understanding of the concepts of science, along with the processes which scientists go through, is seen as key to the development of this literacy (National Research Council, 1996).

Since the Standards were published in 1996, our world, our schools, students and teachers have changed. The need for science literacy has increased along with the enhanced skills required by the 21$^{st}$ century, in terms of technology and adaptability. A new Framework for K-12 Science Education (National Research Council, 2012) was released which outlines the Practices, Crosscutting Concepts and Core Ideas which will enable our students to understand and participate as informed citizens in the world as it exist today. The Framework has as its goal the development of scientifically literate citizens who are lifelong learners.

**Science Literacy through Science Journalism**

The Science Literacy as Science Journalism project, SciJourn (2011), uses science journalism as a means of helping students become more engaged in science learning and communicating what they have learned. The SciJourn project has as its goal the development of students who understand the importance of science in everyday life and have the ability to read and write about science in a knowledgeable and skillful manner.

The SciJourn Project began in 2009 with a pilot group, received funding from the National Science Foundation and has developed two Cadres of participating teachers. I am a member of Cadre I, receiving my training in science journalism and literacy during the summer of 2010. I have implemented the methods with 305 students in 16 courses during the three years that I was a member of the SciJourn program, 2010-2013. The SciJourn activities which I lead my students through centered on their reading and discussing science news articles related to the content topics being covered during coursework, their acquisition of the methods of investigation and writing techniques used by journalists and finally their creation of a science news article of their own which incorporated these skills and understandings. One particular aspect of science journalism which I developed in depth with my students was the use of science journalism as a method of supplementing student research projects, usually carried out to be entered into the Greater St. Louis Science Fair and similar competitions.

As an active teacher-researcher for the past three years, I have developed my own practices for integrating science journalism activities into my classroom. This implementation focuses on authentic research practices as the vehicle for developing the scientific practices of my students. They carry out laboratory investigations which connect science content to their everyday and future lives. The students utilize interviewing of stake holders and experts as a companion piece to laboratory work. As they carry out investigative techniques, they identify the relevance to their own experiences. Students have entered their projects into venues such as our regional science fair and the national Ecybermission competition where their deeper insights into and personal connections with their topics have served them well. This combination of the science journalism with the science fair and other such projects was unique to my classrooms and are the focus of this study.

**Problem Statement**

Schools in the United States are striving to improve the science literacy and practices of their students. In my classroom, it is becoming increasingly difficult to interest students in carrying out long term science research projects such as the science fair. Science journalism has been used successfully in area classrooms to increase student interest in science and its connections to their lives (Farrar C. , 2012). What is not known is the impact of integrating science journalism with student research projects.

**Purpose of the Study**

The purpose of this study was to examine the changes in teacher practices and student behaviors when science journalism was used to supplement and replace existing traditional activities typically carried out during the student research projects such as the science fair.

## Research Questions

The following research questions were explored:

1. What happens when students are trained in the research practices used by science journalists, and then use them in their own research projects, representing the findings of their research with science news articles and news releases?
    a. What happens to the teaching practices in the classroom?
    b. What happens to the learning behaviors of the students?
2. What benefits are provided by the integration of science journalism activities into the student research practices in high school chemistry classes?
3. What teacher scaffolding and classroom activities characteristic of an implementation of journalistic practices are most effective in the knowledge construction process?
4. To what degree does the use of journalistic activities with the student research project coincide with and enhance the development of the scientific practices outlined by the Framework for Science Education?

## Significance

The Science Journalism Standards used within the SciJourn project, when combined with the National Science Education Standards for Inquiry (National Research Council, 2000) and the recently developed Framework for K-12 Science Education (National Research Council, 2012), provide a powerful impetus for the use of journalism activities to foster science literacy.

Assessing and evaluating information is one of the important skills developed by the students participating in SciJourn activities. A natural extension of the work being carried out in the SciJourn project was to see if these abilities can be applied to student research such as science fair projects. Classroom practices and student behaviors were examined to determine if the use of science journalism enhances the student use of the essential practices described by the Framework for K-12 Science Education. This was accomplished through student activities during which they collected, interpreted and represented data, as well as created and critiqued explanations that answered their questions.  Student research projects such as the science fair can enhance the following student's practices of science as defined within The Framework especially when a science journalism perspective is used:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information (National Research Council, 2012, pp. 3.5-3.6).

This research study adds to the existing body of knowledge of science pedagogy by providing insights into classroom practices that successfully enhance the development of the essential science practices outlined in the Framework for k-12 Science Education. The goals for this study were to determine to what degree students develop the abilities needed to carry out scientific inquiry, to clearly and logically communicate their results using science journalism approaches and to show that the student use of science journalism skills to supplement their research processes will enhance the development of their science practices. This amalgamation of SciJourn practices with the student research process is unique to my classroom. Close examination of this approach can perhaps inform other science education practitioners who carry out science research projects with their students.

Expected outcomes of this study:

- Classroom activities and teacher scaffolds which enhance the integration of science journalism activities into the science fair research process will be identified.
- Classroom activities and teacher scaffolds which enhance the interest of the students in current issues as the focus of their science fair projects will be examined.
- Insight into the student knowledge construction practices which occur during information gathering, interpretation and creation of a science news article, press release and science fair report will be sought.
- The understanding of the benefits provided by scientific journalism activities to the development of science literacy by the students involved in these activities will be enhanced.

**Delimitations**

1. Only one teacher’s students were observed within one school.
2. The classroom observed was limited to the discipline of chemistry, grade level 11.

3. The science journalism activities are developed, improved and used in an ongoing cyclical, emergent process over the course of three subsequent years.
4. The students are in a private, religious-based school is located in the suburbs of the St. Louis Metropolitan area.
5. The school is a 1:1 laptop school and students were trained in the use of laptops.
6. The students are all female and predominantly of European descent.
7. The teacher as the researcher-participant design of this study includes inherent bias.

**Assumptions**

1. Science Literacy can be defined and measured.
2. The SciJourn sequence of learning activities enhances the acquisition of science literacy.
3. The benefits or constraints of a particular pedagogy on student knowledge construction can be observed and assessed within a classroom setting.
4. The benefits or limitations of a particular pedagogy on student interest in current issues can be observed and assessed within a classroom setting.
5. Science news articles and news releases can be created by students as representations of their understandings.
6. Student artifacts, observations and interviews can reveal information about their science interest level and knowledge construction processes.
7. The 2011 Framework for Science Education is a valid guide for effective science education pedagogy.

**Definitions of Terms**

The following represent my understanding and context of the terminology which I used in this study.

Framework: The Framework for K-12 Science Education which provides a description of the content and sequence for optimal for science pedagogy as determined by the National Research Council (2012).

Knowledge construction: The generation of understanding and meaning by and within the brain of the learner created from interactions with others and the environment.

Practice: The dimension within the Framework for K-12 Science Education which outlines the skills and the knowledge to implement them employed by practicing scientists and engineers and which should be experienced and practiced by students during their science coursework.

Scaffold: The supports provided within the learning environment which aid in the knowledge construction process (Wood, Bruner, & Ross, 1976).

Science Fair Project: A standard practice used in many elementary and secondary science education programs to develop the scientific practices of the students. The student typically carries out an independent research project using materials available in the normal household or school. The project is presented to the science fair community to be judged by a set of criteria usually including the problem, background research, hypothesis, description of the procedure and variables, data and its analysis and the conclusions drawn.

Science Literacy: There are many definitions used for science literacy which will be explored in chapter two of this study. The working definition used within this study is the understanding of science practices and concepts needed to function as an informed citizen in the world environment.

## Summary

Much has been written on science literacy and the different pedagogies that have been proposed to enhance its attainment by learners in the science classroom. This study investigates a unique pedagogy, the use of science journalism combined with the student research process, as one means to enhance student learning. Investigating the possible usefulness of such pedagogy to provide insight for science practitioners was the aim of this project. The instructional strategies designed and the student behaviors observed as science journalism activities were integrated into the student research practices were examined during this three year study in order to provide these insights. Reflective journaling by the teacher-researcher on successes and challenges during the process along with observations of classroom activities and student artifacts were examined to provide understanding of the impact which this integration has had on the teaching and learning processes.

## Organization of the Study

In the following chapters the background, methods, outcomes and findings of this study will be presented. Chapter Two will discuss more fully the conceptual framework for this study based on a review of the literature which is currently available on science literacy, the Framework for Science Education, knowledge construction, student research projects and the use of science journalism in the classroom. It will also demonstrate the need for a study which combines these facets. Chapter Three will outline the methodology used in this study along with describing the setting and participants. The subsequent chapters will present the results of the reflective journaling, observations, interviews and artifact examination and what they reveal about changes in teacher practices and student behaviors brought about by integrating science journalism with the student research process. The implications of the changes brought about by the pedagogy used will also be discussed. As with all action-research studies, the results will be shared with the community, in this case the community of science practitioners, in order to inform their practices and to receive their feedback on the strategies used.

# Chapter Two

## Conceptual Framework

The purpose of this study was to examine the changes in teacher practices and student behaviors which occurred when science journalism was used to supplement and replace existing activities carried out during student research projects such as the science fair. The study's goal was to determine those features of science journalism which when introduced into student science research projects brought about positive changes in the teaching and learning practices in the classroom.

The conceptual framework for this study is comprised of the four concept areas of science literacy, science journalism, student research projects and the knowledge construction process and how they intersect within the secondary chemistry classroom. The Framework for Science Education, the Next Generation Standards, and the Common Core are all tangents which intersect with these concepts for the science practitioner, so their impact on the conceptual framework of this study are also examined. The work carried out in this study was viewed and reviewed through the lens of constructivism, which posits that learning is knowledge construction.

### Knowledge Construction

The active engagement of students in the process of learning is considered by constructivists to be the key to developing understanding. Students develop knowledge through the interaction of their experiences with the ideas which they possess prior to these experiences. The active engagement of students in the process of learning is seen as a key to their understanding (Dewey, 1916; Bruner, 1956). Bruner (1960) posited that learners construct cognitive structures in their brains from information which they gather through their senses and build onto prior knowledge that they posses. These cognitive structures, often called schema, organize the information and experiences and then form the prior knowledge for the next learning event. Learning then, involves information processing within the human brain (Ausubel, 1968 , Bruner, Goodnow, & Austin, A Study of Thinking, 1986).

Learning is traditionally carried out in the social setting of the classroom with the student's classmates and their teacher as mentor and co-conspirator to provide the social interaction that will mediate the learning. "Cognitive structures are first formed socially and then reconstructed internally" according to Scardamalia and Berieter (2006, p. 206). Vygotsky's work (1978) is often used by social constructivists to make the point that learners can accomplish with the help and cooperation of others such as teachers and classmates what they could not do as easily alone (Polman J. , 2000, p. 34). Learning then is best achieved within a social setting where students talk, carry out investigations together on problems which are meaningful to them (Bransford, 2000).

Often knowledge or information becomes compartmentalized by the students. It is seen as inert, unable to be perceived as useful in the future (O'Neill & Polman, 2004). Students may learn information to pass tests but will not understand or be able to use this new information (Bransford, 2000). Bransford sees the ability of students to transfer their learning to their everyday lives is "the ultimate purpose of school based learning" (2000, p. 78). Others also see the need for "A practice-based scientific literacy" (O'Neill & Polman, 2004, p. 262). Organizing learning around authentic problems from the student's lives will strengthening the knowledge construction processes of the students. Using the journalistic style of reporting, combined with laboratory research on topics of importance to the individual student will provide for these authentic problems for the classroom. It will also serve to assist students in taking control of their own learning, becoming active knowledge creators rather than passive knowledge consumers.

Constructivists posit that students can create objects such as reports, graphs, movies and infographics with the use of technology tools to represent their understandings of patterns that they find within data that they collect (Scardamalia & Berieter, 2006; Bransford, 2000). As I approached this inquiry on the changes which occur with the integration of science journalism with my students in their research projects, I did so through the lens of these constructivist beliefs.

**Science Literacy**

Science education practitioners, the teachers of science content, look to the professional community for guidance on the content to be covered and the skills to be acquired. In 1996 the National Science Education Standards were developed and published by the National Research Council with members from the National Academies of Sciences, the National Academy of Engineering and the Institute of Medicine with input from science education practitioners. They began their discussion of the standards for the science education community by defining what is meant by science literacy. Their focus in defining science literacy was on the individual's needs in order to become a functioning and contributing adult member of society. Specifically a scientific literate person would be able to:

- Ask, find or determine answers to questions derived from curiosity about everyday experiences;

- Describe, explain and predict natural phenomena;
- Read with understanding articles about science and engage in conversations about the validity of the conclusions;
- Identify the scientific issues underlying national and local decisions;
- Express positions that are scientifically and technologically informed;
- Evaluate the quality of scientific information based on its source and the methods used to generate it; and
- Pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (National Research Council, 1996, p. 22).

In addition to describing what the individual should be able to know, understand and do, the National Research Council targeted inquiry as a central component of the means to bring about this science literacy.

In 2012 a revision of the National Standards was developed by the National Research Council in the published Framework for K-12 Science Education. They include science literacy goals which focus on those necessary for all citizens:

> By the end of the 12th grade, students should have sufficient knowledge 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 be able to continue to learn about science throughout their lives (National Research Council, 2012, p. 1).

The Framework for K-12 Science Education moved the parameters of science literacy forward by describing science literacy in terms of what an individual should be able to show in their practices as well as what content areas and crosscutting skills they need to master the eight essential practices of science as:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information (National Research Council, 2012, p. 42).

All eight of these essential practices play a role in the research process of students. From asking questions that have meaning to the student, engaging in argumentation from evidence, to communicating information to others, each applies to this research study as the practices of science journalism were applied to the student research process. The use of these eight essential practices when combined with the journalism processes was expected to have an impact on the science literacy of the students involved.

**Science Journalism**

The concept of science literacy grew from the National Standards for Science Education and within the SciJourn program. The research team developed a set of literacy standards that align with the National standards as well as the recently developed Framework for K-12 Education.

According to the SciJourn team, the scientifically literate individual is able to:

1. Identify personal and civic concerns that benefit from scientific and technological understanding,
2. Effectively search for and recognize relevant, credible information,
3. Digest, present, and properly attribute information from multiple, credible sources,
4. Contextualize technologies and discoveries, differentiating between the widely accepted and the emergent; attending to the nature, limits, and risks of a discovery; and integrating information into broader policy and lifestyle choices, and
5. Fact-check both big ideas and scientific details. (Saul, Kohnen, Newman, & Pearce, 2012, pp. 42-47).

Farrar (2012) developed an instrument, the Scientific Literacy Assessment, to determine if the science journalism activities used in the SciJourn program increase the science literacy of the students. Her study determined that gains were shown in the scores on the Scientific Literacy Assessment when the students completed science journalism activities. Moreover she found that a positive correlation between the extent to which the activities were incorporated into the classroom activities by the teacher and the size of the gain in the students' assessment scores.

**Common Core**

The SciJourn view of science literacy also aligns with the Common Core Standards for Science and Technical Subjects which are being emphasized as a part of the science classroom landscape. There are ten English and Language Arts Standards which relate directly to the science classroom, the majority of which relate directly to the science research process and also align with science journalism as the method for addressing those standards. The Common Core Standards for Literacy in Science and Technical Subjects for grades 11 and 12 (Common Core State Standards Initiative, 2013), for example, call for students to be able to:

- Provide evidence in science and technical textual material to support positions and assertions.
- Summarize the main ideas, concepts and information found in scientific text.
- Follow experimental procedures or performing technical tasks and then interpreting the results.
- Interpret symbols and scientific lingo, terminology so that they have meaning in the context in which they are used.
- Categorize information and concepts to demonstrate understanding.
- Contextualize reports to the main body of science, probing areas which still need to be investigated.
- Put together multiple sources of information, from various formats in addressing a scientific dilemma and synthesize it into a representation of their understanding.
- Evaluate and verify scientific claims made with other information sources.
- Analyze conflicting viewpoints to make sense of them.

- Read and comprehend science and technical texts of the level designated as appropriate to the grade level.

The common core standards are the same skills that are needed to carry out and report on the types of scientific research that commonly take place during laboratory experiences and science fairs, which are the focus of this study. The addition of argumentation and using evidence to support a position adds another dimension, one that is aligned with the practices of investigative reporting.

**Laboratory Work**

The laboratory practices taking place in high schools across the United States were researched by the National Research Council's Board on Science Education at the request of the National Science Foundation and the findings were published in *America's Lab Report* (National Research Council, 2005). They found that for the most part the laboratory experiences available to most students in the United States were poor. Laboratory experiences were usually carried out isolated from the content being studied. In addition, they were often not so much experiments as procedural studies similar to completing a recipe in a cook book.

> Instead of focusing on clear learning goals, teachers and laboratory manuals often emphasize the procedures to be followed, leaving students uncertain about what they are supposed to learn. Lacking a focus on learning goals related to the subject matter being addressed in the science class, these typical laboratory experiences often fail to integrate student learning about the processes of science with learning about science content. Typical laboratory experiences rarely incorporate ongoing

> reflection and discussion among the students, although there is evidence that reflecting on one's own thinking is essential for students to make meaning out of their laboratory activities (National Research Council, 2005, p. 6).

The goals for laboratory experiences to improve the situation were developed by this council to include the following:

- Enhancing mastery of subject matter.
- Developing scientific reasoning.
- Understanding the complexity and ambiguity of empirical work.
- Developing practical skills.
- Understanding the nature of science.
- Cultivating interest in science and interest in learning science.
- Developing teamwork abilities (National Research Council, 2005, p. 195).

Achievement of these goals can be facilitated when science journalism activities are integrated with the laboratory experiences.

**Integrating Science Journalism**

Science journalism skills when used with course laboratory experiments or during independent research projects can deepen the experience. They address all of the main features of a formal laboratory or science fair report and then layer the addition of contextualization to life outside of the classroom and connection to the life and future role of the student as a citizen and consumer. These objectives provide for a deeper student engagement.

A typical laboratory or science fair report usually begins with identifying a problem or question upon which the experiment will be designed. It then moves into a background search into what that problem entails and what is known about the topic. In science journalism approach the problem is more student focused. Narrow, localized, and relevant topics catch and hold the interest of students as well as science news readers. In order to carry out background research a student must be able to read, often complex and technical science text. They must be able to locate credible sources for the material and then sift through the text to make sense of it.  Background research activities can be streamlined and enhanced by the journalistic approach. Adding first hand interviews of stakeholders and experts in the field brings a facet to the normally staid process and allows students to grow in their self-efficacy.

Once background research has been carried out the next step in student research projects typically is to develop and state a hypothesis that points to an appropriate controlled experiment. It is a means of stating a claim about the nature of a particular phenomenon that will be studied. In science journalism this stating of a claim or taking a position is then followed by supporting evidence. In an appropriate scientific experiment the data provides that evidence. A detailed set of procedures is developed listing what will be controlled in the experiment, what will be manipulated and the consequences observed. In the world of the science reporting, the world experience is the experiment and the reporter makes the observations. Life is rarely controlled.

Collecting data, organizing it into tables and graphs and then drawing conclusions about what the data shows are next in the normal flow of a school science report. In this stage the student justifies their position, relates their findings to what they predicted based on their research and then discuss the flaws that may have contributed to their findings being less than definitive. Often the process of contextualizing the findings is completely bypassed. “So what?” is the refrain of a good science editor. Why should anyone care how your experiment turned out? Why should you care? In the big picture, what does it tell us? When students are carrying out investigations that they have designed around a problem that impacts their own lives, they care and they are able to provide answers to these questions. When students are doing cookbook laboratory exercises which hold little or no interest to them, they have difficulty answering the basic question of “So what?”

When science journalism is integrated into the student research process, changes occur. The journey begins with a discussion of finding ways to connect or hook the teenaged student into the overall research project itself. To be successful at developing true student understanding the topic to be researched should connect with the student on several different levels. Projects undertaken successfully include those to which a student can relate as an individual, as a teen in society today, as a citizen of the world of tomorrow and as a student of science. Bridges need to be formed, practical methods that move the students beyond immediate, day to day survival to a broader understanding of their own place in the world.

These bridges to connect the teen often arise from empowering the student to choose a topic which can catch and hold interest through the difficult research stages. The aim here is to foster student connections to the world at large and narrow and focus the problem into one which they can and would like to solve. Deciding on a topic to research is one of the most defining aspects of the research process.

Methods and modeling strategies to use within the science classroom to aid student understanding of the complex text which is ubiquitous to the genre are vital to the success of the student research process. Many of these strategies address the Common Core Standards for science and technical subjects. Use of visual imagery in the creation and interpretation of graphics are key components when journalism is used in the process and is critical in developing an accurate understanding of data mining of numerical data. The use of student interviews of stakeholders and experts on research topics are often vital sources of information. Face to face, telephone and email interviews along with methods of finding experts in the local community who are open to being interviewed by students are integral parts of the process. The students' research process also includes carrying out an investigation of their own creation, where they collect or generate the data themselves. They still carry out actual experiments to test hypotheses which they have generated on their topic or they collect data by surveying the school community.

Science journalism activities involve classroom discourse as a key component from the brainstorming of topics at the onset to the final editing and communication of the research findings. By interactions and conversations about their developing understandings, the students are able to form connections between ideas and construct new understandings with the help of the social setting. Peer editing and feedback comprise one of the pillars for the journalistic research process. In this study, grade 11 students will be selecting a topic to research which connects with their life and interests, keeping them actively engaged in the process. Much of the topic selection process and the development of their project ideas will be carried out in the social setting of the classroom to provide the social interactions that mediate their development of the science practices.

Gordon Wells in *Dialogic Inquiry as Collaborative Action Research,* observes, "...as a teacher and a class of students spend time together, they construct shared knowledge, not only about the content of the curriculum but also about how they interpreted and acted upon that content." During the science journalism experience, the boundaries often blur between the student and the teacher. Often the roles are reversed in my classroom, especially when it comes to using a new technology tool. I have found that embracing this role reversal and actively engaging the students as co-researchers leads to a more engaged group of learners. I have learned for example to work with my students on the Specification Sheets, rubrics, for their projects, allowing them a voice in the development of the project. They can help with monitoring their progress towards the goal upon which they collaborated, increasing their own meta-cognition. As journalism strategies are discussed and students learn to use them, this self reflection aid in their knowledge construction process as well as their feelings of self-efficacy (Bransford, 2000).

Students are able to use several methods common to journalists to represent their research findings. These include: science news articles, digital laboratory reports, infographics, movies and news releases of their findings. Communicating their findings to the school community and the greater community at large is vital to student empowerment as well as being an essential science practice. Once students become associated with a success in the science area, they see themselves from a different perspective and their learning trajectory is changed.

**Previous Research Studies**

Hope (2012) studied the level of engagement which students participating in science journalism activities expressed during interviews and on the Youth Engagement with Science and Technology (YEST) survey which she developed. She used her findings to create a model of engagement in science which centers on the interaction of student interest, teacher supported participation in science activities such as SciJourn and student self identification as scientists.

Kohnen (2012) studied through phenomenological interviews and surveys how teacher motivation and the teacher approach to science journalism activities affected their view of the genre of science journalism. "As students and teacher engaged with science news both as consumers and producers, they came to appreciate the importance of science and to see science as an interesting and relevant field" (Kohnen, 2012, p. ii).

The SciJourn approach is one that has been shown to increase student's literacy skills (Farrar C. , 2012) and has a proven track record with over 4,000 students since 2010. Farrar's Science Literacy Assessment has shown gains in the science literacy skills defined by the SciJourn team for students in a program of science journalism implementation.

Others have researched the integration of literacy into the discipline of science and more studies will be carried out with the implementation of the Common Core in the next several years. Alvermann *et al.* (2011) pointed out that the science education community needed to develop practices for this domain specific integration and then provide explicit instruction to the pre-service teachers. Creech and Hale (Creech & Hale, 2006) carried out an inquiry into integrating reading into science coursework through the use of quarterly reading projects based on a reading apprenticeship model. They modeled their classroom inquiry on the Strategic Literacy Initiative (Schoenback, Braunger, Greenleaf, & Litman, 2003) which uses this apprenticeship model to integrate literacy into specific content areas.

Research has also been carried out by practitioners on methods to improve the science research projects of students. Porter *et al.* (2010) carried out an action research project to determine the level of instructional support and teacher practices which improved the writing of conclusions by their students. Bernard (2011) observed a class of students as they moved through the science fair research project stages to develop an understanding of how the students themselves felt about carrying out such a project. He found that the students started out being reluctant to participate and daunted by the task of selecting an appropriate topic. As the students persisted through the project stages their ownership and interest increased as they began to experience success in their endeavors. He pointed out that many pre-service science teachers are not taught how to manage or carry out research projects with their students, that this is an area that needs to be improved. Harland (2013) discusses methods for managing the student research projects, targeted at the classroom teacher. She describes the methods which have worked in her classroom to develop the time management skills of both the teacher and the students.

**Summary**

While research exits on science literacy and its impact in the classroom and student research projects in the classroom there is a need for research into how literacy activities can be successfully integrated with the student research projects such as the science fair. I was unique among the 40 SciJourn trained teachers in my integration of the SciJourn processes with my student science fair projects. The activities that I developed were unique in their approach to both journalism and student inquiry projects. My strategies and their development over time as well as their impact upon my students warranted an in depth examination. As I carried out this study I took the stance of a teacher-researcher. My action research approach to integrating science journalism activities into my classroom was explored during this study to identify retrospectively what changes in my practices and the behavior of my students occurred. My action research methodology is outlined in the following chapter.

# Chapter Three

# Methodology

## Introduction

The action research model was the approach used in this study and applied to the use of science journalism during student research carried out as a part of their high school chemistry coursework. The purpose of this study is to examine the changes in teacher practices and student behaviors which occurred when science journalism was used to supplement and replace existing traditional activities typically carried out during the student research projects such as the science fair.

The research questions for this study evolved throughout the study to include:

1. What happens when students are trained in the research practices used by science journalists, and then use them in their own research projects and represent the findings of their investigative research with science news articles and news releases?
    a. What happens to the teaching practices in the classroom?
    b. What happens to the learning behaviors of the students?
2. What benefits are provided by the integration of science journalism activities into the student research practices in high school chemistry classes?
3. What teacher scaffolding and classroom activities characteristic of an implementation of journalistic practices are most effective in the knowledge construction process?

4. To what degree does the use of journalistic activities with the student research project coincide with and enhance the development of the scientific practices outlined by the Framework for Science Education?

**Action Research**

This is an action research descriptive qualitative study of one teacher's classroom over a three year period. In order to adequately evaluate the effectiveness of a particular teaching method, carrying out the study within the classroom environment itself is fundamental. An action research project provides the opportunity to view first hand the interface of the instruction by the teacher and interactions within the classroom community with the knowledge construction by its members.

Action research begins with the interest of the teacher researcher to improve her practice, which in this case is the teaching of science in secondary school. According to Merriam (2009) action research is a type of applied research, meaning that it is carried out in order to bring about an improvement in the area being researched. Participants are involved intimately in this process which typically takes place in a specific, designated setting (p. 4). All of these criteria for action research apply to this study. It took place within a specific classroom setting. It intimately involved my students and me as the participants. It had at its core the improvement of my practice as a science teacher with a specific goal of improving the learning process through the integration of science journalism into student research practices. The key characteristics by which Creswell (2008) categorizes action research also align with my study design. These include: a) a practical focus, b) the participatory and reflective practices of the teacher as researcher, c) collaborative in nature, d) dynamic and iterative, e) having the development of a plan of action as the goal, and f) having the intent to share this plan with others in order to bring about positive change (p. 607).

I am both the researcher and the participant teacher in this study. I have observed my students as they moved through a series of activities which I designed that to develop their ability to carry out authentic research and communicate their findings based on that research. I determined through this study the extent to which this is able to be accomplished and which scaffolds that were developed proved most helpful to the process. My students and I were collaborators in this study. They were aware that they were participants in a research study and were asked to provide feedback throughout the project. The knowledge construction activities which were carried out by the students were examined through the use of direct observations, and artifact examination including student created science news articles and press releases, student process work, and responses on surveys about the course practices. Students provided feedback during class discussions used to unpack each activity which was carried out. This feedback was used to improve the process from within, as it was carried out in an iterative fashion. Audio taping of classroom sessions provided a record for later review. I reflected in a journal each day throughout the study on the events that unfolded during the class periods and what I anticipated for the next. The goal of the process was to improve my practices in the teaching of chemistry and to be able to share how and why my practices have changed with other chemistry teachers through a published book or articles and sessions at professional meetings.

This action research study will focus on the changes which occurred during the implementation of a series of classroom activities based on the use of a science journalism format as part of the student research processes. The focus was on the interaction between the activities, the students and the participant-teacher-researcher. This chapter will discuss the design specifics, classroom activities and participants along with the data collection and analysis techniques that were used in this study. It will also discuss trustworthiness, biases and confidentiality issues that arise from an action research study by a classroom teacher.

**Participants**

The participants in the study were students in the teacher-researcher's chemistry classes during the three school years of 2010-2011, 2011-2012 and 2012-2013. The 305 students in total were students of grade 11 sections of Environmental or Honors Chemistry and students of grade 9 Introduction to Chemistry. From this total, the 116 Honors Chemistry students will be the focus of this study. The Honors Chemistry course is offered to students who have excelled in their prior mathematics and science courses and want to challenge themselves. These students were enrolled in a full year course of chemistry for grade 11 during this study. They had successfully completed the two required freshman semester courses of Introduction to Chemistry and Introduction to Physics as well as a year of required General Biology. Many of the students were enrolled in the honors sections of the freshman and sophomore science courses. They had successfully completed Algebra and Geometry coursework. They were enrolled in a third year of math during the course of the study. Many of the students were also enrolled in the honors sections of their math courses. Often these are students who plan on majoring in a science field during college. An independent research project is carried out by each student as a requirement of the course.

The school where this study took place is a religion-based all female, college preparatory, high school located in the western suburbs of the St. Louis metropolitan area. The students who attend the school come from all areas of the metropolitan areas ranging from Granite City, Illinois, the northern and southern suburbs as well as from the metropolitan center itself. In terms of ethnicity, the majority (typically over 90%) of the students are of European descent. The students who attend the school are typically of middle to upper socioeconomic status as it is a tuition based program. My own personal demographics as the teacher researcher may also have had an impact on the results of this study. I live in a western suburb of the St. Louis metropolitan area. I am a female of European descent and consider myself to be of moderate socioeconomic status.

One aspect of this school community which made this project viable is its usage of technology. This is a 1:1 laptop school where each student leases a computer from the school and then is expected to bring it for use in each class during the school day. Wireless internet access at top speeds is available throughout the building. Server space, internal drop boxes, along with school wide email and discussion boards for communication aid in the integration of technology within the classroom. Three technology support staff members are available to trouble shoot throughout the school day with malfunctioning software and broken hardware. These technology devices and services made the implementation of a computer based series of activities possible for use in the classroom. In addition to the hardware, each student had been trained in the basic usage of technology throughout their previous two years of study. They were capable of creating PowerPoints, documents, importing pictures and communicating through email and Blackboard. Their technologic abilities were verified through introductory lessons during the beginning activities in this course.

