EFFECTS OF STORYTELLING ON STUDENTS BELIEFS AND ATTITUDES ABOUT THE NATURE OF SCIENCE AND DOING SCIENCE

by

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ABSTRACT

The purpose of this study was to investigate how storytelling, combined with opportunities for dialogue and inquiry, would impact middle school students' beliefs and attitudes about the nature of science and doing science. Specifically, the study sought to determine if storytelling sessions, involving science mysteries and historical narratives about scientists and their discoveries, would be effective instructional aids for helping students understand the way science is conducted. The study involved thirty-one sixth graders in two sections of a life science class. The storytelling sessions and related inquiry activities were implemented on a bi-weekly basis during a three month period. Pre and post-treatment surveys and interviews, periodic questionnaires, and daily observations were used to assess students' perspectives and reactions. The results of this study showed that storytelling combined with dialogue and inquiry improved students' attitudes about doing science and generated fresh depth and breadth of perception about the nature of science. The historical narratives were well suited to making science facts more meaningful and memorable, while the science mysteries were more effective in helping students generate investigative questions.

INTRODUCTION AND BACKGROUND

Stimulating student engagement in learning is an age-old challenge. Teachers want to make the most of every instructional minute they have. But competing for attention in a world that is constantly flashing from one image to another is an uphill battle. In my science class, hands-on activities and teacher led demonstrations are surefire ways to captivate student interest. Yet, when it comes to the spadework of digging into a text, taking notes from a lecture, or analyzing data students are prone to disengage - the drift into idleness being displayed in slouching postures, side conversations, and lack of participation in discussion.

In these situations, I sometimes employ a tactic aimed at revitalizing the scene. I tell a story. The effect seems almost magical. Heads come up, voices hush, and all eyes fasten to mine. Indifference quickly fades as they react spontaneously to the invitation to participate imaginatively in the story.

Not only do stories put students in a receptive state, they seem to make information meaningful and memorable. For these reasons, I have come to appreciate storytelling as a tool for unlocking students' minds. The problem is that, to date, my approach to using storytelling has been rather piecemeal and haphazard; a rare excursion from the routine. As consequence, I suspect that I have only begun to tap into storytelling's hidden potential. This paper examines how the learning process would be affected when storytelling is developed into the central platform for delivering instruction in my classroom.

I teach at Oaks Christian School in Westlake Village, California, which has a current enrollment of approximately 1,500 students in grades six through twelve. Tuition is just under $30,000 per year for all grades. Admission is competitive, based on a variety of criteria ranging from primary school grades, Independent School Entrance Exam score, an interview, essays, and interests. Nearly all of the graduating students go on to attend four year colleges and universities, with several students matriculating to top colleges. Many of the students come from affluent homes, including a handful of children of celebrities. However, our school values diversity, and thus it has established a generous scholarship program which allows for the enrollment of a substantial number of less privileged students. The academic program is rigorous, the arts are strongly supported, and the athletic programs are highly competitive (http://www.oakschristian.org/).

Each grade level in our middle school has eight sections of students the core classes. My teaching load is split between sixth and seventh grade. I teach two sections of sixth grade life science and four sections of seventh grade integrated science. The research group for my study consisted of my two sixth grade classes. The combined total of students in both classes is thirty-one of which fourteen are girls and seventeen are boys. The ethnic makeup of the participants in the study includes two African Americans and four Hispanics, while the rest are Caucasian. Many of the students' parents have advanced degrees, including a few who are medical doctors or who work in science related fields. In this context, parental support for academics is strong, and students tend to be high achievers.

If there is one thing I have learned during my fifteen years of teaching, it is that I still have much to learn. Through this study, I will able to look at the practice of storytelling from entirely new vantage points and make personal use of what I discover. Beyond that, I hope to be able to develop practical tips and strategies that can be implemented by colleagues across the spectrum of grade levels and curricula.

The purpose of this action research based project was to determine how the strategic use of storytelling in the science classroom, combined with opportunities for dialogue and inquiry, will affect student students' beliefs and attitudes about the nature of science and doing science. The specific sub-questions are as follows: How will storytelling affect student participation in discussion? Can stories provide an effective springboard for hands-on inquiry activities? Will students