The participants were students who had registered for the course sections which were being taught by the teacher-researcher. I explained the process that I was using to the students and asked them to be collaborators in the process with me, helping to find the best way to create a record of what we were learning about science journalism and science practices and what I was learning about scaffolding their knowledge construction. The 165 student participants over the three years of this study were asked for and gave their assent to participate. Their parents were asked and gave informed consent to allow their under 18 years of age children to be the participants in the study. These assent and consent forms were sent as letters to the parents and explained to the students during class time and to the parents during open house. Students agreed to have their classroom interactions observed and recorded. They were agreed to give feedback to the teacher-researcher. Permission was given for their projects and process work to be examined by the teacher-researcher. One aspect of this informed consent and assent is that regardless of participation in the study the student was expected to participate in all classroom activities. In most studies students for whom parental consent and student assent is not given would not be taped but their work would have been evaluated by the teacher in the normal methods used in the course. For this study all 116 students in my courses provided student assent and parental consent.

**Instrumentation and Positionality**

In this study, I, the teacher-researcher was the instrument for the collection of the data. I was immersed in the situation, an insider in the processes which took place within my classroom setting and, hopefully, an accepted collaborator with my students. A level of trust develops as students and their teacher work together over the period of the school year. This level of trust enables the members of the classroom community to be open in their responses and to participate fully in an action research process. I have been a teacher at this school for over 30 years and am well liked and trusted by students in my role as teacher and provider of learning support. My student's evaluation of me at the end of each semester attest to this as well as interviews of my previous students conducted by the SciJourn, research team during the 2010-2012 school years.

My classroom has been the subject of two full years of research by the SciJourn team. That research involved outside researchers observing, videotaping and interviewing my students which gradually faded as I took over the task of videotaping the classroom during SciJourn activities. This was intentional on my part as I felt that the presence of the outside researchers changed the classroom dynamic. Once the outside researchers moved into their data analysis process and faded from prominence in our classroom, my students and I were able to recapture the collaborative nature of classroom instruction. My students were at ease with me as the researcher even though a video camera was in use during the much of the process. They came to view it as just another classroom fixture. During the third year of this study then, I became the primary teacher-researcher in the classroom, sharing my student's work with the SciJourn research team.

I was an insider then in terms of being a part of the classroom processes. I was trusted by my students and viewed as a part of the normal classroom processes. The research activities of audio taping and videotaping classroom events were eventually viewed as part of the normal classroom processes. Discussions with me and with the entire class were part of the normal classroom activities of which I was an insider. I was also an insider in that I myself have gone through learning the SciJourn process in order to prepare these activities for the students. I have researched and located credible sources of article to use with my students during Read Aloud-Think Alouds. I have learned how to collect data in a science journalistic manner. I have learned how to correctly analyze data and create graphs showing the trends. I have struggled with the same technology issues with which my students grapple as they create their science news articles and news releases.

In other respects I must view myself as an outsider. I do not think it is possible for someone other than the learners themselves to fully view the knowledge construction process which they undergo. The learner can provide clues as to what is going on but might not even realize the steps which she goes through. So in that respect I will always be an outsider in terms of the knowledge construction of my students. I also will be an outsider in terms of my age in comparison to that of my students and my power status as their evaluator, the person assigning their grade. I am perceived as more of a mother figure by my students, quickly transitioning to that of a grandmother. I am not privy to the private conversations of my teenage students nor do I want to be. I am an outsider in terms of the social worlds in which the teens travel. This outsider status was mitigated by the trust which I built with my students and the sense of collaboration which I endeavored to instill during the learning processes in my classroom.

## Data Sources

### Reflective Journaling

My reflective journaling is a key part of the data that I collected and analyzed in my study. As I carried out classroom activities related to the science journalism and student research I recorded my daily reflections in my journal.  I examined these reflections on the process as a whole in order to gain insight into the knowledge construction processes taking place during these activities. Much of my reflective journaling took place as I planned out the day's teaching and learning activities, expressing what I was trying to achieve. Other reflections took the form of jottings, notes written as I moved through the classroom and interacted with the students. Others took place after the class, during my preparation time, when I thought back on the activities, focusing on what was achieved, what worked and what did not, what I saw in terms of new understandings and engagement.  I added notes to my journal during SciJourn meetings, which occurred four times per year and when I attended a SciJourn centered event such as the student presentations at the annual board meeting.

In addition to the journals, the lived experiences in my classroom over the three year period covered within this study contributed to my body of knowledge about classroom strategies and student reactions to them. Recollections based on this lived experience also became a part of the data which was used to garner insights into the process.

My daily lesson plans were created on my laptop and copied to Blackboard for the students. A copy of these was transferred to the external hard drive which contains the research data. Each lesson plan was dated and described in the file name in order to keep them organized. In a similar manner my daily reflections were recorded either via audio tape or transcriptions of jottings and then dated and described in the file name which will be transferred to the external hard drive. The external hard drive was backed up at regular intervals with a second hard drive which is also to be kept in a secure location.

### Collecting the Student Data

The data for this project was collected during the 2010-2011, 2011-2012 and 2012-2013 school years as I worked with integrating SciJourn into my Environmental Chemistry and Honors Chemistry courses. I obtained informed consent from parents and informed consent from the students themselves for them to participate in my research study under the SciJourn IRB. My students took pre and post tests on their science literacy and interests in science developed by other researchers on the SciJourn project (Farrar, 2012, Hope, 2012). My students' process work and final products of their activities were archived for reference by the SciJourn research team and were reexamined during this study. My classroom lesson plans were archived and reexamined for this study. Classroom activities and discussions which were either video or audio taped by me for use by the SciJourn research team were reexamined based on the objectives of this study.

The methods that I employed in order to carry out my observations and to collect data during the classroom activities included:

- Audio taping or videotaping classroom activities to capture teacher and student behaviors;

- Collecting for review any student work pertaining to the student research process to capture the extent to which they are able to demonstrate their understanding of concepts and the extent to which they express ownership of their research;
- Examining the communications between the SciJourn editor, Alan Newman, and those students whose science news articles or science press releases were submitted for publication in The SciJourner;
- Reviewing student email communications with me about their research project;
- Reviewing the student responses on the end of the project surveys;
- Collecting my daily lesson plans that involved in the student research projects to examine their emergent design;
- Examining and assessing the final science fair projects of the students and their performance at the Greater St. Louis Science Fair for evidence of their use of the practices of scientists as defined by the Framework (National Research Council, 2012); and
- Examining and assessing the final science news article and press releases crafted by the students for evidence of science literacy.

The software program Audacity was used to audiotape overall classroom activities as well as class discussions during the student research process. An external microphone was attached to my laptop before class began to enable the recording of entire class sessions. A video, flip camera, with an external microphone and tripod was used to videotape teacher presented activities and classroom discussions during science journalism and student research activities. The video camera was in place, recording before the class began. It was angled in such a way as to catch as much of the classroom as possible. My students, as collaborators in the process assisted in determining our best method for this recording of the process. When possible, I asked student participants to do member checks on my interpretations of these tapes of our sessions. These member checks involved conversations with the student participants, recalling the conversation from my reflective journaling and then asking them if I had caught the main idea and experiences adequately.  According to MacLean and Mohr (MacLean & Mohr, 1999), this is another important part of the action research process.

Assignments related to the student research process and science journalism activities were copied before they were returned to the students and then coded with the student's IRB code number which was created for each student participant in the SciJourn study. Most of the process work completed by my students was given to me in electronic format through the use of the drop box portion of our teacher share folders or through the use of Blackboard. Each teacher in our school has a location on Blackboard where students can go to access course information and documents and to turn in assignments to a specific teacher. Once a student had uploaded their process work, I created a copy of the document with that student's IRB code to be saved on an external hard drive. The original document is usually evaluated using track changes and returned to the student electronically. A copy of this evaluation/response was also copied to the external hard drive with the student coded number.  This external hard drive was kept in a secure location where it was not accessible by anyone other than me.  My laptop was locked at all times when not in use to provide a secure location for my reflections, grades and tests as well as the data for this research project which was awaiting transfer to the external hard drive. The hard drive was kept locked in a secure location in my home.

These steps were taken to not only insure that data is not lost but also to maintain confidentiality.

A comparison of the work of my students over the three years during this study provided insights into how the integration of science journalism practices into the student research process affects student knowledge construction. Comparing the classroom practices that are evidenced on the videotapes and audiotapes as they evolved during this study also provided an added dimension to the study.

**Other Data Sources**

In addition to the other data sources, the data collected by the other SciJourn researchers on my students and my classroom activities was available for me to review. Jenifer Hope, Cathy Farrar and Angela Kohnen were the three SciJourn researchers who studied events in my classroom. Jenifer Hope collected audiotapes of my classroom activities which are available in the SciJourn archives. She also interviewed three of my students. Transcripts of these interviews were available for my use in the analysis of the impact of journalism on the science research process of my students. Angela Kohnen carried out detailed interviews with me on my emerging practices as I developed my classroom pedagogy during the course of this study. I reviewed transcripts of these interviews during the data analysis of this study. Angela Kohnen also interviewed three of my students about the impact of the science journalism on their learning processes. I viewed transcripts of these interviews to glean insights into changes in my student’s learning behaviors. Cathy Farrar developed the Student Literacy Assessment which was taken by my students at the beginning and end of their SciJourn experiences in my classroom. The tests have been archived in the SciJourn files and my student's results are represented in the findings presented in her dissertation (Farrar C. , 2012).

These three SciJourn researchers each had a different focus for their projects and these differed from mine. Hope's research focus was on changes in student in engagement in science, Kohnen's was on how teachers made sense of the genre of science news and Farrar's focus was on testing gains in science literacy which occurred during the implementation of science journalism activities. While their projects informed my perspective, my focus was very different from theirs. My focus was the improvement of my classroom practices and the improvement of the understanding of chemistry content and science practices by my students.

**Students as Collaborators**

In the article, *Dialogic Inquiry as Collaborative Action Research*, Gordon Wells describes the importance of being a "participating member of a classroom community" in order to develop true understandings. He observes, "...as a teacher and a class of students spend time together, they construct shared knowledge, not only about the content of the curriculum but also about how they interpreted and acted upon that content." He goes on to say that "In order to win the trust and active collaboration of teacher and students, it is necessary to be an active participant oneself, joining in activities and treating students and teachers as experts about their own learning and teaching" (Wells, 2009, p. 52). This study was in collaboration with my students, which allowed for them to be the experts about their own learning.

My students were invited to become collaborators with me when I first introduced the SciJourn process to them and had them sign informed assent and take home the informed consent for their parents to sign. When they had read over the previously published student articles in copies of The SciJourner, especially those of their classmates, they had become very dedicated to the prospect of creating a SciJourn article worthy of being published. This motivated them to do all that they could to help the process develop and progress. My students during the past three years have willingly shared their insights into what works for them in the process and what does not. They have critiqued my lessons and made suggestions to improve them. They have critiqued my classroom presentations and I have been able to use much of this feedback to develop the pedagogy that I use in my classroom overall but with the SciJourn activities in particular. At the end of each project stage we held class discussions about what changes are needed in our process for it to work better for all.

The collaboration of my students was vital part of this study. I depended upon their openness to new ideas and their wonderful ability to critique what was happening in our classroom. Perceptions of the instruction process by my students informed my practice. At times it seemed as though my students were developing the process and I was the observer. One incident stands out in my mind from one of the first times that I implemented a SciJourn lesson in my coursework in fall of 2010. I was working with my students on topic choice and we were looking over some of the possible topics listed on a SciJourn handout, *Science Topics* (Science Literacy through Science Journalism Project, 2011). There were a number of topics in most categories except for chemistry, which had very few. One of the students brought attention to this. They were a little upset by what they perceived as an oversight and decided that we should make a list of chemistry topics and they proceeded to do so on the chalkboard. The students then decided that this process was not working as there were too many ideas and coming too fast to record them so they asked if I had index cards that they could use instead which could be posted later.. We were able to create a collage of dozens of chemistry topics which has now been incorporated into the master list on the SciJourn *Science Topics* document. I was further astonished later that day when the second section of my students upon entering the room said that they were excited to make their list of science topics and then compare them with the other class' list. I had not even mentioned the activity at that point. The students from the first section had been agents for developing interest without my asking them and perhaps without their conscious notice.

Another area where student collaboration was vital was during the discussions that I carried out with them. I discussed their research projects with each of them as their project unfolded and they trusted me to be honest and forthright in my responses to their work. Besides having a set of questions that asked about their thought process such as, "What were you thinking when you wrote this", I also asked them if they had any thoughts about the process itself. I recorded my reflections about them and then shared these with the students to see if I have captured their thoughts accurately.

My students were collaborators in the research process as they carried out group discussions which will be audio taped or videotaped. The SciJourn activities are centered on group activities and discussions. During these discussions the students had to trust each other as well as their teacher in order for the activity to have value in terms of learning or knowledge construction. If students are not being open and authentic in their responses, then the activity can devolve into a farce and nothing will have been gained as a result. This level of trust and openness does not appear automatically in the classroom;

it develops over time and involves all members of the classroom community in its growth. My students and I were continually progressing together toward this common goal of mutual trust.

During the peer editing process my students were collaborators with each other as they tried to assist one another toward the goal of crafting the best article to represent their understandings of a particular issue. They needed to trust each other and be open to constructive criticism. They also needed to be capable of authentically critiquing the creation of another student. I have been working on methods of developing this critiquing ability in my students during the course of this study. Like many female teenagers, they generally did not want to hurt the feelings of others. They want to be liked and seen as good or nice. The culture of our school promotes this attitude among the students. Constructive criticism is able to be a positive activity, one that promotes growth for the receiver. I discussed this issue frankly with my participant students, to assuage their feelings of being overly critical towards their peers.

I asked my students to share their knowledge constructions openly with their classmates during their final presentations to the class of their research projects. This culminating activity took place by their display board during the science fair held at our school. The display of their work is viewed by the entire school community over the period of one week with parents and faculty explicitly invited to view the results of their work.

I shared the results of my research, my emerging themes and findings, with my students during class discussions as I worked through the data review and analysis phase of my study. They were able to verify the patterns which I saw and at times added to them. In the following chapters I will be using examples from student artifacts to support my findings and their content and context were verified with their creators.

The conversations with my students, with the other SciJourn teachers and researchers, and sharing my developing ideas with Dr. Saul, Newman and Kohnen who were deeply involved in the SciJourn program brought the facet of member checking to my research process. My findings and the resulting report are be richer because of the multiple perspectives that these member checks bring with them. According to Zeni, "Collaboration and communication are the best guides to preventing the ethical dilemmas of practitioner research" (2001, p. 164).

**Sorting through the Data**

According to MacLean and Mohr (1999) it is best to carry out data analysis in an ongoing manner so as to aid in the evolution or emergence of your process and findings. This ongoing analysis process provides much to the action researcher. It allows for clarification of the research question, allows the researcher to see if a shift is necessary. It can be used to determine subsequent steps needed in the research. The data analysis can confirm the thoughts or hunches of the researcher. They can help to validate the findings (MacLean & Mohr, 1999, pp. 57-58). I listened to audiotapes, viewed videotapes, looked over student process work, read over my reflections, and reviewed my lesson plans as often as feasible in order to determine what was working and what was not. As these features began to emerge I discussed them with my project advisors as well as the student participants, my collaborators. I then used their feedback to realign my lesson plans and classroom activities. Through this iterative process over a three year period, the types of changes taking place began to fall into distinct categories.

Once the categories or themes for the changes that were occurring in teaching practices and student activities were determined, the student artifacts, my journal and the classroom tapes were reexamined to locate the cases or instances that best illustrated these changes. The findings are presented as a discussion of the themes found through the analysis of the data along with descriptive narratives with examples that illustrate how each theme reoccurred in the document analysis, classroom dialogue and my reflections. The themes chosen to illustrate the changes which occurred during the classroom practices changed as the study developed and took me in directions that I could not have predicted at the onset. The themes were emergent as the study progressed.

The data analysis process was a back and forth process that evolved as the work proceeded. It involved constantly comparing themes that emerged to each other as well as to the project overall. I examine the data to see if it allowed for triangulation of each theme, for example, whether the theme was found in student dialogue, student artifacts, as well my reflections. The sharing of emergent themes with students and research colleagues as they developed also adds to the trustworthiness of the data analysis process as their feedback was incorporated. I shared my emerging findings with other SciJourn teachers and researchers as well as the science teaching colleagues at my school. Mohr, in her studies on how teacher- researchers work, found that, “The support of trusted colleagues in a research group gave teachers researchers a chance to analyze what they did as teachers and to understand their relationship with their students” (2004, p. 49).

**Ethical Issues**

One ethical issue that I confronted was the need to journal about what I actually observed not what I want to observe, to honestly represent what happened in the classroom, not what I wanted to happen. I have seen the success of the SciJourn process during the three years in my classroom. I wanted the developing pedagogy of activities to succeed. I had to take care not to let this desire for success to skew my perception of what was actually happening while using these teaching interventions.

My school administrators have very public expectations that my students will continue to produce quality work that will be published and garner recognition for our academic program. The SciJourn research team also has expectations that students will continue to provide insights on learning for the educational research community. This created a pressure to perhaps twist or represent what happens in the best light possible. It creates a pressure to try whatever is necessary so that these expectations are met.

Countering these performance expectations was the responsibility which I had to my students. I needed to make sure that my participant students were not “disadvantaged for the possible benefit of future students” (Zeni, 2001, p. 160). I needed to make sure that I did not spend all of my energy and classroom time on the SciJourn process. I also needed to help my students to develop the core ideas and concepts which they need to build their overall knowledge base for chemistry. I could not privilege my journalistic activities over the required curriculum.

Another ethical dilemma that I faced was how to represent my positionality and assumptions that I bring to the study when they were changing and emerging as the study progressed. I am not the same teacher or researcher that I was when I began the SciJourn process. My pedagogy and epistemology has changed to be more aligned with that of the social constructivists. This process of growth continued for me as I collaborate with my student and SciJourn colleagues during this study and will continue in the years to come.

Power in the classroom is one area where an ethical dilemma can arise for a research practitioner. I am lower in the power hierarchy than my administrators and my department chair and for that reason must make sure that my classroom pedagogy fits into a rather narrow range of acceptable practices. I, as the adult, hold some measure of power over my teenage students. I hold the power of their grade for example which in turn can affect their future. So my student participants viewed me in most instances as a person with some power over them. Working against this perception was a part of my daily struggle to work toward a more cooperative or collaborative classroom where the students and I worked as a team toward a common goal. Realistically my students usually viewed me as the captain or perhaps the team manager, rather than one of the other players on the team.

**Trustworthiness**

Any perception formed by a human being is filtered through their own prior experiences. As a teacher-researcher I am no exception. It is inevitable that my own perception will color the conclusions which I draw about the processes which take place within my classroom. By using videotape, audiotape and student artifacts I have hopefully brought a measure of objectivity to this subjective process. The extent of the data collected by these more objective means, the rigor with which they were collected, and the method of using themes while analyzing them increase the trustworthiness of the process. The triangulation of the data between the different sources (audiotapes, videotapes, artifacts and reflective journaling) also increases the trustworthiness of this study. The reoccurrence of themes while coding the qualitative data provides the objectivity which complements my subjective view as the researcher. Finally the member checks with students and conferencing with my advisors additionally verifies the trustworthiness of the findings and allowed me to see instances where assumptions are interfering with my understandings.

The confidentiality of the participants in this study was upheld at all times. The names of the students involved were replaced with IRB code numbers which will be used on all documentation and written reports of this study. The students were asked to provide assent to be the participants in the study, after being informed of all that was involved. Their parents were asked to provide consent for the participation of their child in this study, after being informed of all which that entails. The process of audio taping, videotaping and analyzing of their student work was clearly explained to them as a part of the Internal Review Process carried out through the University of Missouri-St. Louis. The permission of the school principal to carry out these research activities has also been obtained in the course of this process. All of the 165 students in courses that were taught by me over the during this three year study have provided such assent and consent.

**Limitations**

The major limitations of this study center on its focus on one teacher's implementation of classroom activities with her students in a specific science discipline in a particular institutional setting. Generalizing the findings to other teachers, other classrooms and other sets of students is problematic. This particular classroom, comprised of all female students in a college preparatory program, limits its generalizability due to the homogeneity of the participants. The 1:1 laptop program used within this school also provides affordances which may not be available in other classrooms. The subject area into which the science journalism was integrated with student research is limited to that of chemistry. Generalizing the findings to other disciplines or fields of study would not be possible without research in those areas. The format of the study, that of teacher –researcher brings with it the biases of that teacher, as the data is evaluated and interpreted.

**Summary**

This action research project involved the collaboration of me, as the teacher, my students, and the SciJourn trainers and researchers. Data collection began with the video and audio taping of teacher presented activities during the beginning phases of the science journalism implementation. Lesson plans and process documents were collected as they were developed. Students were interviewed on their view of the process. My journaling and reflections were carried out regularly during the three school years that I implemented science journalism activities into my classroom. Since the process of integrating science journalism into the student research practices is an iterative process, the changes in my classroom practices as revealed by my reflective journaling and lesson plans over the three year period became an important part of my data analysis.

The following chapters of this dissertation discuss the data and the interpretations which were made about patterns that were revealed when the data were examined. The changes in teacher practices as revealed by an analysis of reflective journaling, lesson plans and other artifacts will be described in chapter four, the changes in student behaviors will be described in chapter five with excerpts provided from the observations and taping along with student artifacts to illustrate these changes. The final chapter will summarize the benefits of the teaching strategies and the practices which developed when science journalism with student research projects were integrated.

# Chapter 4

## Changes in Teacher Practices

### Introduction

The research questions for this study include determining what happens to the teaching practices in the classroom when students are trained in the research practices used by science journalists, and then use them in their own research and represent their findings with science news articles and news releases.  This chapter will discuss the changes which implementing this science news protocol brought to my teaching practices. It will also present those teaching scaffolds and classroom activities which I found to be most effective in the knowledge creation processes of my students and enhanced the development of their scientific practices.

I first became aware of the use of journalism to increase the science literacy of students when Dr. Saul presented as a guest lecturer in my doctoral seminar in May of 2009.  As I listened to her describe the grant proposal for the study that would be carried out, I began to ponder whether this process was needed at my school or would be helpful for my students.

I noted in my reflective journal:

> "I can relate to the connection between literacy and science I just was having trouble connecting it to my situation in grades 9-12. Upon reflection and listening to her presentation about the science journalism study, I do see some ways to connect to my courses and students.  The students in my school struggle with the ACT science skills portion, most of the science teachers don't directly teach to this test section as they

> believe it is mostly reading skills. Perhaps this is an example where scientific literacy activities such as the journalism project would help. I really thought that the activities describing her students doing in classes would be beneficial to my students and get us away from lecture-lab, lecture-lab, and lecture-lab. I would like to learn more about her techniques."

As I thought about this connection between literacy and journalism, I found my interest deepening. In a personal interview with one of the SciJourn researchers, I described my epiphany:

> …….once Dr. Saul was talking, ……, in class I started to see that it's like you could read science, you can write science, but you just will not understand a thing, …….as I'm teaching my classes I see this all the time that kids often can do really well at answering the questions; they can even get an A in the class, ….., and be able to give back any answer they think you want, but when you really start talking to them about the phenomenon they don't even have a clue what was really going on, and so then I started taking a different understanding of that word literacy than I had before. So, that's how I started like opening up my mind to the idea that, you know science literacy really does fit in my school even with the high reading and writing skills ...they only learn what they have to learn, what they have to do to get the A and they learn nothing more than that. Even if they see themselves as ... going to med school they still don't get the connection that science is actually outside of the classroom and actually

> connects up to them as a person, and that's the part of science literacy that I, that's my big aha moment in all of this is that that's what I'm after in my classroom. That's been missing for all these years in my teaching. I mean been really working hard on getting the kids to understand the science concepts but not to understand as much how they fit to that and how it has anything at all to do with like the real world outside of the classroom….

Like many teachers, when I am considering whether or not to adopt a new teaching method or use a new activity in my classroom, I question what impact it will have on my students and me as a teacher. How does this fit in with what my principal is expecting of me? How does this fit in with what the science teaching professionals tell me I need to do with my students? How does this technique connect to what I want to cover, am required to cover, in my courses, with my students? Will I be able to make this new pedagogy work, do I have the personality to convey it successfully to my students? Will my students be helped by the new process or will it interfere with their learning? Will the students be open to this change in pedagogy? This chapter will discuss, from my perspective, the iterative process that evolved as I worked to integrate science journalism into my existing curriculum.

**Deciding How to Implement Science Journalism**

The process of integrating science journalism into my existing pedagogy began with the decision to become involved in the Science Literacy through Science Journalism project, to apply for and subsequently attend the two week training program during the summer of 2010. One of the pilot teachers for the SciJourn project, Angela Kohnen, spoke on the final day of that training session about her method of implementation. I found in her presentation the seed for this research project:

> Angela Kohnen as an English teacher at… paired science journalism with the research paper her students did on social justice. Her students did the research paper first and then converted it to a science journalism article. I wonder if this would work for me with the science fair. Students could do reading of current issues and then write a science article that might develop into their project. Or could they do the science fair first and then write about it? Maybe the background section? Will this work?

I went back and forth with these ideas, reflecting back on what I was currently doing and trying to form connections to this new pedagogy with my students. Eventually, I began by introducing the project to my honors chemistry students as a part of their science research process, a required project for the course which concluded typically with an entry into the local science fair.

**Independent Project Practices before Science Journalism**

Before this study began, before I became involved in the SciJourn project, I had read *America's Lab Report* (National Research Council, 2005) and it had made me unsatisfied with the independent research project format which I was using at the time with my students. I felt that the laboratory work was isolated not only from the content being covered within our coursework but also that the students were failing to connect with the subject matter on which their research was based. They were carrying out their research only as a means to an end, not to learn from it. So I was considering how to improve it to make it more meaningful when I became involved with science journalism.

Before this study, my students had carried out their science fair project work almost entirely outside of the classroom. It was considered an independent project and involved very little interaction within the classroom community. Reflection and discussion with peers were not a part of the process.  My roles in the progression were that of taskmaster and evaluator.  I began by giving then a four page document entitled, “Honors Chemistry Independent Research Project Deadlines.” This document listed step by step what was due during each month or time frame as the students carried out their science fair project. It listed the milestones, deadlines along with some detailed instructions on what was required to be turned in and when.  This pre-study science fair procedure document from 2009 is available in Appendix A.

The general process usually began in September with the student choosing their topic, submitting five possibilities for my evaluation of their suitability. In the following months the student would elaborate upon their topic choice by describing the problem that they were addressing. They would then begin carrying out their background research. Detailed parameters were given to the students for acceptable topics and the breadth of the background research to be completed. I provided feedback on their completed background research in the form of evaluating whether or not it met the established criteria. The students moved on to craft an experimental design which I critiqued and then carried out a trial run of the process to see if their design was functional. My evaluation of their experimental design was focused on how well it addressed the specific procedural steps required in project reports by the Greater St. Louis Science Fair judges. I would make suggestions to help the student align their experimental design to these requirements. I also would evaluate the student’s process work at this time by viewing and critiquing their log book. The student would carry out their research experiment in their home or if necessary for safety reasons, in one of the laboratories at the school after hours. They would record and analyze their data and then complete their report by stating their results and conclusions. My role during this phase was that of consultant, providing help when problems arose. In February another milestone and deliverable was due from the students, that of the report. A detailed listing of 25 specific criteria to be met was provided to the students at the onset of the project and used by me to evaluate whether or not the criteria had been correctly met. The next phase of the science fair included their creating a visual poster display of their project for the school pre-fair and ultimately the Greater St. Louis Science Fair. My role during this phase was again that of evaluator or judge, determining the extent to which each of the items in the criteria established by the Greater St. Louis Science Fair were met by the student. This end product, the science fair display, comprised the communication of student work to the school and St. Louis communities.

Although the entire process which I now use for the science fair has changed drastically since I began using the science journalism protocol with my students in 2010, I will focus on those areas in which I have most significantly changed the project design; topic selection, background research and method of student communication about their project.

**Topic Selection**

Prior to this study and the use of the science journalism protocol, I provided little guidance to the students for making their topic selection, assuming that since they had carried out science fair projects since grade school that they were adept at the process.

Table 4.1

*Topic Selection Prior to Study*

| | |
|---|---|
| September: | Visit the Greater St. Louis Science Fair Website:<br>http://www.sciencefairstl.org/<br><br>Purchase a composition notebook for your log book.<br>Write entries for researching topic, final decision of topic.<br>Show brainstorming about how you go about exploring the topic.<br><br>Submit a list of five chemistry topics for feedback.<br>Topic must be:<br>▪ chemistry based<br>▪ secondary level in rigor<br>▪ beyond what is covered in the typical high school chemistry course (look over your textbook)<br>▪ a controlled experiment |

Table 4.1 is an excerpt from the Honors Chemistry Independent Research Project Deadlines document given to my students in 2009 prior to the integration of science journalism. I gave very little in class instruction other than directing them to the science fair website, providing little guidance on what to do at the site. I tell them to show evidence of their brainstorming about their topic selection in their log book and to submit a list of their top five choices to me. I provided guidance of a sort here by listing the qualities which an acceptable topic must possess. These qualities include the idea of rigor, going beyond what will be covered in the course. They also included the parameters of being strictly a chemistry based topic and a controlled experiment. One year I even had the students create a master list of science fair projects using their textbook and science fair project websites and books. The majority of the topics chosen by the students were those that had been done previously by others in the past.

Table 4.2

*Titles of Student Science Fair Projects, 2007-2009, Prior to Study*

| |
|---|
| Which paint prevents corrosion of iron? |
| Polymer Absorbency |
| The Digestion of Starch by Amylase in Relation to pH |
| Type of Pill Versus Time Needed to Dissolve |
| Temperature's Affect on the Conductivity of Copper |
| Flat or Fizz : The effect of Temperature on Soda |
| The Affect of Bactericides on Rusting |
| Soda's Effects on Teeth |
| Prevention of Apple Oxidation |
| Apple Dehydration |
| Effects of Temperature on Batteries |
| Factors Affecting How Well Different Textiles are Dyed |
| Deicers: Are they worth their salt? |
| Do *Rhizobia* affect non-leguminous plants? |
| Does It Make Scents? Do more expensive perfumes last longer? |
| Effect of the Nutrient Ratio in Fertilizers on Lima Beans |
| Effects of an Eco-Friendly Detergent on Plant Life |
| Is a Dog's Mouth Cleaner than a Human's? |
| Metal for Breakfast? How much iron is in breakfast cereal? |
| pH Level of OJ over time |
| Smoking: The Reason Your Plants Are Not Growing? |
| The Effect of Different Hand Sanitizers on the Growth of *E.Coli* Bacteria |
| The Effect of Different Light Sources on the Prevention of Growth of E. coli |
| The Effects of the Car Pollutant, Antifreeze, on Living Organisms |
| The Effects of Fertilizer on an Aquatic Environment |
| What is the Effect of Road Salts on the Growth of *Poa pratensis*? |

A few students occasionally would take a prior experiment and twist it in a different, unique direction. This is evident from looking at the titles of some of the projects carried out by my students during the 2007-2009 school years displayed in Table

4.2. Many of the students were choosing to do repeats of projects using bacteria culturing techniques which they had carried out during their previous course, Biology, adding in a chemical substance such as hand sanitizer, or soap. Others grew plants and tested the impact of adding chemicals such as road salt, antifreeze, detergents, or smoke to them. Those projects that focused solely on chemistry did so in a simplistic manner, testing pH using test strips or using magnets to collect colloidal iron from breakfast cereal.

During the three years of this study, I modified the Independent Research Project design in an iterative manner. I would try something; see if it successfully engaged the students and accomplished the objectives that I had for using it and if it did, I would retain it. If it did not, then I would try something else. Even those ideas and activities that were successful were modified and honed down over time. An excerpt from an interview of me as one of the science teachers implementing science journalism carried out in July of 2011 illustrates the iterative nature of my implementation, in this case of the Read Aloud-Think Aloud technique:

> … I even started out trying to like about once a week do a Read Aloud that connected with the material and then start doing like activities, and….I ended up coming up with some combination of those that worked the best for me, …whenever I would try and do … a Read Aloud and then we would do the classroom activity they would get so into that article that they couldn't make that transition to the classroom work, so then after a while I started to realize that maybe what was really happening was they were learning more from the Read Aloud than they were from the classroom stuff. So, then I started doing … instead of the lesson as a Read

> Aloud it became … the actual classroom activity became the Read Aloud instead of a part of the class…. So, we spent the class on this article about this topic that we were on and it just seemed to work better (Davidson, 2011).

This process of testing and revision continues to date as I try activities, keep those that work well and accomplish the learning objectives for the students and tweak or even discard those that do not work well.

As I read over my journals of reflections which I kept during the three years of this study and reviewed how my lesson plans had changed during that time, three major differences exist between the process which has evolved and that used prior to the integration of science journalism. First of all, the process of topic selection begins during the opening days of the school year, in August and is completed in late October, and it has become a scaffolded process. Secondly, the process takes place within the classroom for the most part and is integrated into the flow of the curriculum. Thirdly, the process involves the students discussing their ideas with each other and me, collecting feedback and receiving encouragement for their emerging ideas. These changes have brought authenticity to the student research project as they engage in topics of current interest in the scientific community as well as the students themselves. These changes have energized the process and generated interest in the student research projects within the school community.

**Brainstorming Activity in August**

In August I begin the school year with a brainstorming activity with the students on how chemistry plays a role in their lives. I begin by asking each of them to list five areas or products in their lives which were developed or improved because of chemistry. I have them compare these to their partner and then to share them with the class. To aid in the sharing the students are given index cards to display their contributions. These index cards are then sorted and grouped into categories by the students. As a class, they create a poster listing the categories and specifics which incorporates their ideas. I am always amazed at how complex this listing become as we move through the lesson. They discover that almost every aspect of their lives relate to chemistry. Table 4.3 shows the results of the brainstorming activity in a tabular format for the 2010 sections of Honors Chemistry. Each year the list varies with the individual students and their understandings of chemistry in their lives. This brainstorming has created an interest in chemistry as evidenced by student comments that I receive on the days when the activity is being carried out or following it:

> “I hear we are doing a fun activity today.”
>
> “I hear that we are going to brainstorm, I bet we can come up with more ideas than the other class”
>
> “I came up with a great idea to add to our poster as I was eating lunch today: the different kinds of milk. What does each do different from the others?”

The poster which was developed as the end product of this brainstorming activity remained on display for several months as we covered the introductory material in the course and began looking for topics for the independent research projects of the students.

Table 4.3

*Brainstorming Activity Results, August, 2010*

| Materials Design | Agriculture /Farming | Cleaning | Pollution |
|---|---|---|---|
| Composites | Hydroponics | Bleach | Environmental Testing |
| Resins | Cryogenics | Bleach Alternatives | Air Quality |
| Plaster | Agriculture | Synthetic Fabrics | Ozone |
| Concrete | Pesticides | Fabric Dye | Ground Level Ozone |
| Adhesives | Herbicides | Fabric softeners | Global Warming |
| Polymers | Fertilizers | Food | Greenhouse Gases |
| Plastics | Soil Quality Testing | Additives | Water Quality |
| Alloys | Land Degradation | Preservatives | Water Purification |
| Paints | Soil Erosion | Packaging | Bottled vs. Tap Water |
| Light Bulbs | Sedimentation | Edible Wrap | What Is In Our Water? |
| Halogen bulbs | Runoff of Pesticides & Fertilizers | Acidic Foods | |
| Fluorescent | | Cheese Making | |
| Ink | | Cooking | |
| Dyes | | Food Flavoring | |
| Metal alloys | | Carbonation | |
| | | Sugar Substitutes | |
| Fuels /energy | Health | Cosmetics and appearance | Other |
| Candles | Antacids | Toothpaste | Scuba Diving |
| Matches | Vitamins | Mouthwash | Photography |
| Explosives | Fluoride Treatment | Shampoos | CSI Testing Methods |
| Fireworks | Hand Sanitizers | Conditioner | Biotechnology |
| Rockets | Antibacterial Soap | Permanents | Minerals on Moon and Mars |
| Bombs | Medical Equipment | Hair dyes | Water on Other Planets? |
| Delivery Methods | IV Fluids | bleaches | Rusting |
| Conservation | Ibuprofen | Hair Straighteners | Conductivity |
| Insulation | Aspirin | Hair Relaxers | Malleability of Metals |
| Producing Energy | Caffeine | Tooth Whiteners | Thermal Conductivity |
| Biofuels | Transdermal Patches | Perfumes | |
| Biodiesel | Nicotine | Cosmetics | |
| Solar Cells | ADD Medication | Carbonation and Teeth | |
| Batteries | Abused Drugs: | Laser Hair Removal | |
| Ethanol | Methamphetamines | Sun Lamps | |
| Nuclear Reactors | Cocaine | Tanning Beds | |
| Radiation | Anesthesia | | |
| Radioactivity | Dialysis | | |
| | Bandages | | |

I have extended this brainstorming with an activity where the students delve into specific materials using the website, What's That Stuff?, available through the Chemical and Engineering News produced by the American Chemical Society (American Chemical Society, 2013).

Table 4.4

*What's That Stuff Activity Description, August, 2012*

| |
|---|
| Objectives:<br><br>Students will become familiar with several materials in their everyday lives. They will be able to describe some of the chemistry involved with producing this material for their use.<br><br>Student Directions:<br><br>Visit the website: http://pubs.acs.org/cen/whatstuff/stuff.html<br><br>Choose any four of the materials available on the site to research.<br>Prepare a Word document which provides the following five pieces of information for each one:<br><br>1. Give the name of the material and its main use.<br>2. Describe the Lede: What did they use to get you interested in reading this?<br>3. How does this material play a role in your life?<br>4. List the three most important chemical facts presented about the material<br>5. Describe the most surprising information that you found about the material. |

The activity which I developed to utilize this website in order to build student interest in the connection of chemistry to their lives can be found below in Table 4.4. Another publication of the American Chemical Society, *ChemMatters*, has also proven useful for helping students to find the connections between chemistry and their lives (American Chemical Society, 2013).

**Modeling Connections with Read Aloud-Think Alouds**

From August until about mid September I augment the brainstorming activity with pre-planned Read Aloud-Think Alouds to strengthen the student's realization of the connection between chemistry and their own lives. For each unit of coverage I have located articles to read with the class on topics related to the unit being covered which are applicable to the student's lives.

Table 4.5

*Topic Planning for Read Aloud-Think Alouds*

| | |
|---|---|
| Safety | Alternate periodic tables |
| The scientific method, practices of science | Chemical reactions |
| Measurement | Reaction rates |
| Divisions of matter | Gas laws |
| Separation techniques | Heat |
| Compounds | Equilibrium |
| Elements | Acids and bases |
| Atoms | Oxidation and Reduction |

Over the past three years, I have developed a set of these Read Aloud-Think Alouds to introduce each topic covered within the course and students have suggested additional articles to me. I have found, through trial and error, that having the students read the article aloud rather than listening to me read it to them helps them to retain their interest in the material being read. For example, when covering the topic of safety in the science laboratory, I use the article, "Chemical Mishap Empties School" about the steps that needed to be taken after a teacher dropped a bottle of concentrated hydrochloric acid while preparing for a laboratory investigation (Nolan, 2001). I also have used the article "Staff Saves High School Sophomore," (First Aid Corps, 2010) to illustrate the need for safety training.

During a Read Aloud-Think Aloud I hand out a copy of the article to each student and then display the article on the Smart Board in the front of my classroom. My students take turns reading sentences aloud while I pause and interject questions. For the article on the chemical spill, once the who, what, when, where, and why and how had been discussed, I would interject the question, "Could that happen here?" Later in the discussion I would ask, "What would we do if something like that happened here?" and

“What if you knocked over a chemical in the lab, what would you do?” I have found that once I ask two or three questions, an animated discussion ensues on the article providing a perfect segue into the coverage of the content topic.

During an interview in August of 2011, I described how these Read Aloud-Think Alouds captured the interest of my students:

> They (the students) wanted to hear how this … connected to them; they wanted to figure out a way, most of them were really into careers in science, so they wanted me to kind of show them that the rest of their life wasn’t going to be boring, sitting and cleaning test tubes in a lab by themselves. So I thought that the SciJourn piece really connected with them. I mean, we’d start doing Read Alouds and I was actually really surprised that these honors juniors in high school, they’re 17 years old, were getting into reading out loud… They started asking for more Read Alouds, they started bringing in Read Alouds unasked; I didn’t even ask them and they would bring them in. We’d post them on the walls and other students would come in and ask, what’s that?
> They didn’t want me to say, “Here, read this and we will talk about it in ten minutes; … it was important to them that they read it out loud (Davidson, 2011).

An extension of this Read Aloud-Think Aloud practice occurs while we are carrying out a discussion of a content topic and a student asks a question, usually centering on relevance of the topic. When this happens, we have a spontaneous research aloud as a class. An example of this came when we were discussing ionic bonding. I posed the question, “Why do we need to know about ions?”

The students were unable to come up with a response. So I said, “OK, get out your computers and look it up, find an answer to the question, why do we need to know about ions?” What followed was an impromptu lesson on how to use a search engine more efficiently; for example viewing the results when using phrases such as ‘Importance of Ions’ as compared to just ‘Ions.’ The impromptu lesson also touched on credible sources. We discussed the credibility of Wikipedia, eHow, and About.com in comparison to organizations such as the American Chemical Society and the National Science Foundation. As the students delved into the role of ions in the functioning of the human body, the batteries in their cell phones and reacting with ozone in the atmosphere due to wave action, they found that academic organizations such as the National Science Foundation provided more credible and robust information. This led to a Read Aloud-Think Aloud of the article, “Making a Splash: Ions and Interactions” (National Science Foundation). RATA activities such as these described enabled the students to become exposed to the variety of connections between chemistry and their own lives. These connections provide ideas for authentic choices for their own science research projects.

**Reading the News Logbook Assignment**

Another strategy which I developed to help the students decide their research topic involves a search of recent news articles. Students are required to read ten science news articles of their choice over a one month period and to reflect upon them in their logbook. They are encouraged to choose articles to read which align with their own interests and hobbies.

Table 4.6

*Student Science Research Logbook Assignment Description, 2013*

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Objective:
Students will be able to determine those areas of chemistry which are of interest to them as possible topics of further research.

This will be carried out in your Log Book/composition notebook which is bound, not spiral. Entries must be neat, organized, handwritten and in your own words.

Directions:
1. In your logbook, start on first page with title of section as something like "Deciding on a Topic for my Project". Write a short paragraph on this page describing how you are beginning your topic research by reading Science News articles to try to decide on a research topic. Describe the topics that interest you before you begin this activity.
Date this page at the top.

2. During the rest of September and October you will read 10 Science News articles on a topic which is of interest to you for your research project.
When searching the archives use chemistry in the topic field and add words to the first field such as environment, toxins, agriculture, biology etc.
Each article read should be connected to chemistry in some way.

Start each article on a fresh page and put the calendar date at the top of the page.
For each article read, provide the following:

- Title of article, date of issue, source as Science News magazine
- Summarize main points of article in your own words.
- Describe how this article connects to your life and interests at this time.
- Describe a possible project, either an experiment, survey or series of observations that you could do on this topic.

Science News is available online at http://www.sciencenews.org/

Alternately you may use the Science in Context of the Gale Databases which is available through the library homepage which relies mainly on articles from the New York Times science section.

Your grade will be based on the completeness of your entries.

---

I have tried using ChemMatters magazines in the past but found that the topics which they gravitated toward afterward were too generalized such as fire or the rates of chemical reactions. Now I require them to use either Science News or the Gale Database Science in Context as the source for their articles. My intent is that they explore what is currently happening in chemistry that is impacting their own lives or connected to an interest which they have. As they read over the articles I have them reflect these connections and consider how the topic could be developed into a full research project. Students often ask if they have to choose one of the topics that they locate during this perusal of science news to which I reply, “No, you do not have to choose one of these topics but the point of the activity is for you to be focusing in towards a topic that you are interested in and can work with.”

**Class Topic Discussion and Fish Bowl**

Once the students have completed the logbook assignment outside of class, the project is brought back into the classroom community through a discussion of topics which the students uncovered through the exercise. We begin with an overall guided discussion where I ask them if they have decided upon their research topic, knowing that this is not the case for the majority. After some discussion of their frustrations and difficulties focusing in on a project which they can fit to the stereotypical science fair project, I provide the following suggestions which I developed by combining my SciJourn training with my existing processes:

- don’t think at this time about the project as an experiment or science fair project;
- think about what activities you are involved in right now;
- think about how chemistry overall relates to your life;
- think about the parts of life that puzzle you;
- try to get away from projects that center on biology, culturing bacteria, things you have done in the past;
- the topic should connect to chemistry;

- the topic should interest you;
- the topic should interest others;
- the topic should connect to real life;
- the topic should be about something that you do **not** already know;
- the topic should be focused and narrow; and
- the topic should be appropriate for a high school student.

I elaborate on several of these points while displaying them via PowerPoint, especially the first one that they should not think in terms of the traditional science fair project. I explain that surveys of their school mates, faculty, or parents could be used in place of the typical controlled experiment. In my doctoral work, I noticed that surveys are an accepted form of research. Several students in the first year of my study, 2010, chose to research topics for which surveys were the perfect vehicle to determine correlation. Their projects which presented their survey results were successfully accepted by the Greater St. Louis Science Fair in the category of observations. I also point out that a series of observations is one of the allowed versions of research for the Greater St. Louis Science Fair, that making observations over time is as acceptable as a controlled experiment. I discuss the probe ware that is available for their use during the projects; pH probes, carbon dioxide and oxygen sensors, conductivity meters and colorimeters. I model for them the process of by giving them specific examples of topics that I myself am interested in at the time. Here is an excerpt from a class discussion which took place in September of 2012 which illustrates my modeling:

> "Right now one of the topics that I find interesting is the use of the eBooks by the students in place of the paper copy. This is being considered as a

> means to save natural resources and to lighten the back packs of the students. Overloading backpacks is another topic of interest to me but back to the eBooks. Do you know that there is a proposal right now from the parent's club asking that we switch completely to eBooks and an eReader and eliminate textbooks all together? How many of you would go for that? (The majority of the students express displeasure at the idea.) I thought so, because what I see from my view here is that you all like the paper books that you often print out paper copies of any assignment that I give electronically, another topic that I would like to research. It would be wonderful to have data to show the administration about what the students prefer in terms of their textbooks. I think that your needs should be made known to the people making the decisions about your books."

Once I have gone over suggestions to develop their topic choice into a research project, we break out into discussions within smaller groups of 8-10 students. The group discussions have a "Fish Bowl" emphasis as students take turns presenting their ideas to the group members who then give feedback and suggestions. My role during this time is to circulate around the 3 large groups to keep the conversations moving and to make sure that each student is able to have the spotlight.

Occasionally I am able to hold a Fish Bowl for the entire class if it is small in size. This works very well, similar to the cadre and seminar discussions in which I participated during my doctoral study. Each student is able to present their ideas for research, receiving feedback from their peers.

Table 4.7

*Reply to Student Email, 'Becky,' October, 2011*

| |
|---|
| The one topic I am particularly interested in researching and doing a science fair project on is how the number of people who have asthma has increased in the St. Louis area in recent years. I have always wanted to pursue a medical career and this would be a good way to sample one aspect of the medical profession, finding how the environment affects disease. Because asthma is a disease of the respiratory system it is highly influenced by the environment, specifically the chemicals found in the air. Research has shown that certain chemicals can irritate those with asthma and even trigger asthma in certain people. Because asthma is so a common disease, especially in the younger generation, I hope that my information will give a better understanding of the disease. I plan on doing this project in two steps; through research on the chemicals found commonly in St. Louis air and through a survey given to those who have asthma. |
| ***This sounds good. What would you be doing as the manipulated variable and the responding variable for your survey? What would you be trying to prove or disprove?*** |

*Note:* Teacher comments in are in italics.

**Individual Topic Choice Dialogue**

Once the students have completed the class brainstorming activities, I begin a dialogue with each student by asking them to email to me their top three ideas for their project. Often the students have already decided upon their topic by this point and it is just a matter of my providing suggestion on areas to delve into or experts to contact as shown in the email from 'Becky' and my reply as shown in Table 4.7. In other cases the student might have three topic ideas of which one would work well in a high school setting while the other two might be more of a stretch as shown in the email conversation with 'Ann' shown in Table 4.8.   Others, such as 'Gina,' have three great ideas and the student is then asked to choose one or to narrow their focus as shown in table 4.9.

Table 4.8

*Reply to Student Email, 'Ann,' October, 2011*

1. Does physically seeing food affect the amount of food you eat? ***We would have to see if this would be allowed as it is a human subject experiment.***
    a. Blind fold the consumer to see if "their eyes are bigger than their stomach"
        i. Use multiple volunteers, but each must eat one meal with a blindfold and another meal of similar proportion without a blindfold
    b. The results could determine whether people eat until they are full or until their food is gone
2. Do different fabrics have different chemical makeup, and if so, how does this affect the rate at which they burn? ***Fabrics have different chemical compositions, the burning aspect is interesting. Wonder about different types of beds like those foam ones. How would you quantify it? Safety first!***
    a. Use different fabrics and test the rate at which they burn
    b. The results could be used to help aware homeowners which kinds of fabrics they should avoid in their homes
3. What types of food improve an athlete's performance the most? ***Again this most likely would not be allowed as an experiment. Maybe if you surveyed athletes after a game about the food that they ate and then tried to correlate the score of the game or the pt. that they scored to the food they ate it would work. You cannot make them eat the food but you can compare what they ate voluntarily to their performance.***
    a. Choose multiple types of food (fruit, vegetables, carbs, proteins….)
    b. Have an athlete volunteer eat each snack and run a certain distance
    c. Compare the times

*Note:* Teacher comments in are in italics.

Table 4.9

*Reply to Student Email, 'Gina,' October, 2011*

A possible science fair topic would be to test makeup products to see which ones expire the soonest. ***How do you measure "expires"?*** I could test different brands, such as Cover Girl, Clinique, Lancome, L'Oreal, and Maybelline. These brands are well known so they might be products that people would be interested in. I could also test different products like mascara, eyeliner, foundation, or concealer. I could measure which makeup product or brand contains the most bacteria after 1 week increments. I use makeup frequently and I have many products that are at least a year old. I want to know which brands have the least amount of bacteria or how I can prevent bacteria from growing in my makeup. The different brands and products might have different ingredients that are combined together and therefore are related to chemistry. ***Would they each be used the same amount? The bacteria come from the uses of them. If you do not have them used the same amount, how can you make a control? Also the article was talking in terms of months and years. You only have until January. Can this show in that small amount of time?***

A possible science experiment would be to test what ingredient in energy and sports drinks cause the enamel on teeth to soften. Energy and sports drinks soften the enamel on your teeth. If I can find the ingredient in these drinks that causes enamel to soften, then I will be able to find what other drinks cause my enamel to soften and our bad for my teeth. This experiment relates to me because I drink sports and energy drinks and I would want to know what ingredient causes the enamel to soften. Other people would also be able to find out what other drinks are bad for their teeth. I could take each ingredient in a sports drink and test each one separately on enamel to see which ingredient/ingredients soften the enamel ***This sounds realistic and doable.***

Another science experiment that I could do would be to answer the question, "Which is most important: the wick or the wax?" I could buy short and fat candles with much wax but not a lot of wick and see if that candle takes longer to burn or if a tall candle with a long wick and not much wax would burn longer. Also, I could weigh the candles and see if they have the same amount of wax, but different wick lengths and test the difference in burning time. Sometime I use scented candles to make my room smell nice, but I am not sure which type of candle I should get if I want the candle to last a long time. Other people might wonder the same thing and by doing this experiment, people would know which type of candle lasts the longest. This is related to chemistry because fire burning is chemistry. ***You might have to actually make candles to get this to work as a controlled experiment. Ingredients in the wax are not often listed on the candle.***

*Note:* Teacher comments in are in italics

Table 4.10

*Reply to Student Email, 'Ellen,' October, 2011*

Topic #1: How does the volume of music/radio in an automobile affect the driver's ability to drive safely and effectively?

- This topic relates to chemistry because the chemical reactions caused by music (excitement, emotions) could affect the driver's mind.
- This holds my interests because I am a new driver, as are most of my peers, and safe driving is very important to me.
- Because I am a new driver, this topic is definitely part of my life and the life of average teenagers.
- I do not already know the answer to this question, although I would assume that the louder, or more upbeat music is, the more distracting it would be.
- I can find this answer through research, by performing test on fellow drivers while different levels of music are playing***. You cannot actually test real driving, that would create an unsafe situation. You would need to develop some kind of task for a person to do while sitting in their car and maybe time them. Like a Sudoku or a crossword or a seek and find or put a puzzle together. Again: not while the car is actually driving. You also cannot play the music so loud as to damage their ears. We might need to locate a decibel meter to make sure.***
- I have not found anyone performing this the same way that I plan of conducting the experiment.
- The answer can be measured by a specific test that has a letter grading system with exact requirements that can be applied to the driver's driving skills with the different levels of volume.

Topic #2: Is hot or cold temperature the best for a person to do the highest quality of physical exercise?

- This topic relates to chemistry because of the chemical reactions of the body to maintain homeostasis. ***Would be good but human subjects are problematic with the science fair.***
- ***Also how do you measure the "highest quality of physical exercise"?***
- This holds my interest, and the interest of others, because like myself, a lot of people are active in sports and physical activity and are very concerned with being at the peak of physical performance.
- This is part of my life and the life of an average team because a lot of teens play sports and exercise.
- I do not already know the answer to this topic.
- This topic has not been done in the same way by anyone else, as far as I know.
- The answers can be found by me through a series of test that I will have different subjects perform in both cold and hot temperatures.
- I can measure the results through timed test ***of what?*** and compare the results ***of what?*** not to other people but to the same person in the different temperatures.

Topic #3: Which method of studying (reading or testing) is the best for retaining information?

- This topic relates to chemistry because the chemicals in the mind are what control memorization and retaining information***. This connection is really a stretch. This study is more of a behavioral study and not really chemistry.***

- This topic interest me and my peers because we are expected to perform at our academic best and finding the best way to retain information would help significantly in doing well in school.
- This topic is a part of my life and the life of an average teen because most teens attend school and want to succeed.
- I do not already know the answer. This experiment has not been done by anyone else.
- I can find this information by doing research by testing different groups of people who have either read information or have tested themselves on information, and then giving them the same test that can show which method is the best.
- I can measure the results through the grades on the test.

*Note:* Teacher comments in italics.

A number of students persist each year in suggesting as their choices projects which they have carried out in elementary or middle school, or topics that are more consumer product tests. These are the students that need more guidance in selecting their topics, so I call them in for a one on one conference. Table 4.10 displays an example of 'Ellen's' choices that would require such a follow up conference.

These one on one conferences take place before or after school and I have the student bring in her log book as an aid to our discussion. I begin the conference by having the student go through her thought process on her topic, "Remind me about what you have been thinking of for your science topic," and "Why does that topic interest you?" are examples of the probing questions that I ask. I then move away from the tentative topic choices of the student and on to questions about the student's interests, "What activities are you involved with outside of school?", "What hobbies do you have?" I am trying to discern if these activities could be used to suggest a possible avenue for a topic. This process is illustrated below in the reconstruction of a conversation which I had with 'Beth' in October of 2012:

Teacher: What outside of school activities are you involved in?

Beth: I don't do much except school work and field hockey.

Teacher: Do you do field hockey year round?

Beth: Yeah, I play for the school in the fall and then belong to a club team for the rest of the year.

Teacher: So you are really pretty good at field hockey then, right?

Beth: Yeah, I really like it.

Teacher: Do you think you will get a scholarship from playing?

Beth: Well, there are not tons of schools that have field hockey programs but I am looking into some that do. Duke and Boston College have them but I am not sure that I would get a scholarship there. Maybe Miami of Ohio, a lot of our girls go there.

Teacher: So you are involved with field hockey almost 24/7 then.

Beth: Yeah.

Teacher: So is there anything about field hockey that might connect with science? Like maybe the equipment materials or safety aspects? Do you wear any safety equipment?

Beth: Well, a lot of us are trying to find a better kind of goggles because the ones that we wear now are really uncomfortable and make it harder to see. I mean, we wear them, because we have to but they really are a pain.

Teacher: So there are different kinds out there now?

Beth: Yeah, about 5 different brands but the coach decides which ones we have to wear.

Teacher: So could you figure out a way to test all of them and maybe rate them for comfort?

Beth: How could I test them?

Teacher: Well, what do you need them for?

Beth: To protect me from the balls hitting me.

Teacher: So, you might want to measure how well they protect you from balls.

Beth: Like throwing balls at them and seeing if they break? Or something behind them breaks? Like maybe a watermelon or something?

Teacher: Maybe there is even a force measuring device that the physics teacher can set you up with.

Beth: So yeah, if I find the best ones, I can tell the coach about it.

The conversation continued for several minutes longer, working out some of the details for the kinds of tests that the student might be able to carry out. This particular topic is connected to chemistry as the materials from which the safety equipment is made and often upon which it is tested are manufactured from materials designed by chemists. At this point in time the topic for the project was the primary focus of the conversation. The details for the controlled experiments or series of observations that will be carried out on the topic usually are worked out once the student has carried out a review of what is already known on the subject as they carry out their background research.

**Student Background Research**

Before I began using science journalism with student research projects I did not do direct training in the literature review process during the course. Students could individually come in to ask for help but for the most part it was assumed that they knew how to carry this out because of their training by their English teachers and their prior work on similar projects. Students were given assignment descriptions and due dates but little else prior to carrying out their research. Table 4.11 describes the process used prior to the use of science journalism during this study.

Now, when we move as a class into the background research segment of our independent research project journey, I begin to speak directly about the concept of science journalism and the style of writing associated with it. I set as the goal for this segment of the process as a science news article of 400-800 words which explains the topic chosen by the student so that it would inform the average citizen of the importance of the topic.

We begin our discussion of the format used by journalists by comparing science news articles to five paragraph essays. I hand out copies of a science news article, usually one published by a student during the previous school year. We look over the article and discuss how it differs from the five paragraph essay format which the students have embedded in their minds by the time that they are high school juniors. After the discussion I present to them the key writing elements in a science news article and have them highlight and color code these in the article which we had been examining.

Table 4.11

*Background Research Assignment Description, November 2009, Prior to Study*

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Before leaving school for Thanksgiving Break background information research is due.

Turn in at least 25 information note cards from a minimum of 5 sources with each source listed on a separate work cited card. At least three of the sources must be non-internet. Include in your research:

- The history of your topic: important people and discoveries
- The significance of your project: why it is worthwhile
- Facts: major terms are defined
- Describe what is known about the topic.
- Other experiments which have been done on your topic
- Information on any chemicals or living organisms used.
- Information on the chemistry involved in your project
- Information on the chemistry involved in your topic
- Information on any special equipment used in your topic

A PARAGRAPH VERSION OF THESE NOTES WILL COMPRISE THE BACKGROUND SECTION OF YOUR FINAL SCIENCE FAIR REPORT.

Note cards will be taped into the <u>back</u> of your logbook upon their return to you after grading and after your write your background paragraph.

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The features which we focus our attention on are modified from the lesson *Science News Article Organization* (SciJourn Project, 2011):

- An interesting and descriptive title
- A lede to catch and hold reader interest
- An explanation of why is this topic is new, important, relevant
- The who, what, when, where, why and how of the topic
    - Who is involved? Who does it impact?
    - What does it involve? What happens during the process?

    - When did it start to be used or important? (Brief history)
    - Where is it used? Where is it important?
    - Why is it needed or important for the reader to know?
    - How does it work? How does it happen?
- Additional background information
- Details on how it works and who it impacts
- Numbers, statistics on how great its impact is or could be
- Comments by others: experts and stakeholders
- Future outlook, where will it be in the future?
- Summary comments and quotes from stakeholders

The beginning of the article is given much consideration as this may be the only section read unless the interest of the reader is caught and held. The overall format of a science news article, that of an inverted triangle, forefronts the important information putting it at the beginning of the article where it will most likely be read. Details and specifics are further on, for those readers who have an interest in the topic and a need or desire to know more about it. A science news article also has a different format for giving credit to ideas and information, that of the in line attribution as compared to a work cited document at the end of the essay.

Besides the organization of the article there are additional differences between a science news article and the common five paragraph essay which make using this format a better choice for the background information section of the student research process. The two most important differences are the emphasis on relevance to the reader and context of the situation to the scientific and civic communities.

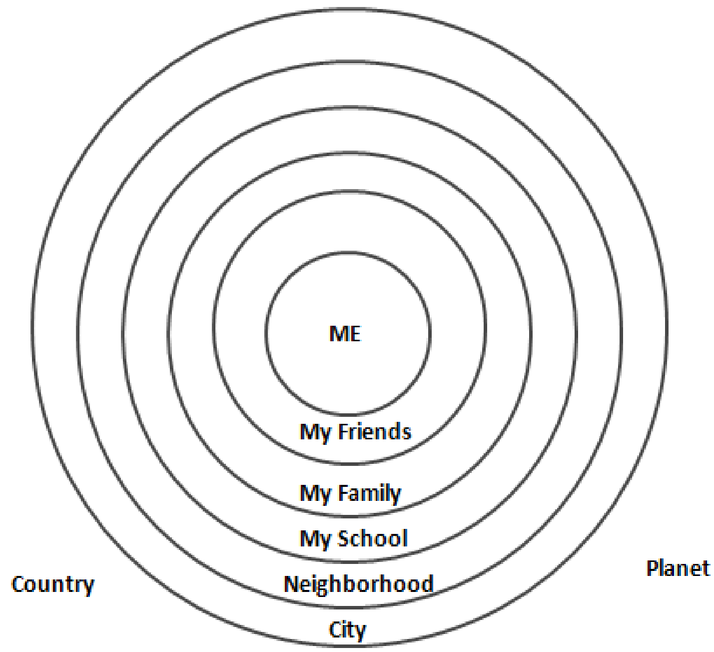



*Figure 4.1.* Relevance from the Viewpoint of a Student

**Relevant Topics**

In choosing the topic to research, students were encouraged to select one which had relevance to their own lives. In the background section they elaborate upon this relevance and extend it to other teen readers and to the average citizen. During class discussions this relevance is often encouraged through prompts such as "Why should I care?" or "Why should anyone care?" If a student cannot answer those questions, then more research is needed or a realignment of their topic choice. I like to think of relevance like a series of concentric circles, beginning with the student and expanding to encompass the community as a whole as shown in Figure 4.1.

Context involves the students connecting their topic to the field of science overall. Often this can be accomplished by establishing a time line of events involving the development of the device or process upon which their topic focuses emphasizing the importance of why that development occurred, the driving forces behind it.

Adding in statistical or numerical data can provide that context in terms of "how much of an effect?" or "how often does it happen?" Knowing the numbers behind the issue often help to develop the level of importance for study in the area. Besides knowing why the process is important and what work has been done on it at this time, the other aspect of context which must be considered is what additional research is currently being carried out, what is still not known at this time, and what else needs to be carried out or considered that is not. According to SciJourn, "The goal of the context paragraph is to show that science has broad consequences, is an ongoing enterprise and is part of a continuum of investigation and learning" (Saul, Kohnen, Newman, & Pearce, 2012, p. 119).

**Interviewing Stakeholders and Experts**

In addition to researching their chosen topic using online and library sources of information, students also interviewed stakeholders and experts for personal insights. A stakeholder is anyone who is involved in a particular issue or event. For example, one of my students was writing about the impact of concussions on performance in school. She interviewed a number of student athletes who had concussions about their view on the subject. She also interviewed teachers and coaches, as other stakeholders. Experts on the topic were located by the students within their community of friends and family or by sending email requests or calling experts that they found online. An excerpt from an interview of one of my students, 'Sue' in May of 2011 illustrates how the students located their experts:

...my dad set up this tour of the Missouri American water plant.

> A guy, Mr. R…, he's the director of ...water quality supervisor, something like that, I'm not sure of the exact title.
>
> So I go a lot of good information from the tour about...tap water.
>
> So that kind of helped me narrow down … what I wanted to talk about because I was talking to … an expert.
>
> I took a notebook to write notes down and I asked questions as we went along, just things that interested me or things that I wanted to remember (Sue, SciJourn Participant Interview 2, 2011).

Another student, 'Marie,' in the fall of 2010, had begun researching the amount of mercury in Compact Fluorescent Light Bulbs. As her expert, she contacted the public affairs official at the St. Louis division of the EPA. This expert shared information with her but then balked when he found that it would be published. I found the SciJourn editor, Dr. Newman's email comments illustrative of the student's efforts to secure this expert's information:

> As for the EPA public affairs official—that person is, frankly, being a jerk. They have no right to dictate to journalists what can or cannot be published. However, as in all adult things, you pick your battles. What this person asked for is OK. In fact, you should send the person the link to the story and thank them for their help….
>
> Your experience with the public affairs official should help you appreciate how much courage it takes for newspaper and reporters to print bad things about powerful companies or politicians. Imagine if it was a senator or company president demanding that you change something or not print it

all. Good newspapers weigh those risks all the time (Newman A. , Email, 2011).

**Specifications for the Science News Article**

Once the students have written their background research as science news articles they are evaluated using the specification sheet shown in Figure 4.12 which my students and I developed based on the SAFI, Science Article Filtering Instrument, developed by the SciJourn team (SciJourn Project, 2011). Before the students submit their news article to me, they peer edit each other's articles using the specification sheet for the article. I advise them to help each other to avoid point deductions by catching the missing items during the peer review process instead of my catching them during the grading process. The peer review process and student behaviors during the process will be discussed more fully in Chapter five, Changes in Learning Behaviors.

Instead of a onetime score, students enter into a cycle of revisions which begins with the feedback which they receive on this specification sheet. Students receive deductions for items which are missing or need improvements but they may earn half of these points back through revisions. Often a student will revise the article three or four times in order to earn back half of the points for each revision. Articles which have been revised to meet all of these specifications are sent on to the SciJourn editor to be considered for possible publication as well as forming the core of the Independent Research Project background section. Articles which have been submitted for possible publication begin another, more intense cycle of feedback and revision where I serve as mediator between the student and the editor.

Table 4.12

*Science News Article Specifications*

| **Item** | **Present, absent, needs improvement** | **Comments** |
|---|---|---|
| Heading with your name, section, date | | |
| Descriptive Title | | |
| Lede to catch and hold interest | | |
| What's new about your topic? | | |
| Why is your topic important, relevant? | | |
| Who, What, When, Where, Why and How | | |
| Context: past research, needed research | | |
| Details and statistics | | |
| Quotes from experts | | |
| Quotes from stakeholders | | |
| Your future plans to research the topic | | |
| In line Attributions | | |
| Original photo to illustrate | | |
| Caption and photo credit for picture | | |
| Work cited for teacher to use | | |
| Article passes plagiarism filter | | |

**Method of Student Communication**

In addition to the Science News Article written by the students for the background section of their project, a news release is written upon its conclusion as well as the standard science fair display board. The students complete an experimental design, followed by data collection, graphing or analyzing their statistics and then forming conclusion based on their findings. These elements are added to the background section to form a report, the key portions of which are displayed on a board for the science fair. Once the science fair boards have been judged and the science fair event reaches its conclusion, I have the students prepare a science news release of their findings which has a drastically different format from that of the science fair report and display board.  A copy of the rubrics used by the judges which is from the Greater St. Louis Science Fair (Academy of Science of St. Louis, 2014) can be found in Appendix B, one for controlled experiments and another for observations. The report, displayed on a free standing board is the primary focus of the judging at the science fair. Students are not interviewed nor do they present their results orally to the judges.

I use the science news release with my students as a means for them to communicate their findings to their peers, the same peers who began the journey with them as they struggled to decide upon a topic to research. The science news release is a condensed version of their project and it is not only written but also presented to the class. The news release is comprised of a descriptive title, a lede, a summary of why the student carried out the project, how they carried out the project and what they found. Students are encouraged to include graphs and pictures as much as possible rather than paragraph descriptions.

The students present the results of their projects in the news release format via 3 minute “elevator speeches” in the classroom. Students take turns displaying their news releases, standing next to them and giving short explanations to their classmates and being the audience for these poster sessions. Usually 6-8 students present their news release at a time with the rest of the class as the audience, moving from poster to poster, similar to a gallery walk.

In table 4.13, the topics for 23 of the students involved in this study are shown, providing the title of their news article and the corresponding title of their science fair project. These examples are representative of the work of the 116 participants in this three year study.

Table 4.13

*Examples of Participant Student Research Project Topics*

| **Title of Science News Article** | **Problem Statement from Science Fair Report** |
|---|---|
| Converting Trash to Energy | What is the effect of different types of biomass on the production of biogas? |
| CFLs: Friend or Foe to the Environment? | If people are knowledgeable of CFLs, do they know to recycle them? |
| Ground Level Ozone on the Rise | Are ozone levels highest in rural, urban or suburban areas and at what time of day are they highest? |
| Should I get a tattoo? | Does the body's reaction to tattoos decrease the more often you get tattooed? |
| The Sandman in the Classroom | Does the progression of the school day affect the level of carbon dioxide in a classroom? |
| The Great Disappearing Act | What is the difference in longevity between fingerprints from people of different ages as measured by analysis of dusting? |
| Does the Mississippi live up to its name? | How does the distance from the source of a river affect the amount of pollution as indicated by pH, sediment, conductivity? |
| Which Bathing Suit is as Tough as the Swimmer in it? | Which bathing suit fabric's elasticity will withstand the chlorine by breaking down the least? |
| The Use of Sunscreen when Young Prevents Skin Cancer when Older | As the age of a person increases and the use of sun screen decreases, is the person more likely to get skin cancer? |
| Cell Phones May Increase Risk for Brain Cancer | Does exposing mealworms to the electromagnetic radiation emitted by cell phones cause them to grow faster? \ |
| Metros "Linked" to Ozone Pollution? | Is ozone pollution increased by the metro system or mass transportation? |
| Breakfast of Champions | How does the percentage of carbohydrates, proteins and fat ingested at breakfast affect the time needed for a student to complete a memory test? |
| Are athletes more likely to kick breast cancer? | Do women who were college or high school athletes have less of a chance of having breast cancer? |
| Asthma and Air Pollution | Is there a connection between asthma symptoms experienced and the amount of allergens and pollutants in the atmosphere? |

Table 4.13 (Continued)

| **Title of Science News Article** | **Problem Statement from Science Fair Report** |
|---|---|
| Can Sports Drinks Lead to the Erosion of Tooth Enamel? | Which Sports Drink Erodes Teeth the Most? |
| The Key to Academic Success: Exercise! | How do exercise and the amount of exercise correlate with the time it takes for the brain to react? |
| A Simple Solution to a Sunny Situation | Does the price of a pair of sunglasses affect the glasses' ability to block out sunlight? |
| Plants: Classroom Heroes | Do plants help to reduce the levels of carbon dioxide in the classroom? |
| Hot threads | Which type of fabric burns less, making it safest for clothing and uses in the household? |
| Burn Baby Burn | Does aerosol sunscreen protect human skin as well as topical sunscreen of the same SPF? |
| What's in Your Water? | How does the amount of hormonally-active chemicals in various points of the Meramec River, change from rural to urban areas? |
| Oceans in Crisis | Is the increasing acidification of the world's oceans impacting the hearing of the fish which live in them? |
| Corn for Fuel or Corn for Food? | Which plant material, when fermented produces the most alcohol for use as a biofuels? |

Before the news releases are displayed and presented, they will have gone through a feedback and revision process similar to that used on the background science news article. Once the students receive the final feedback from their peers during the gallery walk those who choose to may submit their news releases to the SciJourn editor to be considered for publication.

An example of the project stages of one student, 'Becky,' from topic selection to science news article to science fair report to science news release can be found in Appendix C.

**Sequence of classroom activities**

Over the course of the three school years in which I carried out this study, I have developed a series of classroom activities for the process of integrating journalism activities into the science project process for my honors chemistry students. In determining the effectiveness of a strategy I would consider the type of talk occurring within the classroom during the activity. Were the student discussions centered on the activity or on the upcoming school dance? Were the questions that they were asking content based or to clarify my instructions? Were the students finished with the activity before the class was over, with ten minutes of idle time or were they rushing out when class ended frustrated because they had only finished half of the activity? I would also ask the students, as I circulated throughout the room, if they had any questions, or if felt that they knew and understood what they were doing. In the best case scenario, at the end of the activity we would unpack the experience and go over what the students gained and what improvements could be made to the process.

These lessons and their sequencing remain a work in progress, evolving with each iteration and group of students as I continue to use them with my current students. Table 4.14 summarizes the process as it existed at the present time, upon the conclusion of the study. It contains the classroom activities and the resulting student processes which were found to be most effective. Each of the classroom activities was scaffolded with visual presentations projected on the screen in the classroom, handouts of materials and other materials as needed. The student processes were scaffolded with directions given orally and in writing along with specification sheets for the desired products.

Table 4.14

*Sequence of Most Effective Activities and Processes*

| | |
|---|---|
| Ongoing: RATAs to introduce content topics | Brainstorming activity on chemistry impact on life |
| | Logbook activity: Reading the news |
| | Fish Bowl activity for topic selection |
| | Individual topic selection meetings of student with teacher |
| | Guided discussion of using Diigo and Evernote while researching |
| | Guided discussion of finding credible sources |
| | Guided discussion of interviewing experts and stakeholders |
| | Guided discussion of inverted triangle format of a news article |
| | Guided discussion of in line attribution |
| | Students research locate credible sources and research on their topic |
| | Students organize their research using Diigo and Evernote |
| | Students locate and interview experts and stakeholders related to topic |
| | Students craft news articles on topic chosen |
| | Peer editing using track changes |
| | Students revise articles |
| | News articles are submitted to teacher for feedback |
| | Students revise articles |
| | News articles are submitted to editor for feedback |
| | Students revise and resubmit articles to editor until published or rejected |
| | Structured laboratory experiences to develop understanding of experimental design features |
| | Students craft experimental designs for research project |
| | Peer editing of experimental designs |
| | Students revise and refine experimental designs |
| | Experimental designs are submitted to teacher for feedback |
| | Students revise and refine experimental designs |
| | Students carry out experiments, observations or survey for research project |
| | Students analyze their data and draw conclusions |
| | Students write their science project reports |
| | Peer editing of project reports |
| | Students revise and refine project reports |
| | Project reports are submitted to teacher for feedback |
| | Students revise and refine project reports |
| | Students craft display boards for science fair |
| | Students present their work to the school community during school pre-fair |
| | Students revise reports and display boards after feedback from peers and school community |
| | Students present their projects at the Greater St. Louis science fair |
| | Students craft news releases which summarize their research findings |
| | Peer editing of news releases |
| | Students revise news releases |
| | News releases are submitted to teacher for feedback |
| | Student revise news releases |
| | News releases are submitted to editor for feedback |
| | Students revise, resubmit news releases to editor until published or rejected |

**Changes in Teacher Perspective**

In addition to the classroom processes for the science research project changing with the use of science journalism, my teacher attitude and outlook have changed. During an interview, I describe how my perception of the needs of my students is beginning to shift:

> …my biggest take away was we need to stop focusing so much on the little scientist (O'Neill & Polman, 2004) and focus on the little citizen, the citizen who needs science to exist in today’s world, and so that is the kind of emphasis I would always give… that we’re using the backdrop of science and chemistry and what’s going on chemically out there, but taking that and … making decisions about it … that’s where the journalism skills come in.
>
> I mean for years and years …I’ve been teaching science class as though everybody in the class is going to go on and get a masters in science and be a little scientist ….I realize that the majority of them weren’t going to, but I still expected them to know the science as though they were going to be, ... now I think the SciJourn’s helping me with this transformation of my thinking to …what they do need to know to survive life on our planet and in the United States in the 21st century? The SciJourn project helped build skills and to see that these pieces of information, this knowledge base was changing constantly and related to them, not something dead and memorized and put in a file box and forgotten about; it actually had some application to their lives … that actually feeds into the ...responsibility to

> try to engage them in science to where they see that it's a part of their life. So, it's not just enough to make this foundation for the rest of their coursework …I believe my responsibility is also for them to see that it does fit with the rest of their lives.
>
> When we get up to the junior honors courses, most of those kids, if you ask them, they're going to be scientists, so I do have to prepare them for college level science work, I do have to prepare the little scientist,. But I also need for them as scientists to understand their role as a citizen and how it affects .the rest… of the planet. So it is not just science for science's sake but science to help others…
>
> It is not enough to be a scientist; you have to be a scientist who's helping the rest of the world and addressing the needs out there (Davidson, 2011).

King (1993) introduced the idea of teachers moving from the stance of sage on the stage to guide on the side. Through my work on integrating journalistic activities into the student research projects, I have begun to understand the value in making that transition.

As I worked with Read Aloud-Think Alouds with my students I found the students to be more attentive and engaged in the process when they were the ones actually reading the articles. I have found that during class discussions if we sit in a circle, and I take the same position as the students in the circle, that the discussion will be more fruitful and longer in duration than if I stand at the front of the room or to the side of the group. I find myself looking for ways to move the center of attention from me as the teacher to that of the students interacting with each other.

Think, pair and share activities have become the norm within my classroom as students grapple with content material. They think about what they have read, try to make sense of it with a partner and then share their ideas with the classroom as a community. Their understandings appear to develop and evolve through this type of interchange, more so than when they just sat and copied what my powerpoints said or tried to jot down what I would be rambling about. I still feel that I need to move further in this direction as I have had such positive reinforcement from the students. Their test scores have risen, not fallen from this approach and I feel that they are better prepared for college. These are anecdotal findings, not quantitative studies. Studies of the science journalism activities such as the think, pair and share activities along with those of unpacking a lesson upon its completion would be helpful in determining their impact upon student engagement.

I have come to realize that even though less of the content areas are addressed during the course of a semester, the depth of student knowledge has actually increased through using the science journalism devices. I use Read Aloud-Think Alouds for most content topics now, not just with the science research project. We discuss credible sources for most assignments, from laboratory reports to free response essays. We Google, search online together to find information that we need to solve a dilemma or to answer a question posed within the classroom community. I have found that if it can be engineered so that a peer makes a reference or provides information to the class, that it is often viewed as valuable as my own suggestions, sometimes more valuable.

I have begun using track changes in critiquing my student's documents and my students have begun using it when peer editing each other's projects. This feature on Microsoft Word was introduced to me in 2010 at the SciJourn training institute and I have used it with success since then. My students are able to follow my comments better as they can clearly read them in situ, rather than off to the side. My students, when introduced to track changes appreciated it even more and several of them use it themselves when reviewing their own papers. As a feedback tool, the track changes feature has been invaluable use of technology.

I have also experimented with different methods of keeping track of sources and sharing them within the classroom community. The digital tool Diigo (Diigo, Inc., 2013) is a social bookmarking program which allows students to bookmark, highlight, tag and comment upon resources that they find of value. They are also then able to share these with individuals, the teacher or the entire class. It has helped my students to become more organized as they carry out their background research and enables me to keep tabs on students who are falling behind. I have begun investigating Evernote (Evernote Corporation, 2013), a digital notebook which allows the students not just to bookmark but to also save entire articles and document, sharing them with other individuals. For long term projects, Evernote might prove to be even more beneficial than Diigo for helping the students with organizational issues. The students with which I have used it feel that it has helped them to keep track of their workload. Several are using it with other coursework, outside of chemistry.

In the past my students submitted a paper for my evaluation one time, on the due date. The feedback which they received, the grade, was final. Since integrating science journalism into my coursework I have seen the positive impact of allowing revisions by the students. I now grade assignments and give constructive feedback, usually with track changes. Students are allowed to revise their work and resubmit it for half back points, half of the deducted points for each improvement that they make. This allows students to catch the little mistakes that make their papers less than professional and to spend additional time to improve their work. My students frequently have problems keeping up with their assignments from the 7 or 8 courses which they take each semester. Allowing them to revise a paper gives them the leeway to focus again on a paper that perhaps the first time they were not able to give it their full attention. The idea of multiple revisions also more closely approaches the reality of scientists carrying out research in the field today. Scientists move through cycles of peer feedback and revisions as they carry out their work.

Peer feedback through discussions and peer editing are also a new feature in my classroom since beginning to implement science journalism activities. I am finding that developing a classroom community, fostering feedback and collaboration is positive for all involved. Trust issues have arisen as I have tried to foster a more communal atmosphere. Students often feel more competitive with each other than collaborative. As more group work becomes the norm in my classroom I anticipate that these issues will be resolved. Currently, I am able to find groups of students within the entire class who are able to successfully form a collaborative unit.

Another aspect in which the classroom dynamic has changed is that now the students are asked to collaborate with me on their due dates and the creation of the specification sheets with which will be used to evaluate their projects. In the past, I made all of the decisions about when projects were due and what features needed to be included. Now when we begin a unit, I negotiate with the students as to the due date, " I am thinking that these will be due in two weeks, what date around that time do you think will work best?" "So, when is the project in English due? Can we work around that so they are not both on the same day?" "So it looks like this date will work for most of you, right?" I have found that I am now negotiating due dates with the students for most major assignments, not just the work on their independent projects. This has impacted the classroom atmosphere, reducing the stress level. It has also helped me to connect on a more personal level with the students.

Discussions of the specification sheet occur several days before the due date. I ask the students to brainstorm with me what should be included in the final project, what features it should include. I am always amazed at how animated this discussion becomes. Some of the students prefer rigid, detailed lists of every feature which must be included and the point value to be associated with them. Others feel that more broad descriptions work better, categories rather than individual directives. Usually by the end of the class period we are able to develop a list of essential items to be included, such as the example given previously in Table 4.12, Science News Article Specifications on page 100. I find it interesting also that if I hold this conversation with three separate classes of students, the resulting specification sheet is almost always identical. Sometimes a class will decide that a feature is needed that differs from the other classes. In that case, I go back to the others and suggest the addition of that feature, explaining that the other section of the course felt it was needed. Usually they will agree to the addition.

An increased openness has occurred during our class discussions as the students have come to consider my classroom as a safe environment. The students have come to realize that not only am I open to discussing their ideas with them, that other members of the class are also interested in what they have to say. In the science fair and the publishing process, the students are competing with each other. In my classes because of this openness the competition is stimulating, motivating rather than destructive. The students realize that all of them are able to be published if they persist and work at their revisions. The students have found that most of their science fair projects are now able to move on to represent our school at the regional science fair.

When working with my students on any project or paper in the classroom, I now emphasize the science journalism research skills. I intentionally teach about locating and evaluating credible sources online. I model this by searching topics with them, modeling the process. For example when we were discussing molecules and molecular bonding, I posed the question, “What is carbon monoxide, is it important to know about?” When no student responded, I asked them to research the topic. After a few minutes had passed, I opened the search engine and typed in “Carbon Monoxide” with the results shown in Figure 4.2. I asked them which sources would be the best ones for us to use and after a brief discussion decided that those from the EPA, the CDC and OSHA would be the most credible. We then went on to discuss why they needed to know about carbon monoxide. This intentional reinforcement of key researching skills, integrated into the daily work within my classroom, has prepared my students for the larger tasks that occur within the course such as their formal lab reports and their independent research project.

The emphasis on relevance of topics for the student research project has impacted my perspective on the content coverage within the course itself. When I am planning out my coverage of content areas, I now brainstorm topics which have connections to the students’ lives, relevance to my teen audience.

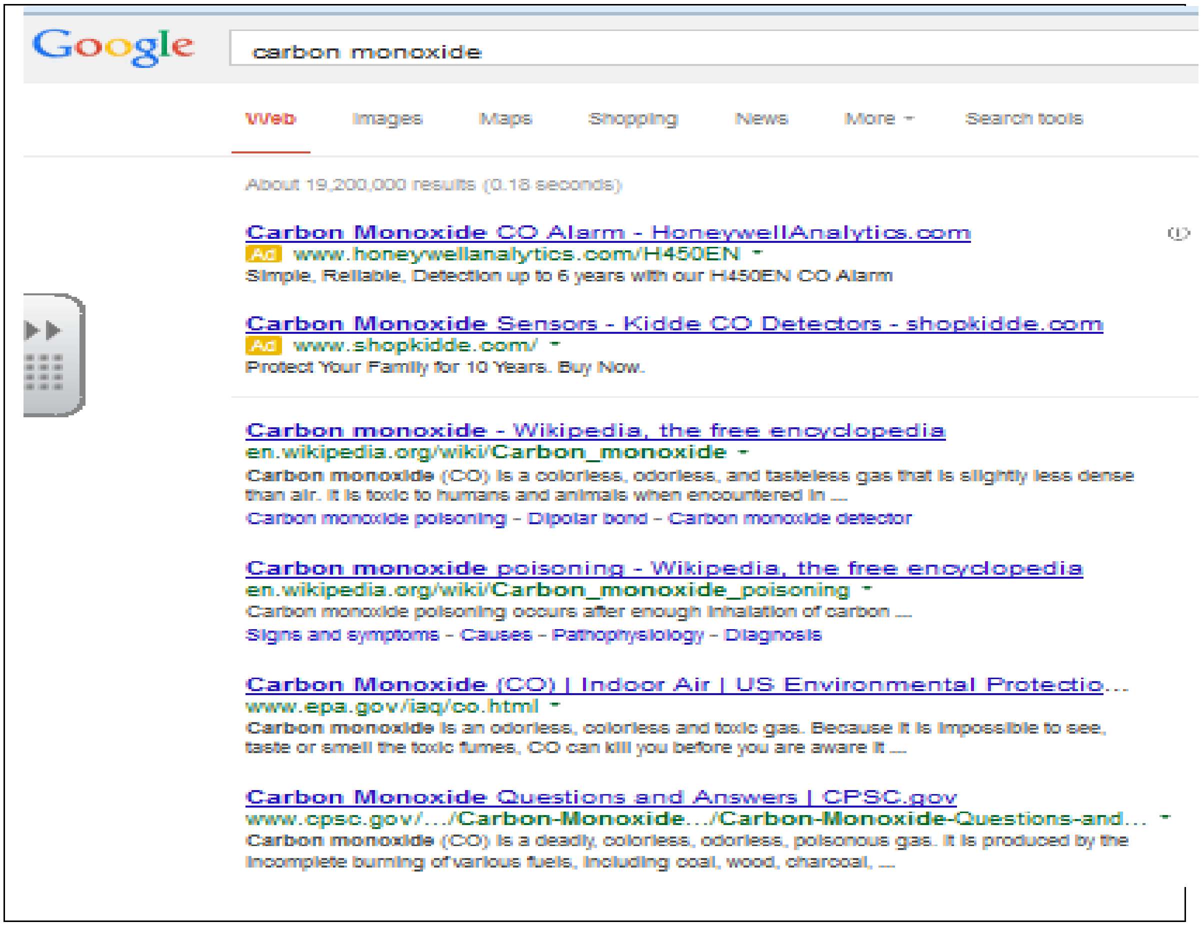



*Figure 4.2.* Results from Search on Carbon Monoxide

I use these topics within our discussion of course material and use them as Read Aloud-Think Alouds to generate interest in more mundane topics. When interest appears to wane on a particular topic, I often ask, “Why do we need to know about this?’ which instigates a spontaneous internet search on the topic and the connection to daily life.

Other changes which have occurred as a result of the integration of science journalism into the independent research project are driven by the topic choices of the students. Often the topics chosen by the students for their research determine the type of projects which the students carry out. In the past, my students were limited by me to carrying out projects which revolved around a controlled experiment. These types of experiments have a rigid format in which the student poses a hypothesis and then tests it by running three or more trials with a control for comparison. When science journalism and the broadened topic selection discussed previously are introduced, the direction of the student research may take students away from the possibility of a controlled experiment. For example, when a student is researching the connection between athletics and breast cancer, a controlled experiment would not be possible with the time frame of three to six months, nor would they be allowed or have the ability to carry out a controlled experiment on breast cancer. This has begun to occur in an increasing number of situations with my students. They are interested in researching a topic which has relevance to their own life and is scientifically significant yet is not able to fit the rigid parameters of the standard science fair project. The solution to this has evolved over the past three years in my classroom. We have found that surveying stakeholders often yields usable data. In the case of athletics and breast cancer, the students involved carried out a voluntary, anonymous survey of the female parents in our school community. Their survey included questions about exercise habits, whether or not they played sports in high school or college, histories of cancer in their family, overall healthy habits, and then whether or not they had ever had any form of cancer of the breast detected and if so, the extent of the cancer. Surveys to look for correlations, such as this study on athletics and breast cancer, fall loosely within the science fair guidelines for observational studies.

There are times when an opposite situation develops, for example, when a student wants to carry out a survey on a topic which is better covered through a controlled experiment. One student wanted to find out if carbon dioxide levels within the classroom were causing students to become sleepier, so she planned to survey the students in the school. I suggested that instead she use a recently acquired carbon dioxide probe to actually measure the carbon dioxide levels within classrooms. The project evolved to a controlled experiment within my classroom where the student recorded the carbon dioxide levels throughout the entire school day, finding that the carbon dioxide level rose dramatically during periods when class was in session. Other students have built on her initial idea to test whether plants change the level of carbon dioxide or if the size of the room impacts the level. The acquisition of additional carbon dioxide and dissolved oxygen probes, conductivity and pH meters, and digital spectrometers has provided new possibilities for controlled experiments.

**Summary**

Integrating science journalism with the research projects of my honors chemistry students has brought about significant changes to the process. The topic selection process has become more authentic and relevant for the students through the practices of brainstorming, modeling through Read Aloud-Think Alouds, reading the news and connecting it to science. The classroom and teacher to student dialogues about topics and the development of topic ideas through Fish Bowl activities have provided for the selection of more robust topics, that are connected to the interests students and to the events unfolding in the scientific community. The background research for their project has been improved by the online research and interviews needed to successfully craft a science news article on their topic. Their ability to communicate their findings to others was given another facet with the addition of the news release about the findings of their research. These changes in my teaching practices have brought the science research project into the classroom, where it is a community event, rather than one which is carried out in isolation by the student.

This integration of journalism and the practices that evolved have also impacted my attitude and perceptions as a teacher. I find that I have shifted my attitude away from the education of little scientists to the education of little scientists who are also little citizens. I have shifted the focus in the classroom from myself as the sage on the stage to that of the classroom as a community of learners. The use of technology to facilitate the sharing within the community, the inclusion of feedback loops, the addition of collaboration and openness to other's ideas have resulted from this shift in focus.

This project describes the beginning of my journey as I improve my teaching practices through the integration of science journalism. It is an incomplete and iterative process which will continually evolve as each year brings additional facets in the form of new students, and events occurring in the world at large. The following chapter discusses how this evolving process of the integration of science journalism has impacted the learning behaviors of my students.

# Chapter 5

# Changes in Learning Behaviors

## Introduction

Research questions include determining what happens to the student learning behaviors when students are trained in the research practices used by science journalists, and then use them in their own research, representing their findings with science news articles and news releases. This chapter will discuss the changes which implementing this science news protocol brought to the behaviors exhibited by students and their impact on the classroom and school dynamics. It will also address the development of the scientific practices of the students and how they were enhanced.

Interviews of my participant students by the SciJourn researchers, Angela Kohnen and Jen Hope were invaluable in providing insights into the dynamics of my classroom and in confirming the perceptions which I had developed. Often I would be immersed in classroom management activities and the finer details of my student's learning practices would escape my attention. This interview data and anecdotal stories which are crafted from my journals and recollections of lived experiences are recounted within this chapter to provide evidence of the changes in learning behaviors which occurred during this study. The examples to provide this evidence are chosen because they are representative of the experiences of my students, not exceptions.

In May of 2013, the SciJourn research project came to its conclusion and an unpacking of the process took place. Table 5.1, provides the response that I wrote during the feedback portion to address the question, "What impact has SciJourn had on your classroom?"

Table 5.1

*Feedback on the Impact of SciJourn in My Classroom, May, 2013*

| |
|---|
| SciJourn has had a major impact in my classroom. It has changed the way that I teach the class, the way that my students view science and the way that my students view themselves as scientists.<br><br>Before SciJourn my teaching was aligned along the lines of the Sage on the Stage attitude. I was the expert in the room and the disseminator of knowledge. As I experienced SciJourn with my students, I began to transition to a cooperative group dynamic within my classroom. As I began using the Read Aloud process, one of the key SciJourn practices, for the first time I noticed the students beginning to feel the agency to present their opinions, to ask questions outside of the proscribed topic, to begin to wonder about science and its impact upon their own lives.<br><br>As the students began to research topics of interest to them individually, I saw the students engage with the knowledge and to begin to add to the knowledge within the classroom itself by sharing what they themselves had learned with the others within the classroom. The students began to want to learn the best ways to find out information on their topics, not because it was for a grade but because they really wanted to know.<br><br>Many of my students have now taken a second look at science as a career. Whereas before they thought of it as boring, or for smarter people or nerds, they now begin to see the connection to their own life and how they might be able to be a part of it. In other words, they are thinking of majoring in some field of science in college.<br><br>Since I teach at an all female school where science traditionally is not the favorite subject, this is an important change. We now have more students who are taking upper level science courses, asking for increased science course offerings and joining up for the science honor society than ever before. Our school is even thinking of becoming THE STEM School for females in the St. Louis area. Maybe not all of this change was due to the SciJourn program but I feel that the 400 students that have been exposed to the process over the past 3 years are definitely the driving force behind this changing attitude toward science as a field of study and area of interest. |

My responses point out some of the changes that the integration of science journalism into the research process with my students has had on our classroom and school community.

After analyzing the data collected in my classroom during the three years of the study, I have found four main areas of change in the learning practices of my students: 1) their motivation and engagement, 2) their formation of a community of learners within the classroom, 3) their emergence as experts and 4) their development of the practices of scientists. In addition I have found that for some students the implementation of science journalism has brought about a trajectory change in their educational outlook.

## Student Motivation and Engagement

Much has been asked of my honors chemistry students as the participants in this study. They have been asked to carry out a scientific investigation of substance. They have been asked to carry out a review of the literature on the topic of their investigation. They have been asked to carry out personal interviews with stakeholders and experts to enhance this review of the literature. They have been asked to craft a science news article on their research and then to refine it through a process of multiple revisions. They have been asked to craft a science report of the findings of their investigation. They have been asked to craft a news release which summarizes the meaning of their work.

What keeps them moving forward in the process? How are they able to sustain their motivation during this process? As I examined the data sources, three factors emerged as the driving forces for their successful completion of their research project and the associated science journalism activities; 1) their increased connection to the content, 2) their desire to become published, and 3) their desire to reach career goals.

### Increased Connection to Content

During the February 2012 in-service for the SciJourn teachers, I noted a comment made by Dr. Polman about the current generation of our students. He asserted that this generation needs a reason to learn, that they need to be shown how a concept connects to their lives, how it will impact them down the road. This resonated with a perception that I already had about teaching students: if you can connect the material to the lives of the students, they will be more engaged and motivated to learn more. In this study, the students have persisted through an obstacle course of required elements for their research project. Their success in this progression for many of them is due to the personal connection which they had to the topic which they chose to research.

I was asked in February of 2011 to respond to a number of prompts by the SciJourn research team to assist them with an article which they were writing about the project. To the question, "Do you feel that writing these papers improved their science literacy?" I responded:

> The biggest benefit to these students in terms of science literacy has been the development of their understanding of how chemistry connects to their lives, that it is not just a tough class that they have to get through. By reading published articles, locating and interviewing experts and then writing an article in a journalistic perspective, the students have made personal connections to at least one topic in chemistry. This personal connection is the key to learning science in my opinion. Interviewing experts also helped them to make connections with people outside of their normal sphere of operation: pushed them outside of their comfort zone. I feel that this also helped them to grow in their understanding of the scientific process as well as careers available to them.

I found that if a student could make a connection between the topic which she was researching and her own life, that she would persist in the process and become less frustrated with setbacks. The addition of science journalism to the student research process has helped the students to form these ties to the real world.

One of my students, ‘Sue’, discussed, in an interview (Sue, 2011), this connection of her research project topic to her life that captured her attention and gave meaning to her science journalism research.

> My science fair project was comparing different types of tap waters from around the country I had accumulated samples of from people traveling on trips … so, I decided to write a article about if tap water is safer than bottled water because I had heard a lot of different opposing viewpoints … of how if one was safer than the other, or if one was worse than the other and, so I, I thought it would be interesting to write an article comparing the two viewpoints.
>
> ...I’ve heard different things, like people saying oh tap water is really bad, you shouldn’t drink as much of it as bottled water and I thought, as I was coming up with my science fair project idea, that was just kind of in the back of my head, like, is tap water better than bottled water? Should I be comparing bottled water from different countries, or, from different regions?

When asked if anything that was learned would come in handy in the future, Sue responded:

> …I think just for my own life, I guess, I think it might come in handy because cost-wise I guess…I don’t drink it as much. So I guess my life

> kind of changed cause of the things that I found out...it will probably come in handy in college, just a different way of doing things.

Sue's connection to her topic sustained her engagement during the project and allowed her to persist through the editing process. Her article was one of those chosen for publication by the SciJourn editor. More importantly, as indicated in the second excerpt of the interview, Sue has changed the everyday behaviors in her life because of her own findings about bottled water.

Another student, 'Jan', was interviewed about her project as well (Jan, 2011). Her project centered on the impact of carbon dioxide on students in an enclosed classroom.

> Jan: Carbon dioxide, well, we began the semester with reading these different chemistry articles to get ideas about what we could possibly do for science fair projects … how this is relevant to everyday life, so, with that, I kind of came across some stuff that was talking about different energy sources … which one produces more carbon dioxide and putting that into the environment and...I kind of was struck by the carbon dioxide …from human respiration ....so I was talking to my teacher about it, and together we kind of crafted this plan….of testing carbon dioxide in the classroom, is it really making students sleepy?
>
> … okay, I'm going to write this paper on carbon dioxide and how it's prevalent in the classroom and how it affects students. I'm going to find if there's any research or any other studies that are linked to this or that prove that this is… causing students to become drowsy and that's really more so what I focused on.

> ...I used a Logger Pro carbon dioxide sensor; put it in a classroom for an entire day and I saw how the carbon dioxide level goes up and down throughout the day.
>
> And I found that … during a given class period it will go up but the minute the students leave the room, it just goes back down.
>
> …I thought that was really interesting that …the level of carbon dioxide in the room is that sensitive.

When asked if she thought that the science journalism project should be repeated with other students, Jan replied:

> I think it’s important that students do more than just stick to their school and their classroom I think people need to get more outside of their comfort zone and expose themselves to different areas of science and different applications of it
>
> … I think it’s a neat experience for students to be able to kind of see a little glimpse of the real world, what it’s like… to have an editor, to have people looking at your work and you know the editing process, I think it was neat.

Jan’s connection to her topic lead her to develop a unique procedure, using digital sensors, to determine the answer to her research question on the carbon dioxide level with classrooms. She tested our classroom for six days, over a seven hour period each day. She successfully completed her science project which won many awards. She successfully completed the rigorous editing process to have her science news article published as well as the news release which she crafted from her study's results. One of the factors which motivated her through the process was her connection to the topic. She wanted to know the answer to her research question, "Does the progression of the school day affect the level of carbon dioxide in a classroom?"

**Desire to become published**

Factors other than the connection to the topic also played a role in maintaining engagement in the process of writing science news articles. Often the student persists because of their desire to reach the goal of being a published author. Sue, during her interview (Sue, SciJourn Participant Interview 2, 2011) touched on this issue.

> Sue: Yeah, I resubmitted it; I think I did it twice after.
>
> Researcher: And did you ever consider just not doing it anymore?
>
> Sue: I kind of, I did consider it but then I thought I've come this far, I've improved it so much, I don't really want to give up.
>
> Researcher: So, was getting it published, was that a big incentive for you?
>
> Sue: Yeah, it kind of pushed me, 'cause I really wanted to get it published cause all the other people in my class were, getting theirs published so I kind of wanted to have mine published too.
>
> Researcher: Then when you found out you were published, how did that feel?
>
> Sue: It felt really good, I was really excited
>
> I went home and told my mom and my dad and they were pretty proud of me,
>
> I guess 'cause they had known I was working on it for so long

> So, I was happy.
>
> It's really rewarding if you do get published, I think that's a good incentive to do one just because it might be a lot of work at first, but... you end up after you've written it with a lot more information about that topic and you can share it with other people and if you get published it's really rewarding.

Sue mentions in the interview the extrinsic rewards that she was striving to attain: recognition by peers and the pride of her parents. She also mentions the intrinsic rewards of knowing that she did not give up and that she was adding to the body of knowledge and sharing it with others.

It is important to note that the majority of the students who have been published persisted beyond what is expected for their grade on the paper for their chemistry course. Once the article has been submitted to me for grading and the student has received credit for her revisions, her work on editing the article for publication no longer has an impact on her grade in the course. Students who persist through the publication point have usually been through six or more editing cycles. Of the 116 participants in this study, 18 were published, and 6 others came very close. There is something about the process of publication that motivates the students, it hooked them and then in the process they learned something.

The interview with Jan (Jan, SciJourn Participant Interview 2, 2011) further revealed the intrinsic motivation which she possessed.

Jan: So, I think it was by the second or third edit one of the girls got her article published. I was crossing my fingers like please let this be my last edit but I still had like a few more things to tweak. And it was fine. Finished those up, sent it in again, and the next time it got published. So, it was all good.

Researcher: So you never really thought, you know, forget it, I'm busy, I do a million things, I don't need to?

Jan: It just like never occurred to me, I'm not exactly sure why. I was just like, eh, okay. You know, it just, everything seemed so doable, it was like, why not just do it, you know?

Researcher: You didn't get points or anything extra for this?

Jan: …here's his comment (the editor), "You did the work, you have the grade. You know, if you want to continue pursuing this, go for it". And, I don't know, it's just a neat experience….I've already done the body of work. Why not just make a few little track changes? And turn it in again, you know, to actually reap the benefits.

Researcher: And when you received the notice that you were accepted for publication?

Jan: Just, it was a nice feeling. Like, oh, that actually happened.

You know… you kind of feel a little bit of relief and you feel kind of accomplished just because… doing something outside of school is really rewarding, I feel like sometimes, just because we're all so focused on the grade, so focused on getting through this semester, next semester, …but

> actually being able to say, yeah, I took the initiative to do something that necessarily wasn't gonna result in a percentage grade for me…
>
> And then to actually… see the benefits of that it, it's a nice feeling.

The motivation exhibited by Jan, despite her additional work not being done for a grade, is remarkable. Not all of the participants persisted in the science journalism process to this same level. Most of the students did appear to exhibit the drive to succeed and to be considered for publication. Others appeared more concerned with how the process would affect their futures.

**Desire to reach career goals**

During an interview (Karen, 2011) 'Karen' discussed her thoughts on her future career goals and how she felt that addition of science journalism to the course curriculum was beneficial in that regard.

> …I like writing and I want to be an author when I grow up so that's what I like about it. … I like the different writing processes that different teachers give me, and I've never written like a newspaper article like this before with the process Mrs. Davidson gave us, so I… learned that too.
>
> …I saw Mrs. Davidson's article that was published on the website, and I thought that was cool how you can get things published on there….
>
> … I liked how everything was really well written in the newspaper, and because I think it'd be cool to like be a newspaper article author someday, and so I liked that.

When asked by the researcher if she had considered being a news journalist before this project, she responded, "I hadn't, but once I did this I really started liking it."

Not all of my honors chemistry students are planning to pursue careers in science. Often they plan to become lawyers or businesswomen. Others, like Karen, plan to become writers or historians. Those that do plan to become scientists find a natural fit with the science research project, those who plan on others careers benefit from the addition of the journalism activities to catch and sustain their interest.

Before becoming involved in the SciJourn process, I had been exposed to the idea of little scientists through a presentation by Dr. Joseph Polman in a doctoral seminar. In my notes I jotted the question he posed, “Why do we want children to learn science? Why educate little scientists when most will not grow up into real scientists?” He went on to describe the need for all students to be scientifically literate in today’s technological society (Polman J. , 2009). This idea of educating little scientists has been one that has driven the changes in my pedagogy described in chapter four. I described my view of the connection between my student’s career plans and the science journalism integration into the curriculum in an interview given to one of the SciJourn researchers in August of 2011:

> ...for the honors kids their writing was important because...the kids were trying to really step into their role as little scientists …that core group were the kids that envision themselves as becoming doctors or becoming research scientists…a lot of them, I think, saw this as “hey, I can get something on my resume if I get a good article together: if I get this, do this right, I can move up …they were taking these steps towards being expert science writers, and for some of them maybe…they were actually little journalists because they want to go into journalism. I did feel like this

> core group there was this agenda that … this is going to move me forward towards my future...that was a driving force for them and all the skills that we learned, they learned them because they needed them.
>
> You know, it's kind of like a just in time type of situation for them; it's like it hit just when they started thinking about college and getting into college...so what do I need to do to get recognized as a journalist or recognized as a science person?, what do I need to do to make this SciJourn thing work for me?, so then they started learning the skills to do it (Davidson, 2011).

I viewed the preparation of my students to be writers as well as scientists as an essential part of my undertaking. Scientists today need to be able to write clearly and persuasively. Scientists need to be analytical about the credibility of the research findings on which they build their own work.

**Community of Learners**

In looking over the data collected on my classroom, I see that the classroom culture has changed since I began integrating science journalism activities into our curriculum. The students have developed from isolated individuals to team members. The classroom is slowly evolving from being teacher centered to student centered, although there still is improvement to be made. The idea of a community of learners holds a different meaning for each institution, for each classroom. I am using the term to refer to the ideal of the students and the teacher, working with each other to enable all to successfully develop their knowledge base. Often a spirit of competitiveness can develop in an honors level science course and the drive to become a published SciJourn author could potentially add to that spirit of competitiveness. By modifying the science journalism activities developed by the SciJourn trainers to fit the needs of my classroom, I found the students becoming more collaborative and supportive of each other and of my efforts as their facilitator.

I have noticed an increased level of student interest and participation in discussions as well as unsolicited contributions of science information by the students. The students participate in discussions during the Read Aloud-Think Alouds and they bring in articles for the class to read. Often the discussions during these RATAs become so animated that a “talking stick” becomes necessary. A talking stick is passed from one person speaking to the next, to control who has the floor in a discussion. I have seen the students move from inanimate consumers of information presented during lectures to producers of information and constructors of knowledge which they share with others. When asked on the course exit poll, in December 2012, 61% of the participant honors chemistry students selected ‘Working with a Partner’ as the skill on which they had made the most progress. Three examples of this move towards a community of learners stood out when I reviewed our classroom videos and my reflective journal: the sharing of topic ideas during an activity called the Fish Bowl, the assistance provided to each other during peer editing and the sharing year to year with the students in the evolution of an article.

### Fish Bowl

When students are working to develop their ideas into a research topic, the Fish Bowl activity facilitates the sharing of ideas and the receiving of feedback from peers. The students are asked to divide into teams with six to eight members and then to move to a corner of the room where they can converse about their topics. The students take turns presenting their evolving ideas to the team and receiving feedback from the other members. They are encouraged to listen as the student presents their ideas and then to each give some type of response to these ideas. The following is an example of one such Fish Bowl conversation which I have reconstructed from jottings taken during the fall of 2012. It features a student, 'Ann' as the presenter of her idea and four other students, B, C, D and E, who are giving her feedback. It also involves the discussion of a tragedy which struck a family member of a school maintenance person, 'Jeff.' Jeff is beloved by the students because of his positive outlook on life and outgoing personality.

Ann: I want to do my project on fire.

B: Why?

A: I don't know, I just like fires, I think they are interesting.

C: Jeff's mom was just in a fire.

D: I know, it is so sad. How is she doing?

C: Don't know, let's ask Mrs. Davidson

B: Mrs. Davidson, how is Jeff's mom doing?

Mrs. D: Not very well, she was burned over most of her body. I am not sure that she is going to make it.

Ann: How did the fire start?

C: I don't know, maybe you can ask Jeff.

B: Maybe he will be too upset to talk to you.

D: Sometimes they start from cigarettes burning on the bed.

Ann: Maybe I can get an old bed and try putting cigarettes on it.

B: What if it starts your house on fire?

E: They don’t let you use cigarettes in science fair projects.

Ann: Maybe I could do like different materials and see how long it takes to start on fire.

E: Make sure they let you burn stuff in science fair projects first.

B: what kind of stuff?

Ann: like couches, tables, beds.

C: that sounds expensive. We have to do like twenty trials or something.

B: It also sounds dangerous.

Ann: let me think about it.

In this discussion Ann, with the help of her classmates, moves from her nonscientific interest in fire to form a personal connection with the topic through fire impacting someone she knew to her developing a scientific interest in the topic of fire.

Jeff did allow Ann to interview him about the cause of the fire in his mother’s home. His mother survived her injuries but is no longer able to live independently. Ann developed her idea into a science news article on the flammability of materials found in most homes. Her science fair project was a controlled experiment which tested the flammability of small fabric samples, from materials commonly found in the home. Her article was successfully published and her project won a number of recognitions at the Greater St. Louis Science Fair. What could have been the result of Ann’s interest in fire without the support of this collaboration with her peers? Would she have been able to reach this same level of accomplishment?

When I think back over the seven Fish Bowl activities which I have carried out with the participants during the course of this study, I have found common phrases which are used by the students providing feedback. These include:

> “Have you ever thought about ….?”
>
> “What if you looked at….?”
>
> “You might want to try….,”
>
> “Where are you going to find the …,”
>
> “Something like that happened to me when I….,”
>
> “I think it would be more interesting if you….,”and
>
> “I read an article about that in…..”

The students, when asked after the activity concluded, speak positively of the experience.

> “I hadn’t thought about that….,”
>
> “I really have a better idea now.…,”
>
> “Lots of new ideas for me to think about….,”
>
> “That worked really well for me….,” and
>
> “I’m going to see if I can find out more about….”

Often the students will form closer bonds with the other students which are developed even further during the peer editing process.

### Peer editing

Peer editing is one of the activities where students worked with each other to share their understandings of the journalistic process and to review the research work carried out by their classmates. Revision is a key component to improving the science research process for my students. Each student peer edits at least three times during the course of the science research experience and receives feedback from her peers on her science news article, her science fair report and her news release before they are submitted for feedback by me, the teacher and/or the SciJourn editor. By peer editing the student editor as well as the writer benefit from the process. The student editor is able to see how another person has approached the task, what techniques they brought to the process. The writer can enhance the quality of their writing through the feedback which they receive.

During the fall of 2012 during a course which I was auditing with Dr. E. Wendy Saul, I noted the following during a class discussion:

> Science teachers usually don't ask for much in terms of revision yet SciJourn is really high on revision. Use your skill as a scientist when doing revisions, to look at the thinking that underlies the writing. If you are not asking the students to revise, you are missing opportunities. Revision is the opportunity to show understanding of the big ideas that matter (Saul E. W., 2012).

I approached the peer editing process with my students with that attitude. Some of my students persisted in the revision process, revising their articles five to eight times and their science fair reports three or four times. While our peer editing process had its flaws in my classroom, the help which the students gave each other in the editing process was invaluable. Jan, in her interview on the SciJourn experience, discussed her feelings about the peer editing process:

> Jan: I think it was all helpful, when we did the peer editing. You know with peer editing you take some of the comments and reject some others but I think that's like an important life skill to learn in general.
>
> I mean I'm looking at the peer one right now and it's like 'maybe do this' 'maybe do that,' …I did the exact same thing when I was editing my friends, it's just, we don't want to be harsh and 'you gotta do this' 'you gotta do that,' especially cause we're all the same age, I mean we're all just kids.
>
> So… I think definitely when you're editing your peers, … a tendency to just be like 'oh, this is good, but maybe just, you know, work on this a little bit more.'
>
> I definitely had more feedback from Mrs. Davidson and people at SciJourn, but… I thought the peer edits were helpful, just kind of like things that they thought was interesting maybe I could expand on their comments (Jan, SciJourn Participant Interview 2, 2011).

Two focuses that I always had for the students during peer editing was their own interest in the article that they were editing and whether they could understand it or not.

> If it's not interesting, nobody's going to read it, and then secondly can you understand it? Can you understand what they're saying? Because if it's not understandable, nobody's going to read it (Davidson, 2011).

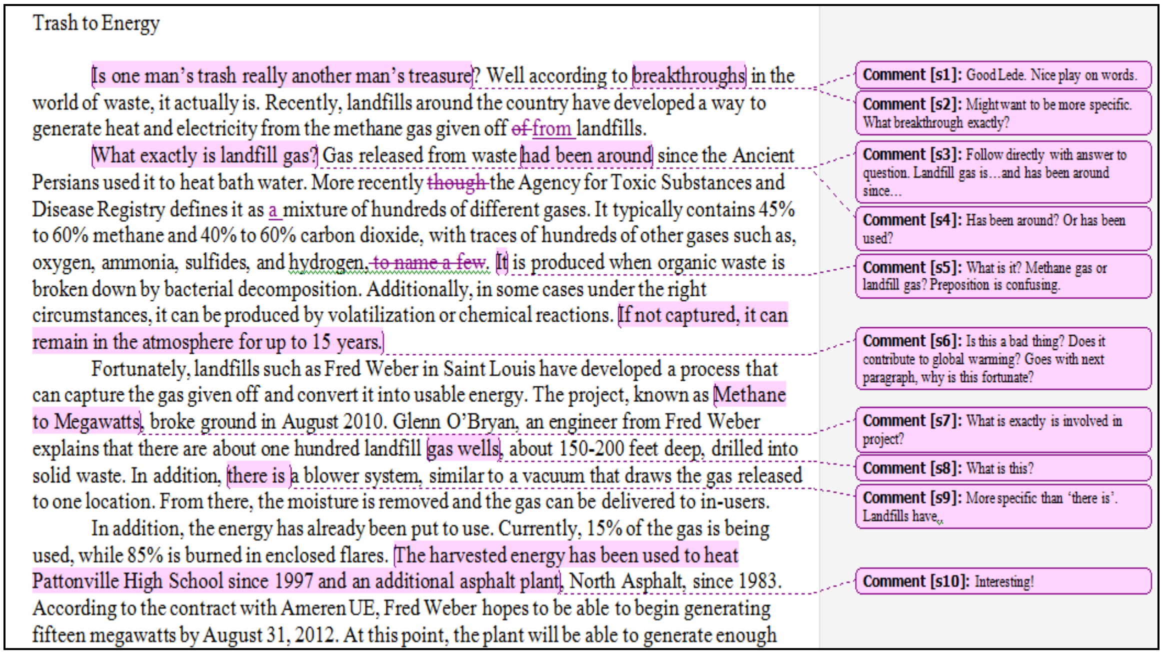
Some of the students responded well to these directions, others found it difficult to move beyond the affirmation of their peer's efforts.

> Karen: It (peer editing) helped a lot because since the article's supposed to be written for teenagers it helped to make like that it wasn't just a paper filled with facts and everything; that a teenager could actually read it and understand what they are reading and be interested in it (Karen, 2011).

The student's ability to provide constructive criticism of another student's work was the topic of a number of discussions within our class and by the SciJourn project staff. Often the students would focus on technical details such as spelling and punctuation rather than the big ideas and concepts that were being conveyed.

Figure 5.1 illustrates a peer edited science news article from the fall of 2010. The peer editor in this case does ask clarifying questions and provides grammar and sentence construction suggestions. The editor does sandwich her criticisms between two positives, a common practice at our school.

I feel that my students have made progress toward the goal of providing constructive criticism to aid their classmates but the process remains a work in progress. I continually reiterate the idea with them that it is not helpful to tell someone that their writing is good when it is not. I would like my students to be able to understand that sometimes you are being more helpful, a better friend when you provide a frank and honest critique.



Trash to Energy

Is one man's trash really another man's treasure? Well according to breakthroughs in the world of waste, it actually is. Recently, landfills around the country have developed a way to generate heat and electricity from the methane gas given off ~~of~~ from landfills.

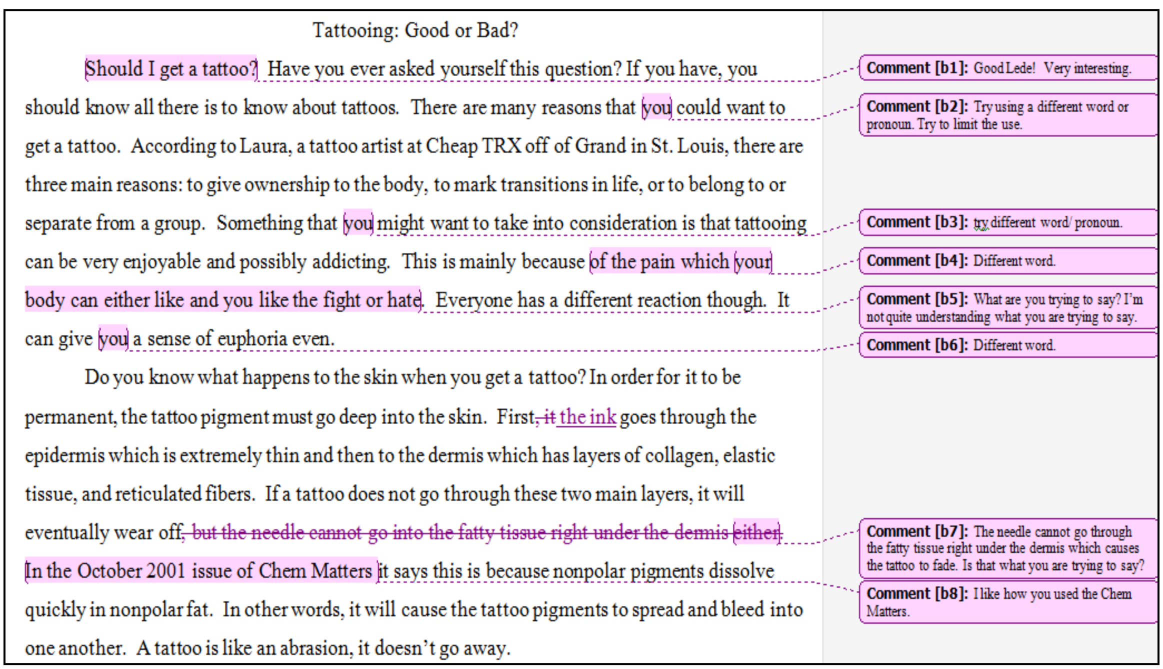
What exactly is landfill gas? Gas released from waste had been around since the Ancient Persians used it to heat bath water. More recently ~~though~~ the Agency for Toxic Substances and Disease Registry defines it as a mixture of hundreds of different gases. It typically contains 45% to 60% methane and 40% to 60% carbon dioxide, with traces of hundreds of other gases such as, oxygen, ammonia, sulfides, and hydrogen~~, to name a few~~. It is produced when organic waste is broken down by bacterial decomposition. Additionally, in some cases under the right circumstances, it can be produced by volatilization or chemical reactions. If not captured, it can remain in the atmosphere for up to 15 years.

Fortunately, landfills such as Fred Weber in Saint Louis have developed a process that can capture the gas given off and convert it into usable energy. The project, known as Methane to Megawatts, broke ground in August 2010. Glenn O'Bryan, an engineer from Fred Weber explains that there are about one hundred landfill gas wells, about 150-200 feet deep, drilled into solid waste. In addition, there is a blower system, similar to a vacuum that draws the gas released to one location. From there, the moisture is removed and the gas can be delivered to in-users.

In addition, the energy has already been put to use. Currently, 15% of the gas is being used, while 85% is burned in enclosed flares. The harvested energy has been used to heat Pattonville High School since 1997 and an additional asphalt plant, North Asphalt, since 1983. According to the contract with Ameren UE, Fred Weber hopes to be able to begin generating fifteen megawatts by August 31, 2012. At this point, the plant will be able to generate enough

**Comment [s1]:** Good Lede. Nice play on words.
**Comment [s2]:** Might want to be more specific. What breakthrough exactly?
**Comment [s3]:** Follow directly with answer to question. Landfill gas is…and has been around since…
**Comment [s4]:** Has been around? Or has been used?
**Comment [s5]:** What is it? Methane gas or landfill gas? Preposition is confusing.
**Comment [s6]:** Is this a bad thing? Does it contribute to global warming? Goes with next paragraph, why is this fortunate?
**Comment [s7]:** What is exactly is involved in project?
**Comment [s8]:** What is this?
**Comment [s9]:** More specific than 'there is'. Landfills have,.
**Comment [s10]:** Interesting!

*Figure 5.1* Excerpt from a Student Peer Edit of *Trash to Energy*, 2010



Tattooing: Good or Bad?

Should I get a tattoo? Have you ever asked yourself this question? If you have, you should know all there is to know about tattoos. There are many reasons that you could want to get a tattoo. According to Laura, a tattoo artist at Cheap TRX off of Grand in St. Louis, there are three main reasons: to give ownership to the body, to mark transitions in life, or to belong to or separate from a group. Something that you might want to take into consideration is that tattooing can be very enjoyable and possibly addicting. This is mainly because of the pain which your body can either like and you like the fight or hate. Everyone has a different reaction though. It can give you a sense of euphoria even.

Do you know what happens to the skin when you get a tattoo? In order for it to be permanent, the tattoo pigment must go deep into the skin. First~~, it~~ the ink goes through the epidermis which is extremely thin and then to the dermis which has layers of collagen, elastic tissue, and reticulated fibers. If a tattoo does not go through these two main layers, it will eventually wear off~~, but the needle cannot go into the fatty tissue right under the dermis either~~. In the October 2001 issue of Chem Matters it says this is because nonpolar pigments dissolve quickly in nonpolar fat. In other words, it will cause the tattoo pigments to spread and bleed into one another. A tattoo is like an abrasion, it doesn't go away.

**Comment [b1]:** Good Lede! Very interesting.
**Comment [b2]:** Try using a different word or pronoun. Try to limit the use.
**Comment [b3]:** try different word/ pronoun.
**Comment [b4]:** Different word.
**Comment [b5]:** What are you trying to say? I'm not quite understanding what you are trying to say.
**Comment [b6]:** Different word.
**Comment [b7]:** The needle cannot go through the fatty tissue right under the dermis which causes the tattoo to fade. Is that what you are trying to say?
**Comment [b8]:** I like how you used the Chem Matters.

*Figure 5.2*. Excerpt from a Student Peer Edit of *Tattooing: Good or Bad?*, 2010

Figure 5.2, illustrates the use of supportive of nurturing language by the peer editor to mitigate the criticisms. She begins her edits with praise for the article, stating that it has a very interesting and good lede. She concludes her critique of the first page with additional praise for the writer's use of ChemMatters as a reference. She sandwiches her criticisms in between these two positive comments but even these are couched in supportive language. Instead of bluntly telling the writer to fix a mistake, she guides them to "try." Instead of pointing out the need for clarity in the writing, the peer editor, turns inward, saying that she is having difficulty understanding the writer's meaning. Many of her comments are phrased as questions, for example; "Is that what you are trying to say?"

On an anonymous exit slip after a discussion about peer editing, one student had the following response to the question, "What do you take away from this discussion?"

> "I think perhaps when I peer edit people's work in the future, I should first question if their information is correct before I focus on little details. I will try to tackle the bigger problems with someone's work, make sure she is correct in that aspect before focusing on less egregious mistakes."

**Evolution of a Project**

The knowledge base created and communicated through the science journalism articles are being read and expanded upon by subsequent classes of students. I will illustrate this by describing the evolution of project ideas which took place over the three years of this study that illustrated this idea that the community of learners developing in my classroom extends over time.

Jan, during the 2010-2011 school year was the first student to begin using digital sensors to collect data for her science research project. Jan used a carbon dioxide sensor and the accompanying computer program LoggerPro to collect data on the carbon dioxide levels in classrooms during the school day. Her article, “The Sandman in the Classroom”, was published in The SciJourner which was read by the students during science journalism activities in the following fall. ‘Sally’ read this article and Jan’s follow up news release which contained her experimental design and results. Sally then decided to determine if bringing plants into the classroom would mitigate the carbon dioxide being given off by the occupants of the classroom. She researched and crafted a science news article entitled “Classroom Heroes” in the fall of 2011. She carried out laboratory research using an increasing number of plants in a classroom over time while measuring the carbon dioxide level using the digital sensor. She was surprised by her findings that rather than decreasing the level of carbon dioxide in the classroom, the plants caused it to increase. Her science fair report, “The Effect of *Spathiphyllum cochlearispathum* on Classroom $CO_2$ Levels,” for her project was entered in the May, 2012 Greater St. Louis Science Fair and discussed how the activity of microbes in the soil or other room conditions could have influenced her results. Three students in the following fall, 2012, designed additional science fair projects to probe the factors which influence the carbon dioxide level in the classroom. ‘Carol’ and ‘Kate’ carried out a revised version of Sally’s project where they controlled the size and openness of the classroom to determine if plants would reduce the level of carbon dioxide present. **“**The Effect of the Number of *Dieffenbachia maculata* Plants on Carbon Dioxide Levels” became the title of their science fair project. They found that when most of the room conditions are controlled, that increasing the number of plants will reduce the carbon dioxide levels in an enclosed room. ‘Mary’ investigated whether the scented candles being burned in many of the classrooms for atmosphere were impacting the carbon dioxide level. Her investigation culminated in her entry into the science fair as “The Secrets of Scented Candles” which discussed her finding of the increase in carbon dioxide levels when candles are used. As each year progressed, the communal knowledge base on the factors influencing the levels of carbon dioxide in the classroom and the best methods for testing these continued to grow. Over the three years of this study, similar evolutions of project ideas have occurred centered on topics such as concussions, sports equipment and drinks, and water quality.

## Students as Experts

Another facet of the emerging learning behaviors that I noticed when I reviewed the audio and video tapes of my classroom along with notations in my journal was the evolution of my students from consumers of information to knowledge creators. Over the course of this study I saw my students becoming the experts on science journalism, science research projects and the accompanying technologies. Through their interactions with students in other classes and teachers, they have begun sharing their developing expertise with the wider school community.

### Expertise in technology

During this project, I noticed that my students have progressed in their use of technology and choose to use it appropriately more often than before science journalism was introduced into our practices. Through this transition some students have emerged as classroom experts on technology. Student participants have also communicated the technology used in this project to others in our school community.

Technology can cause a lot of issues in the classroom, even within a tech savvy school. Our school is a one-on-one laptop school. Most teachers assume that the students are competent at the use of this technology but I have found that my students struggle at times. To exemplify this difference between teacher expectation and student reality I will recount the events which occurred when I began using Evernote (Evernote Corporation, 2013), an online notebooking program with the students for them to use when collecting their background information in 2012.

When my students were instructed to download the program from the website to their laptops, I was surprised to find that some of them were very slow and awkward at downloading the program. Some tried to download the MAC version onto their PC's, for example. Many did not understand the concept of a browser or how the browser being used would affect how the computer interacted with the Evernote program tools. Many were reluctant to switch their browser to Mozilla Firefox (Mozilla, 2014), as recommended as they were familiar with Google Chrome (Google, 2014) and wanted to only use that browser. They had difficulty with the concept of having to select a different user name than the one that they were familiar with as that one had already been selected by another user. They became frustrated easily with the downloading process and would begin to drift away from the classroom activity into checking their email and surfing the web. I had to bring them back to the task at hand; downloading and beginning to use the Evernote program. Some of the student comments that were repeated by the different classes as they moved through the same process included:

"How did you do that?"

"Mine is not working."

"Can I go to tech? (The technology support office)"

"I am not there yet, slow down!"

"Can you go back to that last step?"

"Can you come over and help me?"

"Can you do it for me, I just don't get it."

By the time that the course evaluations are given in May, my students were comfortable with technology and recognize that it is used daily. Over 90% of my students respond on these evaluations that they use technology every day in my class. Approximately the same percentage agree with the statement that they are comfortable using the technology in their coursework for my class.

In each class one or two students emerged as the technology leaders and began to help other students or make announcements to the class overall about how to navigate this new terrain. They caught on to the process quickly and were able to help others get started. They also freely gave feedback to me to disseminate to the entire class. Some of the comments from one tech savvy student, 'Jane' included:

"The download takes awhile."

"The password has to be at least 8 characters."

"You might need to hit the enter button twice."

"You can't use the Firefox download on Chrome."

"You need to update your Java."

"Here, let me show you."

These technology leaders became empowered through this sharing of their expertise. One student, Jane, stands out in this regard. Jane had been very uncommunicative for most of the 2012 fall semester prior to the Evernote downloading session. She participated in class activities but rarely volunteered to answer questions during class and usually sat off to the side during discussions. When the Evernote program was introduced, Jane came into her own. She ended up moving around the classroom, going from table to table explaining how to move through the downloading process. She came over to me and had a long conversation about the flaws in our school's bandwidth which was creating the downloading backlog for us. As the weeks of the background researching unfolded, Jane was a sought out member of the class, her advice asked not just for the work in our class but for other technology projects as well. Jane began to participate in class discussions, often surprising me with her insights. I believe that Jane's role as the class tech adviser enabled her to move forward from her normal position on the periphery of the classroom.

By the time that we finished our first activity online research using the Evernote program, I found the students were starting to experiment on their own with its features and even sharing it with their other teachers, in their other coursework.

> "I showed this to Mr. T., my theology teacher and he loves it. He is going to let me do my reflections for the unit on Evernote," one student shared with the class.
>
> "You shared your chemistry notebook with the theology class?" asked another.

"No, I made a separate notebook to use just for that class," responded the first.

"Oh, I didn't know you could do that!"

"Yeah, it is really easy, look here…."

As my students moved through the stages of their research project, they became more connected to the technology programs which they used. They came to understand the need for keeping track of their background research and it sources. They found the Evernote program to be very helpful in achieving that objective. After our initial struggles to download the program, the students developed familiarity with its features and soon began using it effortlessly.

I found a similar pattern with each piece of technology that we used in the course of this project which included training in the use of online databases, using the track changes feature of Microsoft Word, using Survey Monkey (SurveyMonkey.com, 2014) for collecting data from stakeholders, using probe ware to collect data and using LoggerPro (Vernier Software & Technology , LLC, 2013) for creating graphs.

The participants were not reticent about sharing their successes in using technology with others. Jan, for example, shared her developing technology expertise with the SciJourn editor in an email response (Jan, Email, 2011) to his request to modify her graphs so that they could be published more readily.

"…I used the Windows 7 Snipping Tool to make the entire graph, title and key into one big jpeg. I hope that works….

During the three years over which this project took place, I was often asked by other faculty members to show them how to use some of these programs, as they had seen them being used by the students and wanted to learn more. I was asked to present a session at a faculty in service on the use of Diigo (Diigo, Inc., 2013), an online social bookmarking site, for example.  During that presentation, I was also asked about track changes and the graphing program, LoggerPro.  Diigo, introduced to help with the science journalism aspects of the student's research project in my course, is now being taught as a part of the digital literacy course for our freshmen students.  I am sure that Evernote will soon be added to this course as well.  My students, through the use of technology in their science research projects have moved from the position of passive consumers of information to agents of change in our school community.

My students have taken on the attitude of being experts in their own right, even with the adult members of our school community. They are now used to working with adults, giving suggestions and advice to their teachers.  Through the collaborative and openness of my classroom and their work with the SciJourn researchers they are not intimidated by adults. Some have even reached the point where they are stimulated by their interactions with adults.

**Becoming agents of change**

Another area in which the students develop expertise through the incorporation of science journalism skills occurs during the peer editing process.  My students use the track changes function on the Microsoft Word program in order to add feedback electronically for their peers. The students enjoy doing the track changes and have not hesitated to share their skill and the benefits of the process with their other teachers, especially the English and Social Studies teachers.  They had often commented on how long it takes their other teachers to edit their work and how often they cannot read the handwritten comments. Once they felt comfortable with their new skill of using track changes, they shared the process with these teachers. One English teacher in particular was very resistant to their suggestions. I journaled about the conversation which we had about track changes in the faculty room in February of 2011:

> In the faculty room today, the subject of the conversation was using track changes during the peer editing process which my students are doing. My friend, 'Lucy', an English teacher was a little upset with me, "Oh my God, Rose, you have opened a Pandora's Box with this track changes. They won't shut up about it!" I started to explain how great track changes were to her and encouraged her to just try it once, but I felt that she was very set in her own way of doing her grading. Others at the table were very interested and some have even come in to see how it works.

Several teachers at my school are now using track changes and peer editing with their students. The sense of agency which their success with track changes provided for them has allowed my students to become agents of change in this regard.

I felt myself trusting in my student's skills as editors to the point where I asked them to help me as experts in this area. In the spring of 2012, I had the opportunity to enter an essay in a Dow competition for needed funds to improve the use of technology at our school, particularly the need for additional digital sensors. I wrote about this in my journal on February 21, 2012:

> Had some of my students look over my essay today. They had a lot of good suggestions. One of them even helped me to improve my lede! I had not thought about it but they also suggested asking for a movie camera for

> us to use with our projects. I had asked the other teachers in the department to proofread the essay and to tell me if there was anything else that I should add but none of them have responded. I know they will be using the supplies though, if I win!

Before beginning this project, learning about science journalism and integrating it into my courses, I never would have asked my students for feedback on my writing, and they would not have been comfortable providing it. With their help, I was able to win the essay contest and garnered $5000 for use in purchasing the much needed supplies for my classroom.

**Published authors viewed as local experts**

While many of my students have developed expertise in their use of technology and in journalistic and science research skills, those students who have persisted in the process to the level of having an article accepted for publication have exhibited a heightened development. They are recognized within our school community as experts in this new process. Science literacy prior to the integration of journalism with the student research projects was not spoken of outside of the science wing. Now it is broadcast through the school community email blasts and used in our recruitment packages. Each published student author has her article on permanent display in the science wing but it is also sent in a link to the entire school community. Several of these articles have been published in the school newspaper. The teachers and administrators in our school make it their practice to congratulate the authors on their success and to question them about what they found in their research. Copies of The SciJourner which contain our students' articles are kept in the board room, the recruitment and development offices.

Jan shows her confidence in her own ability as a science news author in the following passage from her exit interview at the end of the SciJourn cycle for her class (Jan, 2011).

On how to write a lede:

> Jan: When you begin your article you have to kind of like capture your audience.
>
> ... I tried to do that and …failed a few times… I had to work my way through it, to try to figure out a way…to present a lede that was still relevant to the article.
>
> …while still, captivating the readers and stuff like that…it was just one of those things that trial and error was the way that I had to figure out how to do it.

Describing how to carry out research and interview an expert:

> Jan: I used a few articles from school database, um, and then I also, my mom's friend…Anyway, well she is a pulmonary respiration doctorate, something like that, so I talked to her and she gave me a few good websites to look at …that's kind of how I started like weeding my way through. …I got general information from my textbook, you know, I know about respiration and all those processes. It was just a matter of finding studies that were similar to this. And, actually I was able to find valid sites really easily …the research was actually pretty smooth sailing.'

> I found some through her (the expert) and she gave me a nice start of like what to look for. And then, I started … finding my own. She gave me a nice start and then I was able to like, kind of fill in all the pieces.
> … she sent me like a PDF of some… studies on carbon dioxide in the classroom and it showed me their data, their procedure, and all that stuff so, it wasn't exactly 'carbon dioxide does this, this, this, and this, an d it causes this.' It wasn't written like that, it showed me all of their information and their entire study and then from that I was able to piece together what exactly all of that meant. I just looked at their data, looked at their conclusions. It was like looking at a science fair project almost.

Jan had become a local expert on not only how to write a science news article but also on how to carry out a controlled experiment. She was confident in her ability to both read and write scientific and technical information. The expertise of Jan and the other published authors soon began to gain the attention of the wider school community.

I brought up this ripple effect in my responses to the prompt, "If there's anything else we should know about this experience, please feel free to share with us" which I was given in February of 2011 by the SciJourn research team to assist them with an article which they were writing about the project. I responded:

> "The students have just heard back from the faculty moderator of our school newspaper that fourteen of their articles will be featured over the next two editions. There will be a spread in the paper on the SciJourn process, written by one of the students in the course who is an editor of the paper…

> I am noticing a community of support developing for my efforts with these students...the faculty sponsor of the school newspaper… became highly interested and began asking me what was happening with SciJourn, she began asking me for finished articles on a monthly basis. I also feel that my principal has made a personal investment to keep up with what is going on with the SciJourn students. She has held several conversations with me about what we are working on. I have found myself touting track changes and diigo in the faculty room. I ended up teaching diigo to the faculty at a faculty meeting. I guess what I am saying is that the SciJourn work for me has moved out of the classroom sphere and into a larger realm, kind of like a ripple effect. Very cool!"

The principal helped to broaden the impact of my student's work because of her intense interest in the project. She had been invited to come to the SciJourn training session in the summer of 2010 and from that point on she felt that the project was a device for positive change in our community. She was particularly interested because one of the goals for our school improvement cycle was the development of student ability to read and write in all curricular areas.

When my students would be notified of the acceptance of their article for publication or won an award for their science research report, I would announce it through an email blast to the entire school community; the student body, faculty, administrators and parents. The principal would follow up these announcements by making a point of finding the student, personally congratulating her on her success and then talking about the article or report with them. The students felt empowered by her interest and when they discussed this in class it often sparked renewed effort in the process.

The principal was also interested in changing the perception in our community that our school is overly focused on athletics. To this end, she wanted to nurture and encourage the academic achievements of our students. Without her interest in the process, it is hard to tell if my own efforts to integrate the science journalism in the classroom could have been sustained at the high implementation level that they were for the three years of this study and beyond.

## Student development of Scientific Practices

One of the research questions for this study was, “To what degree does the use of journalistic activities with the student research project coincide with and enhance the development of the scientific practices outlined by the Framework for Science Education (National Research Council, 2012). In the following sections, I will address each of the eight practices, providing my insight into their implementation within this study and providing evidence to support my assertions when possible.

### Asking Questions

According to the National Research Council, the scientific practice of asking questions involves, “ …formulating empirically answerable questions about phenomena, establishing what is already know, and determining what questions have yet to be satisfactorily answered” (National Research Council, 2012, p. 50). As mentioned in chapter four, Read Aloud-Think Alouds were introduced into my teaching practices in order to help students to see the connection between chemistry content material and their own lives. In addition to providing them with a wealth of possible topics for their individual research projects, these Read Aloud-Think Alouds also developed their ability to form questions and seek answers to them.

As I reviewed my journals I found that Read Aloud-Think Alouds were the activity where I was most surprised by what happened in my classroom. I thought that we would read through the article together, discuss how it related to the topic we were covering and then move on. What did happened was that after the first paragraph being read the floodgates opened and the questioning began. The interest level of my students grew exponentially with each science news article that we read together. This happened so consistently that it has now become the expected goal for the activity.

As a RATA begins in my course, all of the students have a copy of the article being read and they take turns reading the short paragraphs. As the reading proceeds, I interrupt the reading sequence to ask a probing question, usually after the third paragraph. It usually is along the lines of "What exactly are they saying here?" or "What does that mean?" As the reading proceeds the students start to ask questions. They, in fact will ask so many questions that it is difficult to move away from the RATA to other activities.

In an audiotape of the August, 2012 SciJourn Professional Development activity, I put into words how the questioning in my classroom had changed since the integration of the science journalism activities.

> The questioning styles in my classroom I believe really have changed. I am not asking students assessment questions, instead I am asking probing questions, when I ask questions and I am encouraging the students to question, and then not having the answers, so then we have to look them

up or ask, does anyone here know the answer to that? So the questioning style is very, very different.

I also noted in my journal that it wasn't just questioning that we wanted but we wanted their questioning to build knowledge.

Below is the list of the questions asked by the students during a Read Aloud-Think Aloud on manmade elements which I recorded in September of 2011. We were reading the article, "Heaviest Elements Yet Join the Periodic Table" from the June, 2011 issue of New Scientist.

"How did they get the atoms to disintegrate?"

"How did they get the new nuclei?"

"So do these new atoms that they are making..., do they exist?"

"How can they know it exists if it only exists for a millisecond?"

"Will we have to get a new periodic table?"

"Why don't they just add another 20 or so to the table, since they know they are going to get there eventually?"

"So they made number 114 and number 116, they know they can make number 115 so why not put it in there?"

"Is it possible that they can't make number 115?"

"I guess I don't understand. How they can call them elements if they only exit for so short of a time?"

"How exactly do they choose which elements to use to bombard each other?"

"Wouldn't they be making a compound by bombarding these atoms and getting them to stick together?"

"How come they don't have atomic masses up there (on the periodic table) for the manmade elements?"

"Why are some of the atomic masses at the bottom of the periodic table in parentheses?"

Prior to the introduction of the Read Aloud-Think Alouds into my teaching practices I would lecture to the students about the use of nuclear fission to create the manmade elements. I would spend about one minute at most on the topic and students seldom, if ever, asked questions about the process. When I look over this list of questions, generated during a ten minute RATA, I see the students developing interest in the idea of making new elements. I also see a misconception expressed by one student that needed to be addressed, that of nuclear fission producing compounds rather than new atoms. Each of these questions provided an opportunity to develop understanding of nuclear reactions and elements. While other educators have found the value of students developing the ability of asking questions, I find that Neil Postman expressed the importance of questioning to learning best. In his article, "Language Education in a Knowledge Context," he posits that "…in the development of intelligence nothing can be more "basic" than learning how to ask productive questions" (Postman, 1980, p. 4). He further states that "…all our knowledge results from questions, which is another way of saying that question-asking is our most important intellectual tool" (p. 5). The Read Aloud-Think Aloud activities carried out during this study have demonstrated their power to pull questions from the students, getting them to think about what they are reading and ponder its connection to themselves.

**Developing and Using Models**

“Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomenon” (National Research Council, 2012, p. 50). In this study the students created drawings and other representations of the events which occurred during their science research projects in the form of news releases.

Figure 5.3 shows the model created by Jan of how the level of carbon dioxide varies during a school day with the presence of students in the classroom. She uses overlays of yellow and blue to indicate when students are present in the room. These overlays, when combined with the graph of carbon dioxide levels, model the connection between student presence in the classroom and the level of carbon dioxide.

‘Nancy’ created a model by combining graphs to show the correlation between online activity on social networking sites and GPA of teens. Through this combination Nancy created the model shown in figure 5.4 to demonstrate the number of students with high GPA’s is larger for groups who do not use social networking.

The creation of models such as these, usually for the news release portion of the science journalism implementation sequence has merged with the creation of infographics to model other areas of student understanding, outside of this study. The ability of students to create infographics to represent the findings of their science investigations is in its infancy at this time, with some level of success for those students who have developed an interest.

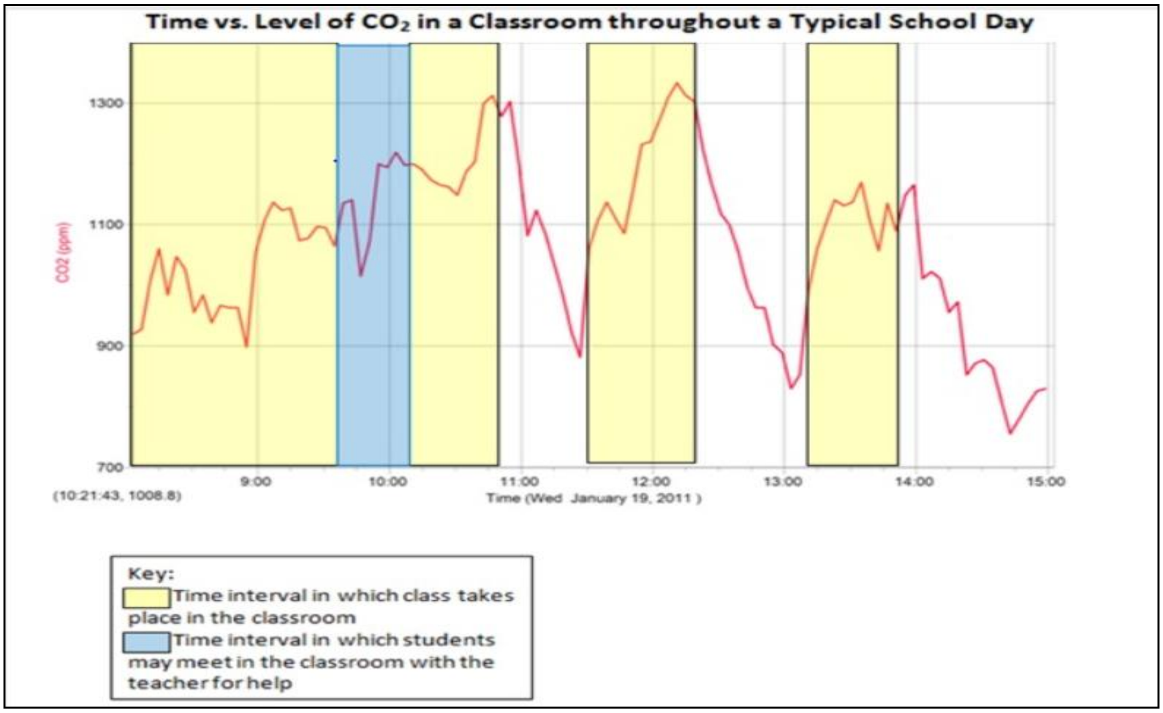



*Figure 5.3.* Student Created Model for News Release of Experimental Results

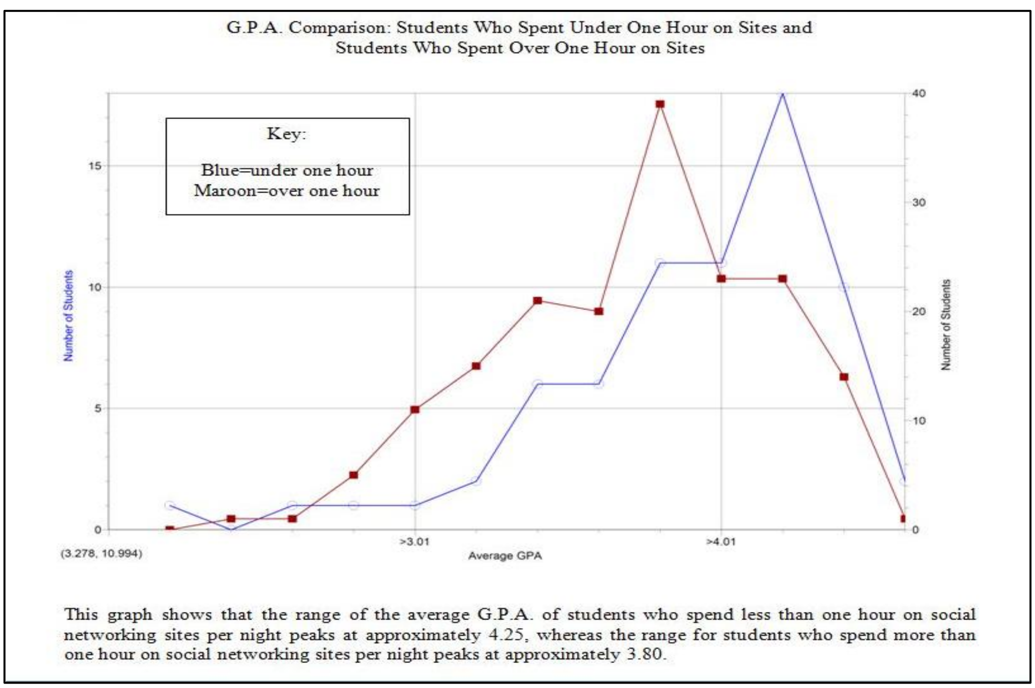



*Figure 5.4.* Student Created Model for Science Fair Report

**Planning and Carrying out Investigations**

According to the National Research Council, “Scientists and engineers investigate and observe the world with essentially two goals: (1) to systematically describe the world and (2) to develop and test theories and explanations of how the world works” (2012, p. 59). My student’s ability to plan and carry out investigations has been improved through the integration of science journalism because their interest in the process has been increased. Before this study began in 2010, my students were able to carry out controlled experiments, in the standard science fair format. They decided upon a problem to investigate, carried out a background literature review on their topic, developed a working hypothesis, designed their controlled experiment and carried it out, collecting their data, analyzing it and then formulating their conclusions. The process was there but the necessary sense making that comes with a personal connection was missing. Integrating science journalism increased the connection between the topic chosen for their research investigations and their own lives which in turn increased their interest in the process. They became interested in finding out how the world works and how it impacts their own lives. This provides the motivation for their investigation. The investigations that resulted from this increased interest have exhibited more depth of understanding in the natural processes observed.

**Analyzing and Interpreting Data**

The practice of analyzing and interpreting data is seen as vital by the National Research Council. “Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing or statistical analysis (2012, p. 61).

During this study, the students have collected and analyzed data from controlled experiments and from observations and surveys. They have created graphs of their data to determine if a correlation existed between their experimental variables as predicted by their hypothesis. This process of analyzing the data is very similar to that which occurred prior to the study. The difference is in the type of data being analyzed. In the past only controlled experiments were allowed. The introduction of science journalism into the coursework brought about a broader selection of topics being researched by the students which in turn expanded the types of data collected as well as the methods used for their analysis. The use of data collected by survey, personal interviews and the use of digital sensors have expanded the data collection process for the participant students. Our editor has worked to inform the perspective of the students on the need to present their findings in context to the greater body of knowledge developed by previous studies. In an email conversation, April, 2012, about my student projects, he asserts:

> My main complaint with school labs is that they make students think they do an experiment and prove something. I worry that your students are not thinking about what their data really says or doesn't say (Newman A. , Email, 2012).

Data analysis remains an area of needed growth, especially in the area of context as noted by Dr. Newman.

**Using Mathematics and Computational Thinking**

The goal set by the Framework for K-12 Science Education is that by grade 12 students should be able to "Express relationships and quantities in appropriate mathematical or algorithmic forms for scientific modeling and investigations" (National

Research Council, 2012, p. 65). During the process used in this study, the students collected data by either carrying out a controlled experiment or by collecting survey data. They then tabulated and crafted graphs of their data to determine if a correlation between their variables existed.

While the students were able to analyze their data, they often did not understand its implications. Dr. Newman expands on his previous point in another email from May of 2012:

> I think your students are doing something really interesting by dealing with real data. But they need to understand what is important to explain and what their data really says (Newman A. , 2012).

The expansion of the student data analysis process to include statistical analysis in the future could serve to improve the validity of the student's conclusions about the significance of the trends found during the analysis of their data.

**Construction explanations and designing solutions**

"The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence" (National Research Council, 2012, p. 52) Through science journalism  integration, the students were asked to construct explanations or to design solutions for problems in the world around them as they crafted their science news article and during the experimentation or survey which followed. Table 5.2 below contains an excerpt from the investigation carried out by one student, 'Jill,' into the increasing problem that is occurring with pharmaceutical drugs polluting natural waterways.

Table 5.2

*Excerpt from Participant Article, What's in Your Water?*

Are you ingesting sex hormones or antibiotics? Anti-epileptic pills or mental illness stabilizers? Average St. Louis high school student Anna Pelch brushes the idea off: "No, never have!" You probably answered similarly to Anna; however, that is incorrect. Recent studies show that these, along with a variety of other over-the-counter and prescription drugs, have been discovered in the drinking water of over 41 million Americans, over 5 million of them being Missourians. Once people consume drugs, unabsorbed traces of them pass through their bodies and are excreted into toilets. When flushed, the wastewater is released into lakes and rivers, such as the Meramec, and filtered through treatment plants, yet drug remnants make their way into your tap water.

How is this possible with superior treatment plants and the intellectual prowess of their employees? The federal government does not necessitate testing for drugs in water, nor has it issued safety standards for filtering medication. Many pharmaceuticals withstand treatment procedures and the U.S. Environmental Protection Agency (EPA) even confesses that no methods have been generated explicitly to eliminate these drugs. Benjamin Grumbles, assistant administrator of the EPA, admits to the issue saying, "We recognize it is a growing concern and we're taking it very seriously." Although over-the-counter medications may seem harmless, when combined with the chlorine used in sewage systems they can become toxic.

However, many pharmaceutical industry officials deny the lethality of drug traces; Thomas White a microbiologist of Pharmaceutical Research and Manufacturers of America claims: "Based on what we now know, I would say we find there's little or no risk from pharmaceuticals in the environment to human health." But when $H_2O$ is the most abundant and imbibed material on Earth, the question still probes scientists: with an increasing ingestion of drugs in the United States, could medication in water eventually leave permanent scars on humanity? Chemotherapy drugs are among those found in tested regions…these can, in fact, act as poison to healthy individuals. Scientists have also found that human breast cancer cells developed two times faster when in the presence of estrogens acquired from catfish in unprocessed sewage.

The most concern is placed on susceptible people, such as the elderly, ailing, and expectant mothers. Poisons expert and biologist Francesco Pomati states: "My wife is pregnant, and I don't let my wife drink the water." He claims this issue is extremely prevalent because medications are meant for certain persons for an allotted amount of time, not for everyone throughout their entire lifetimes. Dr. David Carpenter, director of the Institute for Health and the Environment of the State University of New York at Albany, proclaims the terrifying reality: "We know we are being exposed to other people's drugs through our drinking water, and that can't be good."

The student, Jill, presents information from four different experts to craft her explanation of this perceived environmental hazard. As a part of their development of science journalism skills the students were taught to locate information from credible sources and to craft news articles which presented the facts to form plausible explanations for events that were relevant to their community and health.

### Engaging in Argument from Evidence

According to the Framework for K-12 Science Education, arguing from evidence is another essential skill that students need to acquire. “Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated” (National Research Council, 2012, p. 52). An extension of this concept of arguing from evidence is the ability to weigh all of the factors in a situation in order to make an informed decision.

Table 5.3 contains the article written by one of the participants, ‘Donna,’ for teen readers in order to provide information from which they can make an informed decision about indoor tanning. The student writer, Donna, uses information which was located online in order to craft an explanation for the connection between the use of tanning beds and skin cancer.

Table 5.3

*Excerpt from Participant Article, Serious Risks with Indoor Tanning*

Corrine, a current high school student, talks to her friends about going tanning at a local tanning salon after school. She eagerly awaited her next visit to the tanning salon, as most teens her age would as well. However, Corrine also asks, “Why do I always get a few more freckles each time I go tanning?”

As of now, there is no immediate impact from indoor tanning except for freckles on Corrine. Until there is a problem with an illness directly affecting her, Corrine will continue to tan, unaware of the penetrating UV rays. At this time, she only has a few more freckles adding onto her skin each time she visits the tanning bed. So far, Corrine has been relatively lucky; however, others are not as lucky in terms of their health.

New research displays that the risk of skin cancer grows to nearly 75% when people begin to use tanning beds. Other studies show that tanning beds are sources of ultraviolent radiation which has been proven to be a definite cause of cancer. Doctors are now seeing a huge rise in the number of the younger generation. Another problem associated with indoor tanning is eye damage, which recently has been associated to eye cancers, states the International Agency for Research on Cancer on their website.

So many people love to have the “golden tan” that encourages a sense of beauty. People of all ages go tanning in indoor tanning beds. Of the 28 million people who use tanning beds, 8.2% are teenagers. The radiation from tanning beds has been proven to be stronger than of the sun, affirmed by The American Academy of Dermatology Association (AADA). The UV rays from tanning beds have been proven to be around 3 to 7 times greater than sunlight. Sunlight gives off UV-B rays and UV-A rays which both are related to aging of skin and increase the risk of obtaining skin cancer. However, UV-B rays cause a more reddish burn, while UV-A rays do not cause a burn unless there are high amounts of exposure. Tanning beds predominantly use UV-A rays, which can penetrate deeper into the skin. The Food and Drug Administration says this light can also destroy all collagen and elastin, which leaves the skin dry and leathery.

The reasons that the skin grows a darker color when exposed to the UV rays is that the skin produces a substance called melanin. Melanin darkens the cells that lie in the epidermis, which is the top layer of skin which is a defense against any further damage from UV radiation. DeAnn Lazovich, a cancer epidemiologist at the University of Minnesota stated, “Melanoma is related to exposure to ultraviolet light. The risk is 74 percent higher for the people who tanned indoors, compared to those who did not.” Studies have shown that people who spend over 50 hours in a tanning bed have a much greater risk compared to those who have refrained from ever using tanning beds.

Younger generations who use tanning beds on a regular basis are eight times more likely to obtain melanoma than others. According to the World Health Organization (WHO) on their website, melanoma can appear years or also decades after sunburn.

Melanoma is the most deadly form of skin cancer, which every year, over 68,000 people are diagnosed. Of these 68,000 people, around 10 percent will not survive. It is found that Caucasians are at the greater risk of obtaining melanoma.

For many years, there have been disputes about whether to ban or make the legal age to a higher age. The AADA says, "Minors should not use indoor tanning equipment because overexposure to UV radiation can lead to the development of skin cancer." Over 30 states restrict the use of indoor tanning facilities by minors. However, the WHO disagrees and believes that minors should not be able under any circumstance to use an indoor tanning bed.

So has Corrine's attitude about tanning changed after learning about this information? "I definitely will not be using tanning beds as often as I have been. Maybe I can try to use self tanning lotions to get that golden brown tan," says Corrine.

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Students carried out scientific investigations where they used the data that they collected in order to determine if their hypothesis was supported or not and to provide evidence to support this determination. In table 5.4, the conclusion portion of a student's science fair report is shown to illustrate how the student argues, using the data of her experiments that her hypothesis was supported. 'Meg' had chosen her topic initially due to an interest in the chemical reaction which takes place in light sticks. Upon further research into light sticks, she encountered bioluminescence. From here, and discussions with the marine biology teacher in our school, she decided to test the impact of some type of change in the environment on bioluminescent organisms. Eventually she decided upon temperature as the manipulated variable in her controlled experiment.

Table 5.4

*Participant Science Fair Project Conclusion, Effect of Temperature on the Intensity of Bioluminescence*

| |
|---|
| The data obtained in this experiment indicates a possible relationship between the intensity of light given off by bioluminescent organisms and the temperature of the seawater in which they reside. The data obtained showed that when the temperature of the seawater was lowered, the intensity of light was greater than that of the intensity of light given off by the control group of *Pyrocystis fusiformis* which did not have a change in temperature. It also showed that when the temperature of the seawater was raised, the intensity of light increased slightly. This data obtained in this experiment shows how rising sea surface temperatures could affect marine organisms. This experiment might provide information on how the *Pyrocystis fusiformis* and other similar dinoflagelletes will respond to the continuing climate change and rising sea surface temperatures. As a result of this experiment, it was determined that the *Pyrocystis fusiformis* did respond to a change in temperature of the water in which they resided it. The hypothesis made prior to the experiment was "If the temperature of the water the bioluminescent algae *Pyrocystis fusiformis* resides in lowers or rises significantly, then the intensity of light that the organism emits will increase." The experimental results obtained from this experiment support the hypothesis as an alteration in temperature of the water that the *Pyrocystis fusiformis* resided in affected the light intensity given off by the organism. The background information obtained prior to the experiment also affected the hypothesis that was made, and thus, contributed to the correct hypothesis. The background information obtained did not discuss specifically about how bioluminescent organisms would be affected by a temperature change in their environment, but rather, how there is evidence of marine organisms, such as plankton, being affected by climate change and rising sea surface temperatures. |
| The results obtained in the experiment did support the hypothesis because they showed the correlation between the temperature of seawater and the intensity of light given off by the *Pyrocystis fusiformis*. The results of the experiment showed that when the temperature of the seawater was raised and was lowered, the intensity of the light emitted by the *Pyrocystis fusiformis* increased. The results showed that when the temperature of the seawater the bioluminescent algae *Pyrocystis fusiformis* resided in was lowered or raised significantly, the intensity of light that the organism emits increased. However, the results show that when the seawater's temperature was changed, the intensity of light only increased slightly. The increase in the intensity of light was much greater when the seawater's temperature was lowered. One possible explanation is that the culture of *Pyrocystis fusiformis* felt threatened or scared when their conditions of their habitat changed. Many scientists think that bioluminescent organisms emit light as a |

defense tactic. It is possible that this is why the organisms reacted like they did when their normal habitat was disturbed. In the experiment, the average intensities of the cold water samples in each trial were very similar. The same goes for the control and for the warm water samples in each trial. There were both peaks in the data and low points. Each of the trials had high intensities and low intensities that did not correlate with the average. A possible explanation for the anomaly is the fact that it is possible that the exact number of dinoflagelletes in each of the samples differed. Another possible explanation could be that the SpectroVis Plus spectrometer was not functioning properly. Because the amount of seawater and *Pyrocystis fusiformis* was so small, error is a great possibility and likelihood. In each of the trials, the range average intensities of the *Pyrocystis fusiformis* in the cold, the warm, and the control water did not differ very much. The data is particularly reliable as the average intensities were very similar. The accuracy of the data is not known. Because the experiment and topic has not been tested before, there is no prior data to compare it with. However, the average intensity of the light emitted by the *Pyrocystis fusiformis* in cold water and the average intensity of the light emitted by the *Pyrocystis fusiformis* in the warm water did not vary greatly from the light emitted by the *Pyrocystis fusiformis* in the water where no temperature change occurred. Possible changes would be done to the experiment is it could be done over again. For example, a greater volume of samples might be used in order to have a great intensity of light to work with because the intensities of light used in this experiment were so small. In addition, a more high tech light sensor might be used because the quantities of the light intensity were so small.

Another problem or obstacle that marine organisms are facing today is ocean acidification, or the continually decreasing pH of the oceans. Another possible project might be testing to see how lowering the pH of the seawater in which the *Pyrocystis fusiformis* resides in might affect the intensity of light which the organism omits. The same steps as this project could be used in order to determine if there is a relationship between a lowering pH and the intensity of light given off by *Pyrocystis fusiformis*. This possible experiment would determine how the bioluminescent organism *Pyrocystis fusiformis* would be affected by the ocean's becoming more acidic. In addition, the bioluminescent organism worked with could also be changed. If a person had the means to take care of a bioluminescent organism such as a cone jellyfish or an Anglerfish, one might be able to perform the same experiment done in this paper, except for substituting the *Pyrocystis fusiformis* for a different, larger bioluminescent organism. Then, the experimenter could determine how either an acidic ocean or a change in sea surface temperatures might affect that bioluminescent organism.

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In her conclusion, the Meg describes the pattern revealed by analysis of the data which she collected, relates the pattern to the hypothesis, connects the pattern to the background literature, hedges and provides an alternate scenarios for the pattern observed, and then points out the need for additional experimentation to further the investigation.

**Communicating Information**

The practice of communicating information has two facets. The first is "… the ability to derive meaning from scientific texts (such as papers, the Internet, symposia, and lectures) to evaluate the scientific validity of the information thus acquired, and to integrate that information (National Research Council, 2012, p. 53).This facet of communication has been expanded through the science journalism activities which were utilized with the participants in this study. Read Aloud-Think Alouds, activities on searching for credible sources, assessing credibility and integrating information into a cohesive science news article were used to develop this practice by the students.

The second facet of this practice is "…. the communication of ideas and the results of inquiry-orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers (National Research Council, 2012, p. 53). The activities carried out within this study touched upon each of these aspects. Students were expected to discuss topic choices with their peers, craft science news articles, carry out and write a science fair report which contained tables, diagrams and graphical elements, and then communicate their finding to their peers orally during a gallery walk presentation. Students also were asked to communicate with the school principal, other classroom teachers and the SciJourn research team, National Science Foundation evaluator and the SciJourn advisory board. The participants impressed each of these adults with their openness and ability to communicate clearly their experiences during the project. This ability to communicate with others and the public is necessary for scientists today given how misinformed citizens often are about the science which impacts their lives.

**Trajectory Change**

At the end of the school year the graduating seniors often return to visit with their teachers. This is the conversation that I had in the spring of 2013 with group of seniors who came to see me on their last day. It was a conversation that helped me at a time when I was feeling a little overwhelmed with all that remained to be completed to close out the semester by confirming the perception which I had formed about the impact of this pedagogy change on the lives of my students.

"Hey Mrs. Davidson," they greeted me, "we just came to say goodbye".

"Oh, the big day is finally here, right? You are moving to the next stage of your adventure!

Where are you going to go to college?" I asked.

"I am going to Mizzou (The University of Missouri-Columbia). I am going to major in bioengineering," one of them, Becky, stated proudly.

"Bioengineering! Great! There are a lot of opportunities for women in engineering. Be sure to connect with the Society of Women Engineers at Mizzou," I remarked.

"Oh, I'm not just going to be an engineer, I plan to go to Washington University for Medical School after I finish the bioengineering degree."

"Wow!"

"Yeah, I really love science but you probably already knew that".

"I wanted to thank you for getting me interested in science with all of the research projects and writing that we did. Until then I thought that science was all memorization and plug and chug.

Now I see how important science is to our health, which is why I want to work in medicine and bioengineering."

This student, Becky, had researched asthma and air pollution and had her science journalism article accepted after numerous revisions for publication in The SciJourner. She carried out a follow up survey of 50 students with asthma to see if there was a correlation between asthma and air pollutants in our area. She entered this investigation in the Greater St. Louis Science Fair and was awarded a Blue, First Place Ribbon.

"I also wanted to thank you for all of the writing experience," said one of the other seniors, 'Gwen.'

"I learned how to write well in my English classes but never realized how important science journalism can be. I am going to Mizzou also but am going to be a journalist."

"Well remember to keep writing the science articles along with the other types of journalism that you will encounter in your program," I reminded her.

Gwen's article entitled "Cell phones may Increase Risks for Brain Cancer" was accepted for publication in The SciJourner. She went on to carry out a laboratory investigation as a Science Fair project, "The effect of cell phone radiation on the growth rate of mealworms." It won a Blue, First Place Ribbon and a Special Award at the Greater St. Louis Science Fair.

"I never could write my science articles to suit the editor at The SciJourner," stated 'Molly', the third senior visiting.

"I just could not get out of my science report rut. But I did enjoy seeing how science fits into my everyday life and how science important science is in our world. We sure read a about so many different topics. I plan to become a research scientist of some sort; I haven't decided what field yet, probably marine biology or environmental biology."

Molly had researched water quality issues in Missouri, especially in the Meramec River, using her work of one of the members of the STREAM TEAM as her impetus. Her article was not accepted for publication because it lacked a narrow focus. She subsequently focused in on one specific aspect of water quality for her Science Fair project entitled "The Effect of Road Salt on Salinity of nearby Waterways." This project was much more successful earning her $750 in Special Awards along with a Blue, First Place Ribbon at the Greater St. Louis Science Fair.

This conversation demonstrates some of the success which I have had connecting the world of science with the lives of my students. These are just three of the roughly 400 students who have gone through the intensive science literacy process with me since I began using science journalism in 2010. The participants of this study were a subset of the students impacted by the SciJourn project in my classroom.

**Summary**

Integrating journalism activities with the science research projects in the honors chemistry courses have led to observable changes in the learning behaviors of the students. The students have become more engaged in the research process. They have developed their expertise as authors and their skills for using technology. They have formed a community of learners within the classroom and have become agents of change within the school community.

The students appear to have become more connected to their research topic which has led to increased engagement in the process. When the topic which they are researching is one that has a connection to their own life, they are more motivated to sustain their research and carry it to greater depths. Students also become motivated to excel in the completion of their project because of their desire to become a published author in the genre of science journalism .Other students become motivated by their interest in pursuing a science career to which they have been exposed during their research for their project.

The students, through the activities brought to the classroom through the science journalism practices of the SciJourn project, have increased their collaboration within the classroom. Through shared activities such as peer editing and discussing topics with each other, the students have come to rely upon each other for support and feedback. The community of learners within our classroom has expanded to encompass the administration and other teachers at the school who in turn are integrating technologies and techniques with a larger number of students.

Each of the eight scientific practices considered essential by the National Research Council (National Research Council, 2012) are reinforced through the integration of journalism activities into the existing student research projects. Students have developed their skills and practices of questioning, creating and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematical thinking, constructing explanations, arguing based on evidence and communicating effectively.

In chapter six, the benefits of this integration of journalism with student research projects will be summarized. The outcomes of the study will be recapped and the implications will be discussed. Limitations of the findings and implications will also be presented along with areas of needed research which this study revealed.

# Chapter 6

## Insights and Implications

### Introduction

When I began the integration of journalism activities with the student research projects of my students, I had many questions about the feasibility of the undertaking. I questioned whether or not the process would fit into the expectations of my principal and whether it would meet the student goals set forth by science teaching professionals. Throughout this project I have found my principal to be supportive and appreciative of the skills demonstrated by my students as they navigated the new terrain which this integration introduced. The content coverage in my courses was enhanced by the merging of its concepts with events taking place in the world outside of the classroom. The scientific practices of my students were strengthened by the merger of journalism with the investigative research process. I also worried at the onset of this project if I had the personality traits to convey the activities successfully to my students so that they would be open to the changes in pedagogy; that it would not interfere with their learning. I found I became more confident as I integrated the practices of the Read Aloud-Think Aloud, peer editing and writing news articles into my methodology mainly due to the positive reception by my students. In turn, my perspective expanded and this brought changes in my attitude toward what constitutes success in the classroom.

**Insights**

Four research questions were posed at the onset of this study:

1. What happens when students are trained in the research practices used by science journalists, and then use them in their own research projects, representing the findings of their research with science news articles and news releases?
    a. What happens to the teaching practices in the classroom?
    b. What happens to the learning behaviors of the students?
2. What benefits are provided by the integration of science journalism activities into the student research practices in high school chemistry classes?
3. What teacher scaffolding and classroom activities characteristic of an implementation of journalistic practices are most effective in the knowledge construction process?
4. To what degree does the use of journalistic activities with the student research project coincide with and enhance the development of the scientific practices outlined by the Framework for Science Education?

The finding and insights for each of these questions will be summarized in the following sections.

**What happens to the teaching practices and learning behaviors in the classroom?**

As detailed in chapter four, significant changes in the teaching practices have occurred over the course of the three years of this study and extend into the present. Read Aloud-Think Alouds are now used to introduce new content topics and to demonstrate the connection between the content and the lives of the students. The student topic choice process for their research projects now takes place within the classroom as a collaborative venture.

The topics chosen for student research are now expanded and based on their relevancy to the interests of the students.  An increased use of technology for the location and organization of reference materials has come about. The interviewing of experts and stakeholders outside of the classroom have become requirements of the research project. Feedback loops have been added to the student research process; revision and resubmission have become the norm. Student activities centered on the crafting of journalistic articles have evolved over time and continue in the classroom. The addition of peer editing and the emphasis on class discussions gave students a voice in the classroom practices, enhancing the ability of the students to collaborate with others and to communicate their findings to the community at large.

The learning behaviors of the students have evolved as the role of the teacher in the classroom shifted.  In chapter five this evolution of learning behaviors was examined through the analysis of classroom observations, student interviews and artifacts. The engagement level of the students in their research topic was found to have increased when they had a role in the decision making.  The students formed a community of learners over time, collaborating with each other in order to improve the products of their research activities. They developed their expertise at locating credible sources for information as well as experts and stakeholders to provide additional insights. Their skills in journalistic writing as well as those involved with crafting a science report improved when the two processes were combined.

Table 6.1

*Summary of Classroom Changes*

| Changes in Teaching Practices | Changes in Learning Behaviors |
|---|---|
| RATAs used to introduce content and provide relevance | Student engagement and questioning increased |
| Discussion based topic selection process within the classroom added | Students played an active role in decision making |
| Topic choices that are relevant are encouraged | Collaboration between the students increased |
| Increased use of technology for learning activities | Student expertise in researching and writing increased |
| Collaborative use of technology implemented through the use of Diigo and Evernote | Student experience and expertise with technology expanded |
| Experimental design process is driven by topic chosen by students | Student sense of agency increased in the areas of journalistic writing and in understanding science |
| Feedback loops designed into the activities | Students became agents of change in the school community |
| Communication of results to the community at large is expanded | Interest in science related activities and careers increased |

As students became published authors they came to see themselves as experts in researching and communicating the findings of their research to others. They were able to successfully complete a science news article, a science fair report and a news release of their findings. The sense of agency by the students increased as recognition for their accomplishments by the school community expanded. They became agents of change within the academic community, sharing their expertise in peer editing, writing, carrying out research and technology with other students and teachers. The unique combination of the journalistic activities with the student research project brought new facets to the students' understanding of science and their own skills. For many, this deepened their interest in science as a field of study and as a possible career path.

Table 6.2

*Summary of Most Effective Sequence of Classroom Activities*

| | |
|---|---|
| Ongoing: RATAs to introduce content topics | -Brainstorming activity on chemistry impact on life<br>-Logbook activity: Reading the news<br>-Fish Bowl activity for topic selection<br>-Individual topic selection meetings of student with teacher<br>-Guided discussion of finding credible sources, interviewing, format of a science news article, inline attributions |
| Feedback loops involving peers, teacher and SciJourn editor | -Students research locate credible sources and research on their topic<br>-Students locate and interview experts and stakeholders related to their topic<br>-Students craft news articles on topic chosen<br>-Structured laboratory experiences on experimental design features<br>-Students craft experimental designs for research project<br>-Students carry out experiments, observations or survey for research project<br>-Students analyze their data and draw conclusions<br>-Students write their project reports<br>-Students craft display boards for science fair<br>-Students present their work to school community during school pre-fair<br>-Students present their projects at the Greater St. Louis science fair<br>-Students craft news releases which summarize their research findings |

**What scaffolding and classroom activities are most effective?**

As the classroom activities were carried out over the three successive school years during this study, they either became more sophisticated and well defined or after implementation were discarded because they either did not improve the practices already in place or they were not accepted by the students as valuable. The sequence of classroom activities that emerged as most effective is summarized in Table 6.2. Each activity was supported with the teacher created scaffolds of learning objectives, handouts, visuals and specification sheets for determining acceptable completion. The success of each of these activities hinged upon the collaboration of the students with the teacher and with each other in the developing community of learners. The process remains ongoing, with improvements and refinements still be made to the process in the classroom even though the study per se has come to completion.

**What benefits are provided?**

The integration of journalism activities with the student research process provided for a more authentic and relevant process for the students than the traditional process which existed prior to this study. The amalgamation of the journalism and independent research brought about a more robust experience for the students and allowed the classroom to evolve into a community of learners. This evolution to a community of learners facilitates the achievement of the goals for laboratory experiences according to the National Research Council, “Learning is enhanced when students have multiple opportunities to articulate their ideas to peers and to hear and discuss others’ ideas” (America's Lab Report: Investigations in High School Science, 2005, p. 81). The student research projects that resulted from the assimilation of journalism with laboratory experiences met the goals established for laboratory experiences;

1. They are designed with clear learning outcomes in mind,
2. they are thoughtfully sequenced into the flow of classroom science instruction,
3. they are designed to integrate the learning of science content with learning about the processes of science, and
4. they incorporate ongoing student reflection and discussion (National Research Council, 2005, p. 197).

Students began working in a community of learners rather than in isolation on their research projects and they benefited from this cooperative experience. The participant students also benefited from the enhanced acquisition of scientific practices.

### Are the scientific practices of the students enhanced?

The eight scientific practices advocated by the National Research Council (A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, 2012) were supported through the integration of journalism activities into the student research projects. Students have developed their practices of questioning through the use of Read Aloud-Think Alouds to introduce each content topic and its connection to life. Students were exposed to creating and using models to represent the findings of their investigations in the news release which they crafted. Students developed their ability to plan and carry out a scientific investigation of substance. Analyzing and interpreting data and then using mathematical thinking to represent the findings were necessary for successful completion of their investigation. Students constructed explanations for their findings, using the evidence which they collected to support their hypotheses. Students were able to communicating their understandings to others effectively by crafting science news articles as well as an entry into the science fair.

## Implications

The school community where this study took place has developed positive attitude toward the pedagogy which was used. The participant students came to be viewed by the school community as successful journalists and science researchers at the conclusion of their participation in this study. They have brought about attitudinal changes to teachers and students outside of the study. They have caught and held the attention of the larger school community for their level of accomplishment in both writing and investigating in science. The change in pedagogy also expanded the expertise of the students and the teacher who experienced it.

Integrating journalistic practices into the research projects of the honors chemistry students in this school brought about changes in the attitude of the students toward science. The pedagogy implemented by their teacher was successful at increasing the engagement of the participants in the learning process and their interest in science. The teacher-researcher has expanded her skill set and is taking steps to transition toward a more student center classroom.

At its conclusion, the expected outcomes of this study were met. The classroom activities and scaffolds that most enhanced the integration of journalism with the science research practices of the students involved were determined and have been detailed in chapter four. These activities also enhanced the interest of the participant students in current issues which had an impact on their own lives. Insights into the knowledge construction practices of the participants were found and presented in chapter five. Understandings of the benefits of this integration were enhanced and evidences given of these on teacher practices in chapter four and on student learning behaviors in chapter five.

This pedagogy could provide benefits for classrooms other than the one involved but further research would be necessary to provide evidence for any assertions of that nature. While this study focused on 116 honors chemistry students over the course of three years, it involved the changes in practices of a single teacher-researcher which brings inherent limitations to its transferability to other classrooms

## Limitations

The findings of this study were collected by synthesizing data from one teacher-researcher. This teacher implemented a unique pedagogy which incorporated journalism with the science research projects carried out by her grade 11 honors chemistry students over the course of three school years. The personality and background of the teacher-researcher and her students during that time were unique to this study. These findings are applicable only to the distinctive community under study.

All of the students involved in this study were female, as was the teacher-researcher. The relationship between them was one of a kind and may have impacted the findings. The school where the study was conducted and a community of learners established is a private, religious based school and the benefits and restrictions provided by this status may have impacted the study. The 1:1 laptop program in use in this school is not present in all schools and this may have provided affordances not available in other situations.

The status of the teacher-researcher as a veteran in the school community and doctoral student may have influenced the outcome of the study. The student, parent and administrative team's view of the teacher-researcher's abilities and responsibilities may have influenced the attitude of all involved with respect to the pedagogy intervention under study. The teacher-researcher may possess a heightened sensitivity and openness toward pedagogy changes and the student learning process because of her involvement in her coursework at the doctoral level and the accompanying study of current thinking and trends in education.

The design of this study with the classroom teacher playing the dual roles of teacher and researcher presents inherent bias. The teacher has a vested interest in the success of the changes in pedagogy but in her role as researcher, she needs to remain objective in her observations. Efforts were made throughout the study to triangulate the perceptions of the teacher-researcher with evidence from other observers and the students themselves. This process might not have been as successful as hoped.

While the majority of the participants expressed positive growth, there may have been students who viewed the process negatively, who were turned off by the experience. Their silence does not indicate agreement that the goals of the study were completely met. There were students who were not able to coalesce with the other learners to the extent that the teacher-researcher observed in the majority of the students. When relying upon student feedback and teacher reflections, the process may be imperfect. It is impossible to know completely what is happening in the minds of others, especially adolescents in a school setting, which limits the trustworthiness of this study to a degree.

The development of the ideal pedagogy to integrate journalism with the science research projects of the students is a work in progress and it may never be complete. There is the need to develop additional activities and scaffolds to fine tune each of the processes outline in this study. There is a need to collect additional feedback from the students on the effectiveness of the process from their point of view. In the emerging processes there were areas in which additional, formal research would provide additional understandings.

**Further Research**

The findings of this study demonstrate that student research projects can benefit from the addition of journalism activities. They also demonstrate the need for further research on the process. Similar studies in different school would determine if the participant demographics and school culture played the causative role in their success or if it was the pedagogy as posited by the teacher-researcher. The role which gender and age played in the acceptance of this pedagogy shift should be investigated to determine if the female, adolescent participants were unique in this regard. Studies carried out where the researcher was an “outsider” to the process may provide additional trustworthiness or affirm the trustworthiness of the use of a teacher-researcher with “insider” status.

The Read Aloud-Think Aloud process was found in this study to be a key factor in catching the student’s interest in the journalistic aspects of the intervention. Additional research on the process itself and the features which bring about this increased interest are indicated. Discourse analysis of the questioning which takes place during the Read Aloud-Think Alouds may augment understandings of the student knowledge construction process taking place. Examining the shifting of teacher and student roles which occur during the Read Aloud-Think Alouds using classroom observations may also provide insights into the process.

Interviews of the student participants in a combination of journalism with science research projects would be beneficial. Obtaining a more detailed view of how the participant experiences the process will inform our perspective. In particular, determining why some of the participants persist through the numerous editing and revision cycles while others opt out of the process would be informative.

Interviews of the participants to determine how their views of themselves as experts changes during the implementation of a similar pedagogy would be valuable. The participants in this study appeared to experience a shift in attitude as the study progressed, from viewing themselves as passive novices to experts who moved outside of themselves to share their expertise with the broader community. Studying this shift in behavior to determine which features of the pedagogy brought about the changes would provide a deeper understanding of how students move from novices to expert status, with an eye toward improving the process and applying it in other situations.

The impact of the changes in pedagogy on the career aspirations of the students would be an interesting follow up to this study. Some students but not all of the students did express a shift in career goals which they attributed to activities which occurred during the intervention. Why did the students change their ideas about science as a career path as a result of integrating journalism with their course coverage? What are the factors that determine if a student will be impacted by this pedagogy to the point where their trajectory changes? The recent push in the United States to improve the number of students pursing science, technology, engineering and mathematics careers provides the incentive for such a study.

Many schools and teachers today are judged by the standardized test scores of their students. In many secondary school settings the student scores on the ACT test are viewed as indicators of the success of the school program, not just the student who is undergoing the testing. A quantitative study of the change which results in standardized test scores such as the ACT when students participate in a program which integrates journalism with the science research projects would be of interest. In the high stakes world of test scores, finding if this pedagogy brings about positive change would be viewed as beneficial.

**Summary**

This research study has provided a glimpse into the changing classroom landscape during the implementation of a pedagogy which combines journalism with the student research projects carried out in high school chemistry coursework. It is hoped that this work will inspire other educators to consider designing and implementing a similar program within their own classrooms to see if they can experience similar success. As the process is implemented in more classrooms, reaching a diversity of student participants, the body of knowledge about this pedagogy will expand and evolve to benefit a greater number of learners. Research studies on these adaptations of journalism by educators will also improve the body of knowledge regarding the enhancement of the pedagogical process.

When I began this project, the title ‘Researching the Real’ was suggested to me by one of my professors, Dr. Saul. In this study I have attempted to provide that experience for my students; the chance to research something that has meaning in their own lives. I am confident that I have provided that for the participants in this three year study and plan to continue refining the process so that my future students can also have the chance to ‘research the real’.

## Appendix A: Science Fair Process prior to study

**Honors Chemistry Independent Research Project Deadlines** **R. Davidson 2009**

September: Visit the Greater St. Louis Science Fair Website:
http://www.sciencefairstl.org/

Purchase a composition notebook for your log book.
Write entries for researching topic, final decision of topic.
Show brainstorming about how you go about exploring the topic.

Submit a list of five chemistry topics for feedback.
Topic must be:

- chemistry based
- secondary level in rigor
- beyond what is covered in the typical high school chemistry course (look over your textbook)
- a controlled experiment

October: Continue working in your logbook, dating each entry.
Submit the final topic of your project for approval.
State the Problem as the title of your project.
State the Question being investigated in your project.

November: Before leaving school for Thanksgiving Break background information research is due.
Turn in at least 25 information note cards from a minimum of 5 sources with each source
listed on a separate work cited card. At least three of the sources must be non-internet.
Include in your research:

- the history of your topic: important people and discoveries
- the significance of your project: why it is worthwhile
- Facts: major terms are defined
- describe what is known about the topic.
- other experiments which have been done on your topic
- information on any chemicals or living organisms used.
- information on the chemistry involved in your project
- information on the chemistry involved in your topic
- information on any special equipment used in your topic

A PARAGRAPH VERSION OF THESE NOTES WILL COMPRISE THE BACKGROUND SECTION OF YOUR FINAL SCIENCE FAIR REPORT.

Note cards will be taped into the back of your logbook upon their return to you after grading and after your write your background paragraph.

December: Continue working in your logbook, dating each entry.
Decide on an experimental design for your experiment.
Gather all necessary equipment to carry it out.
<u>Perform a dry run or trial run to see if it really will work.</u>
Write up your experimental design as a separate section in the log book. Put a tab on this section in the log book.

In the experimental design include:

- project title
- problem/question
- hypothesis
- the Independent (manipulated) Variable
- Dependent(responding) Variable
- the Control that will be used for comparison
- the variables which will be held constant
- the equipment that you will use
- step by step description of how the experiment will be carried out
- the number of repeats and variations of the IV to be performed
- Safety rules that you will follow as you carry out your experiment

December before exam time: Log books collected. They should include:

- Ideas, development of project problem.
- Research notes (note cards), development of hypothesis.
- The experimental design for procedure and all variables.
- Detailed description of procedures carried out.
- Description of equipment and results of dry run.
- Dated entries, handwritten, tabs for different sections.

You want to turn in the logbook with sufficient time allowed so that they can be evaluated and handed back to you before Winter Break. If they are turned in late in December, you will not get them back in time to begin your experiment over Break.

Winter Break in December- January

Work on any additional research called for by the dry run of your experiment.

Carry out the actual experiment and record all of your data in your log book.

Winter Break is the best time to carry out the actual experiment, all trials.

THE REPORT WILL BE DUE IN THE BEGINNING OF FEBRUARY

Report Includes in this order:

- Title on first page (All other pages are numbered)
- Acknowledgements
- Table of Contents with page numbers
- Abstract
- Background material/Research
- Work Cited (MLA or APA)
- Method of Investigations which includes:
    - problem
    - hypothesis
    - materials
    - procedure
    - variables
    - description of control used
    - number of trials
    - pictures or drawings of set up
- Findings which include:
    - computer generated data table
    - pictures of results
    - computer generated graph
    - paragraph summary about the graph
- Conclusion and Recommendations
    - connect to hypothesis
    - include discussion of errors
    - future studies
- Reflection Questions
- Appendices: Math work + safety forms + pictures

SAVE REPORT FILE BECAUSE THEY ALWAYS NEED REVISIONS AND IMPROVEMENTS!

| | |
|---|---|
| February- March | Refine, redo report and/or experimental trials as needed.<br>Work on assembling final display on Science Fair Board for the school Science Fair. |
| March: | School Science Fair. |

.

We use the same judging rubric that you can find at the Greater St. Louis Science Fair website: http://www.sciencefairstl.org/2009Fair/Rubrics/Exp09_v2.0_rev_101508.pdf
The top projects will be entered in the St. Louis Science Fair at Queeney Park.

- Three items are prepared and put on display in the third floor hallway for the judges to look over.
    - First is the handwritten log book in a composition notebook.
    - Second is the full report in a binder.
    - Third is the display board that is a visual display of the main steps in your project.

- All three of these items should be labeled with the title of the science fair project.
  - The display board should have the title prominently displayed.
  - The logbook and report should have the title on a label on the cover of the book or binder.
- Display boards come in several sizes and a variety of colors. Any color is acceptable. 30" is the maximum dimension of the base.
- Usually the Problem, hypothesis and background go on one part of the board, the experimental design on the other which includes materials, procedure, variables and on the last portion are the data tables, graphs, results and conclusion. Not every word in your report needs to or should be displayed. The display is a summary of the most important aspects of your project. The details are in your final report.
- The display board should be professional, colorful and neat. It should not include any handwritten or hand colored items. It should not have any pictures other than those used to illustrate your set up or results. Pictures of your set up or result are essential but may not include the faces of any person.
- No school, teacher or student name may be anywhere on the project. This includes the report, the logbook and the display.

TAKEN FROM THE GREATER ST. LOUIS SCIENCE FAIR JUDGING SCORESHEET:

**DISPLAY**

- Easily Viewed: Display faces forward, materials easily read.
- Labels: Sections of study design are labeled
- Attractive: Uses color for emphasis, good arrangement, graphics
- Text on Display: Correct spelling and grammar, clear and concise writing.
- Creative Approach: Evidence of researcher's original input into display design

**LOGBOOK**

- Contains detailed thoughts, feelings, observations, revisions, & actions made during the entire process during the school year.
- Handwritten, dated entries and no identifying information
- Documentation of the development a step-by-step procedure (w/safety)
- Contains detailed research notes and bibliography
- Competed data table contains raw data completed during experiment
- Development of problem statement and hypothesis
- Variables - IV and DV present
- Explains why the topic is chosen
- Trial run conducted and logged
- Interpretation of results (in conclusion) to discuss trends in data
- Index cards of research for background should be taped into log book

## Appendix B: Judging Rubrics from the Greater St. Louis Science Fair

**GRADES 6-12**
Judging Criteria
**Experiment**

Academy of Science - St. Louis Science Fair
Science-Technology-Engineering-Math
Inquiry-based learning at its best!
Sponsored by Monsanto Fund and SunEdison

**Sequence Number:** ______________

**Row:**_______**Position:**_____

| Project Elements | Description of Criteria | Possible Score | Score |
|---|---|---|---|
| **DISPLAY BOARD SCIENTIFIC PROCESS:** | | | |
| Title & Description | Title of project and overview of project | 0-5 | |
| Testable Question & Hypothesis | Testable Question: Asks a specific, measurable, cause & effect question or clear purpose of project.<br>Hypothesis: Expresses a reasonable prediction about how specific changes affect the expected outcome. | 0-5 | |
| Background | History – highlights important people or discovery<br>Significance – explain importance of this project<br>Facts-tells what is known about the topic and explains major terms & definitions<br>Method-tells how this topic has been studied before (steps, equipment, measurement)<br>Bibliography-includes at least 3 sources | 0-10 | |
| Trials | At least 3 trials are indicated. | 0-5 | |
| Procedure & Conditions | Describe process for Experiment. Includes step-by-step process of Experiment. Independent/dependent/control variables are discussed throughout. Variables are clearly defined (independent, controlled, dependent). May be worded as "What I changed," "What I kept the same," and "What I measured." Includes when, where and how of study. High score would indicate that the project can be repeated after reading. | 0-15 | |
| Data and Identification | • Use photos/illustrations/graphs to show Experiment. All data should be clearly labeled and identify the Experiment.<br>• Graphs should contain title, x and y axis labeled and intervals are equal.<br>• High score shows steps in the process of experiment and is clearly labeled.<br>*(Note to student: Items that are valuable or valued by the student are not to be displayed – use photos/illustrations instead)* | 0-15 | |
| Conclusion & Reflection | Reflects what the student has learned. Were there any surprises? What would you do differently or to continue the project? Includes statement answering problem and hypothesis. | 0-10 | |
| **LOGBOOK:** | | | |
| Signed Safety Form & guidelines | All projects are required to have a signed safety form (placed on the inside cover of log book). Students should also provide detailed descriptions on how they followed the safety guidelines in their logbook. | 0-10 | |
| Dated Entries | High score indicates that student has written process, observations and data in log book during experiment. Clearly written with dates and comments. | 0-15 | |
| **OVERALL CREATIVITY/INNOVATION/ENGAGEMENT:** | | | |
| Creativity/Innovation/ Engagement | Student demonstrates an understanding of the subject matter or innovative/creative way of approaching their project. | 0-10 | |
| | Total Possible Score | 0-100 | |

**TOTAL SCORE:**

**GRADES 6-12**
Judging Criteria
**Observation**

Academy of Science - St. Louis Science Fair
Sponsored by Monsanto Fund and SunEdison

**Sequence Number:** ______________

**Row:**________**Position:**_____

| Project Elements | Description of Criteria | Possible Score | Score |
|---|---|---|---|
| **DISPLAY BOARD SCIENTIFIC PROCESS:** | | | |
| Title & Description | Title of project and overview of project | 0-5 | |
| Problem & Hypothesis | Problem: statement clearly states what is being observed and what pattern/phenomenon will be noted about the observed object(s).<br>Hypothesis: predicts expected pattern/phenomenon derived from the observed data. | 0-10 | |
| Background | History – highlights important people or discovery<br>Significance – explain importance of this project.<br>Facts-tells what is known about the topic and explains major terms & definitions<br>Method-tells how this topic has been studied before (steps, equipment, measurement)<br>Bibliography-includes at least 3 sources | 0-10 | |
| Procedure & Conditions | Describe process for observation. Includes detailed process for observation. High score would indicate that the project can be repeated after reading. | 0-10 | |
| Data and Identification | • Use photos/charts/graphs /illustrations to show observation. All data should be clearly labeled and identify the group, relationship or trend.<br>• Graphs should contain title, x and y axis labeled and intervals are equal.<br>• High score would show steps in the process of observation clearly labeled with observation details.<br>• Observation: high score indicates that student has observed 10 samples or more to demonstrate diversity.<br>*(Note to student: Items that are valuable or valued by the student are not to be displayed – use photos/illustrations instead)* | 0-15 | |
| Results | Diagram or Table clearly labeled to show answer to problem & hypothesis. | 0-5 | |
| Conclusion & Reflection | Reflects what the student has learned. Were there any surprises? What would you do differently or to continue the project? Includes statement answering problem and hypothesis. | 0-10 | |
| **LOGBOOK:** | | | |
| Signed Safety Form & guidelines | All projects are required to have a signed safety form (placed on the inside cover of log book). Students should also provide detailed descriptions on how they followed the safety guidelines in their logbook. | 0-10 | |
| Dated Entries | High score indicates that student has written process, observations and data in log book during collection. Clearly written with dates and comments. | 0-15 | |
| **OVERALL CREATIVITY/INNOVATION/ENGAGEMENT:** | | | |
| Creativity/Innovation/ Engagement | Student demonstrates an understanding of the subject matter or innovative/creative way of approaching their project. | 0-10 | |
| | Total Possible Score | 0-100 | |
| | | **TOTAL SCORE:**_______ | |

*REVISED for 2014 Fair*

## Appendix C: Examples from one student's process:
## Science News Article, Science Fair Report, News Release.

**1. Example of a Science News Article**

### Asthma and Air Pollution

Sammy could feel her chest tightening. Suddenly, she realized that she could no longer breathe. What had started out as a normal school day for 11-year-old Sammy Zuehlke, dramatically changed when she experienced an asthma attack. "At first I didn't know what was going on," said Sammy. "But when I realized I couldn't breathe I was so scared, I thought I was going to die." Teachers rushed Sammy to the hospital and, although she was alright, others have not been quite so lucky.

Recent studies done by top universities throughout the country have led many scientists and medical professionals to believe that there is a direct correlation between the increased amount of pollution in the air and the escalating percentage of the population affected by asthma.

Asthma is a chronic or long-lasting, inflammatory disease of the airways that affects over 60 million people worldwide. According to the Asthma and Allergy Foundation of America (AAFA), many symptoms of asthma can be caused by irritants or allergens that are inhaled into the lungs, resulting in inflamed, clogged and constricted airways. Patients who have asthma often experience this kind of temporary closing of the airways, which prevents air from entering their lungs. This lack of oxygen often causes wheezing, breathlessness and in severe cases death.
The AAFA reports nearly 11 asthma-related deaths a day, resulting in nearly 4,000 deaths each year.

According to studies from numerous U.S. universities, including the University of North Carolina at Chapel Hill, Harvard University, and the University of Illinois at Chicago, the number of hospitalizations due to asthma related reasons has increased by an extraordinary 4.5% in a 10 year period. In that same amount of time death rates from asthma have risen 31%, with mortality rates of African Americans nearly four times those of Caucasians. Although the root causes for this increased asthma prevalence is under debate, many specialists seem to believe it is a result of a "domino" effect caused by an increase in air pollutants.

The U.S. Clean Air Act of 1970 established six "criteria" pollutants: sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, and particulate matter and lead. There is very little evidence of association between asthma rates and exposure to lead or carbon dioxide; however, numerous studies have shown there is evidence of association with the remaining four.

Increases in particulate matter, or the mixture of tiny particles and aerosols that are suspended in the air we breathe, are associated with increased respiratory mortality and hospital admissions of asthma. The current U.S. standard for particulate matter is 150 micrograms per cubic meter of air ($\mu g/m^3$) in a 24-hour period. Numerous epidemiological studies done in the late 1990s showed that the lowest level at which asthmatics will be affected is above 50 $\mu g/m^3$ for particulate matter. Researchers at Harvard's School of Public Health also found that with each 10 $\mu g/m^3$ increase in particulate matter, there was a 3% increase in asthma attacks, bronchodilator use and lower respiratory symptoms. In addition, researchers found that ozone is associated with hospitalizations for asthma, although it has been difficult to separate the effects of the ozone from the effects of acid aerosols—tiny particles that have very high acid levels.

A series of reviews published in 1996 by Michael D. Lebowitz, a pulmonary and critical care specialist from the University of Arizona, showed that the lowest level of ozone that will affect asthmatics is an ozone with 0.08 parts per million (ppm)—the ratio of potentially harmful chemicals to non-harmful ones found in our air. The current U.S. standard is 0.12 ppm in a 24-hour time period. A clinical study done by the U.S. Environmental Protection Agency (EPA) in 2001 has also revealed that asthmatics subject to a 0.16 ppm ozone have increased reactions to the pollutant compared to non-asthmatics.

Clinical studies done in 1995 by Hillel S. Koren, a consultant for Environmental Health LLC, showed that asthmatics have harder time breathing after they have been exposed to both sulfur dioxide and nitrogen dioxide. A study involving various researchers found that participants with asthma exercising in areas with a sulfur dioxide concentration of 0.5 ppm experienced wheezing and had difficulty breathing.

Many scientists believe that these pollutants can also lead to increased sensitivity to allergens. A study performed in 1996 by Ian Gilmour, a consultant for the EPA, showed that animals exposed to increased ozone, sulfur dioxide and nitrogen dioxide levels had heightened sensitivity to allergens. Researchers believe that this increased exposure to pollutants reduces lung response resulting in longer residence of the allergens in the lungs which in turn leads to increased asthma attacks; however, scientists are still researching this.

So do air pollutants really affect asthma? Well Sammy seems to think so. "I can definitely believe that pollutants could have triggered my asthma attack."

**2. Example of a Science Fair Report**

**Asthma and Air Pollution**

**Abstract:** In order to determine how air pollution has affected asthmatics, a survey was given to a group of 57 people. Each person answered questions regarding their diagnoses, symptoms, and other aspects of their disease, which were then collected into multiple data tables and graphs. From these tables and graphs it was determined that the majority of patients believe that their asthma symptoms increase during months of high allergen and pollution levels. In addition, it was also concluded that more than half of the participants believe that their asthma symptoms have increased within the last five years.

**Problem:** Why have the number of patients affected by asthma increased at such a high rate in the past five years?

**Hypothesis:** If the number of chemical irritants (such as allergens and air pollutants) found in the air increases, then the number of people affected by asthma and asthma symptoms will increase.

**Background Information:** The earliest recorded reference to respiratory distress, a disorder characterized by “noisy breathing”, was found in China in 2600 BC. However, it would be nearly two thousand years before an official term would be used to describe this respiratory distress. In 400 BC, Hippocrates, an ancient Greek physician, described a disease in which patients experienced heavy wheezing and difficulty breathing, calling it *aazein, from which we get the modern word asthma. In addition to coining the name for the disease, Hippocrates was also the first physician to identify the relationship between the respiratory disease and correlating climate. Nearly one hundred years later, the first official medication for this disease was created. In 50 AD, Pliny the Elder recommended the use of ephedra, an herb found in red wine, to remedy asthma symptoms. However, new advancements in medication did not continue to evolve again until the 1900s when doctors began to use allergy immunotherapy, a process where patients were injected with large doses of an allergen, to treat asthma.* Epinephrine injections (adrenaline) and aminophylline tablets emerged as popular forms of treatment during the 1940s and 1950s. Since the Allergy and Asthma Medical Group & Research Center was founded in 1969, there have also been many therapeutic advances as well. The use of bronchodilator medications and cortisone steroids has minimized the side effects that were previously experienced with tablet and liquid medication. Although asthma has been a known entity for over two and a half millennia, nearly 25 million people in the United States still suffer from this condition. However, scientists have come a long way in understanding its causes and triggers since its emersion in 2600 BC and have made large strides in our ability to treat and control it.

Today scientists know that asthma is a chronic or long-lasting inflammatory disease of the airways that affects over 60 million people worldwide. According to the Asthma and Allergy Foundation of America (AAFA) many symptoms of asthma can be caused by irritants or allergens that are inhaled into the lungs, resulting in inflamed, clogged, and constricted airways. Patients who have asthma often experience a temporary closing of the airways which prevents air from entering their lungs. This lack of oxygen often causes wheezing, breathlessness and in severe cases death. The AAFA reports nearly 11 asthma related deaths a day, resulting in nearly 4,000 deaths each year. Because of this, it is extremely important that scientists continue to study asthma in order to learn more about how to prevent future deaths.

Recent studies done by top universities throughout the country have led many scientists and medical professionals to believe that there is a direct correlation between the increased amount of pollution in the earth’s ozone and air supply and the escalating percentage of the population affected by asthma. According to studies done by numerous universities throughout the United States including the University of North Carolina at Chapel Hill, Harvard University, and the University of Illinois at Chicago, the number of hospitalizations due to asthma related reasons has increased by an extraordinary 4.5% in a ten year period. In that same amount of time death rates from asthma have risen 31% with mortality rates of African Americans nearly four times those of Caucasians. Although the root causes for this increased asthma prevalence is under debate, many specialists seem to believe it is a result of a “domino” effect caused by an increase in air pollutants. The U.S. Clean Air Act of 1970 established six “criteria” pollutants; sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, and particulate matter and lead. There was very little evidence of association between asthma rates and exposure to lead or carbon dioxide; however, numerous studies have shown there is evidence of association with the remaining four.

Increases in particulate matter, or the mixture of tiny particles and aerosols that are suspended in the air we breathe, are associated with increased respiratory mortality and hospital admissions of asthma. The current U.S. standard for particulate matter is 150 $ug/m^3$ (or the micrograms per cubic meter of air) in a 24-hour period; numerous epidemiological studies done in the late 90s showed that the lowest level at which asthmatics will be affected is above 50 ug/m3 for particulate matter. Researchers at Harvard School of Public Health also found that with each 10 $ug/m^3$ increase in particulate matter, there was a 3% increase in asthma attacks, bronchodilator use, and lower respiratory symptoms.

In addition, researchers found that ozone has also been associated with hospitalizations for asthma, though it has been difficult to separate the effects of the ozone from the effects of acid aerosols which are tiny particles that have very high acid levels. A series of reviews done by Michael D. Lebowitz, a pulmonary and critical care specialist from the University of Arizona, in 1996 showed that the lowest level of ozone that will affect asthmatics, is an ozone with 0.08 part per million (ppm)—the ratio of potentially harmful chemicals to non-harmful ones found in our air. The current U.S. standard is 0.12 ppm in a 24 hour time period. A clinical study done by the U.S. Environmental Protection Agency in 2001 has also revealed that asthmatics subjected to 0.16 ppm ozone have increased reactions compared to non-asthmatics.

Clinical studies done by Hillel S. Koren, a consultant for Environmental Health LLC, in 1995 have also revealed that asthmatics have a harder time breathing after they have been exposed to both sulfur dioxide and nitrogen dioxide. A study produced through the correlation of various researchers of Toxicology and Industrial Health found that while exercising in areas with a sulfur dioxide concentration of .5 ppm, participants with asthma experienced wheezing and had difficulty breathing.

Many scientists believe that the interacting of these pollutants has also led to increased sensitivity to allergens. A study performed by Ian Gilmour, a consultant for the Environmental Protection Agency (EPA), in 1996 showed that animals exposed to increased ozone, sulfur dioxide, and nitrogen dioxide levels had heightened sensitivity to allergens. Researchers believe that this increased exposure to pollutants reduces lung response resulting in longer residence of the allergens in the lungs which in turn leads to increased asthma attacks; however, scientists are still researching this.

**Procedure:** In order to test the hypothesis, a group of about fifty to sixty people who are affected by asthma will take an online survey. This survey should include questions along the lines of when the person was diagnosed with asthma, how certain allergens or pollutants affect their asthma, and if they believe an increased rate of those affected by asthma is due to increased pollutants in the air supply. The survey used to carry out this experiment is in the appendix following this report.

**Observations:** For this experiment a survey consisting of ten questions was given to 57 people over a one week period. Each question was related to either the participants' medical history or their experience with asthma. The results from this survey are as follows.

**Data:**

| **Question 1:** | |
|---|---|
| Possible Response: | Number of Participants who Responded that way: |
| Male | 21 |
| Female | 36 |

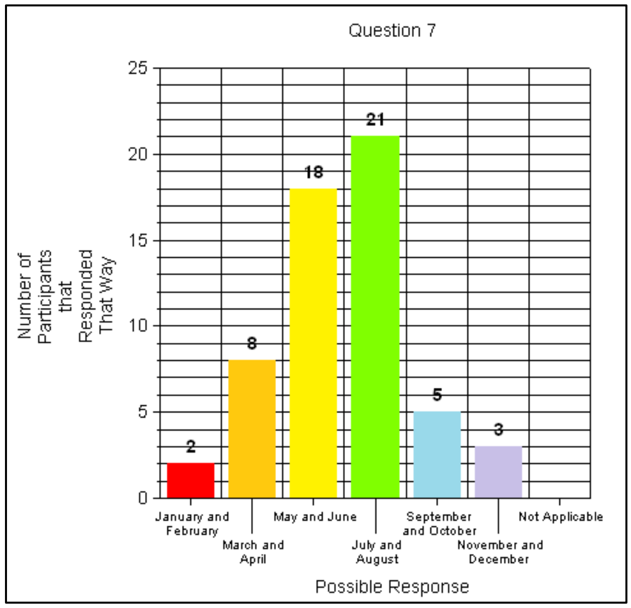
| **Question 2:** | |
|---|---|
| Possible Response: | Number of Participants Who Responded that way: |
| Between1980 and 2000 | 26 |
| Between 1960 and 1980 | 22 |
| Between 1940 and 1960 | 9 |

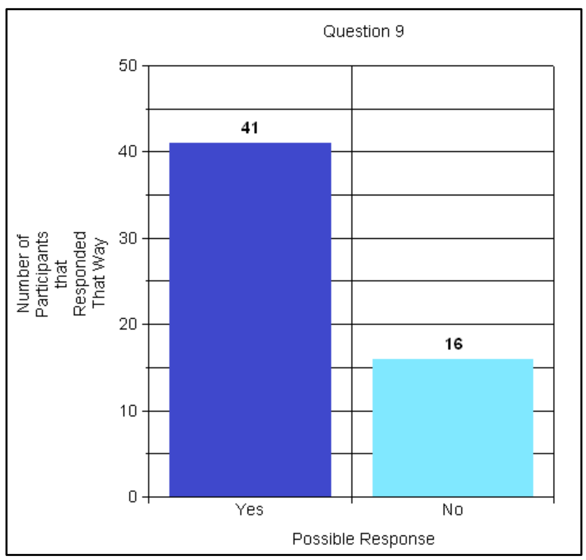
| **Question 3:** | |
|---|---|
| Possible Response: | Number of Participants who Responded that way: |
| Less than 1 year | 1 |
| 1 year to 3 years | 1 |
| 4 years to 10 years | 7 |
| Entire life | 48 |
| **Question 4:** | |
| Possible Response: | Number of Participants who Responded that way: |
| Yes | 57 |
| No | 0 |
| **Question 5:** | |
| Possible Response: | Number of Participants who Responded that way: |
| Yes | 57 |
| No | 6 |

| Question 6: | |
|---|---|
| Possible Response: | Number of Participants who Responded that way: |
| Date symptoms stopped | 0 |
| N/A | 57 |
| **Question 7:** | |
| Possible Response: | Number of Participants who Responded that way: |
| January and February | 2 |
| March and April | 8 |
| May and June | 18 |
| July and August | 21 |
| September and October | 5 |
| November and December | 3 |
| Not Applicable | 0 |
| **Question 8:** | |
| Possible Response: | Number of Participants who Responded that way: |
| Yes | 35 |
| No | 23 |

| Question 9: | |
|---|---|
| Possible Response: | Number of Participants who Responded that way: |
| Yes | 41 |
| No | 16 |
| **Question 10:** | |
| Possible Response: | Number of Participants who Responded that way: |
| Yes | 25 |
| No | 32 |

**Data Analysis:**




**Results:** The results collected during this experiment showed that 21 participants experienced elevated symptoms during the months of July and August. In prior research, it was found that July and August usually have the highest levels of allergens and air pollution as compared to the other ten months. It was also revealed that only 2 participants experienced elevated asthma symptoms during the months of January and February, both months with very low allergen and air pollution levels. Based on this information, the data collected during this experiment corresponds with the hypothesis because patients experienced elevated symptoms during months of high allergen and air pollution levels. In addition, data also reveled that 72% of participants (41 participants) believed that their asthma symptoms have worsened over the past 5 years. Based on prior research, it was found that allergen and air pollution levels have increased over the past 5 years. Therefore, the data collected once again agrees with the hypothesis.

**Conclusions:**

From the data collected it was determined that the majority of people who participated in the survey believed that their asthma symptoms have increased in the last five years, especially during months with high allergen and pollution levels. This data not only supports the hypothesis but also the correlates with the research listed in the background. The information collected in this experiment can have a major impact on not only scientists who research asthma, but also all people who are affected by the disease. By understanding how both air pollution and allergens affect asthmatics, doctors will be able to prescribe medication accordingly (i.e. higher medication during months of high allergen levels) which will hopefully alleviate some of the symptoms that asthmatics experience.

As previously stated, the information collected during this experiment does correlate with the hypothesis. Data revealed that 21 participants experienced elevated symptoms during the months of July and August, which have some of the highest levels of allergens and air pollution. In addition, only 2 participants admitted having elevated symptoms during January and February, which have the lowest levels of allergens and air pollution. This information clearly shows that because allergen and air pollution levels were elevated during the months of July and August, asthmatics experience increased symptoms. However, variation in answers did occur because other factors also affected the symptoms that each participant experienced. Some of these factors include exposure to allergens (other than those in the air), illness, tobacco smoke, stress, and exercise. Nevertheless, the data collected during this experiment is quite reliable because it was taken from a large number of people and therefore does not express any personal perceptions or opinions.

One way this experiment could be improved would be by giving the survey in persona rather than over the internet. This would help clear up any confusion that arose during the survey and would insure accurate answers.

The information collected through this experiment can give great insight to medical professionals and scientists who work with asthmatics. By understanding that asthmatics tend to have elevated symptoms when exposed to environments with higher levels of allergens and air pollution, scientists can work figure out ways to alleviate these symptoms (whether through medication or other methods). One way to further this experiment is to put asthmatics in varying environments (some with high levels of allergens and air pollution and others with low levels) and allow them to use an inhaler or other form of medication and see whether it really improves their breathing abilities.

**Science Fair Report Works Cited**

"Asthma." *World of Health*. Gale, 2010. *Gale Science In Context*. Web. 28 Nov. 2011.

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McGovern, Victoria. "Taking a world view of asthma. (NIEHS News: under the scope)." *Environmental Health Perspectives* 110.9 (2002): A514+. *Gale Science In Context*. Web. 28 Nov. 2011.

"The five worst environmental threats to children's health." *Journal of Environmental Health* 60.9 (1998): 46+. *Gale Science In Context*. Web. 28 Nov. 2011.

**Science Fair Report Appendix:**

Asthma Questionnaire:

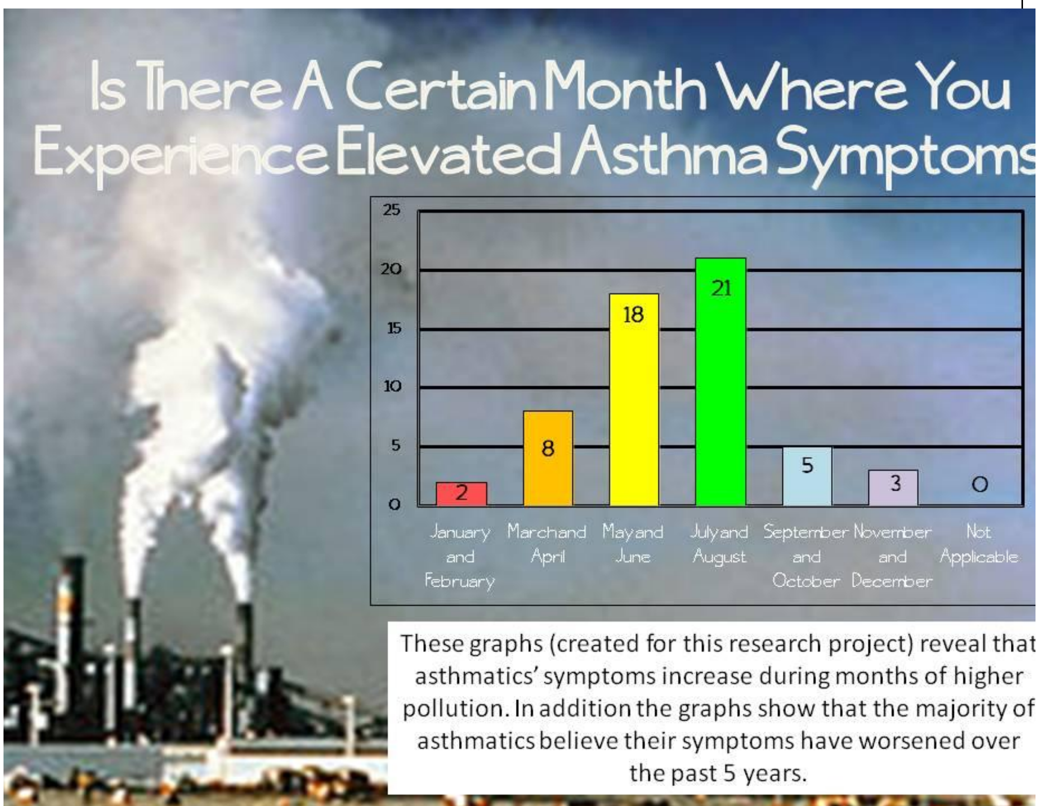
1. Are you male or female?
    a. Male
    b. Female
2. When were you born?
    a. Between 1980 and 2000
    b. Between 1960 and 1980
    c. Between 1940 and 1960

3. How long have you lived in St. Louis?
    a. Less than 1 year
    b. 1 year to 3 years
    c. 4 years to 10 years
    d. Entire life
4. Have you ever been diagnosed with asthma?
    a. Yes
    b. No
5. Do you currently experience asthma related symptoms?
    a. Yes
    b. No
6. If not, when did your symptoms stop?
    a. Date symptoms stopped: dd/mm/yyyy
    b. Not applicable
7. If you still experience symptoms of asthma, is there a certain time of year when you experience elevated symptoms?
    a. January and February
    b. March and April
    c. May and June
    d. July and August
    e. September and October
    f. November and December
    g. Not applicable
8. Do you suffer from seasonal allergies?
    a. Yes
    b. No
9. Do you feel that you asthma symptoms have increase in the past 5 years?
    a. Yes
    b. No
10. Are you currently taking medication to control your asthma symptoms?
    a. Yes
    b. No

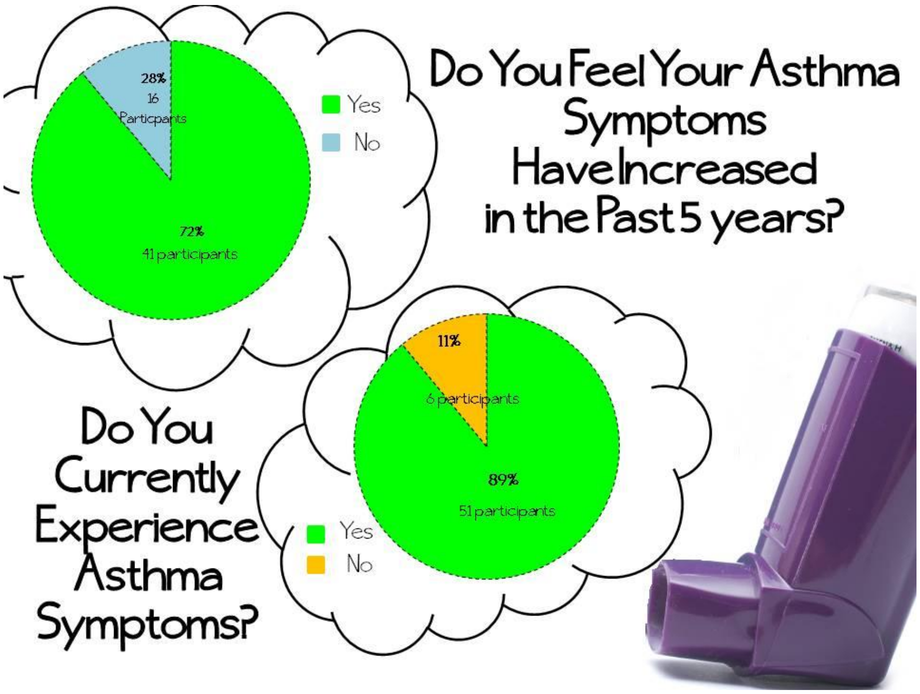
**3. Example of a News Release**

# Just Take a Deep Breath, If You Can!

A recent study done at ## # high school has revealed a startling correlation between the increased asthma rates across the nation and the depreciating air quality. In order to determine how air pollution has affected asthmatics, a survey was given to a group of 57 people. Each person answered questions regarding their diagnoses, symptoms, and other aspects of their disease, which were then collected into data tables. This information was compared to allergen and pollution levels using graphs.




The results collected during this experiment showed that 21 participants experienced elevated symptoms during the months of July and August. In prior research, it was found that July and August usually have the highest levels of allergens and air pollution as compared to the other ten months. It was also revealed that only 2 participants experienced elevated asthma symptoms during the months of January and February, both months with very low allergen and air pollution levels. Based on this information, it was concluded that asthmas symptoms increase during months of higher pollution proving that there is a correlation between increased asthma symptoms and the depreciating air quality. In addition, data also reveled that 72% of participants (41 participants) believed that their asthma symptoms have worsened over the past 5 years. Based on prior research, it was found that allergen and air pollution levels have increased over the past 5 years. Therefore, the data collected once again suggests that there is a correlation.



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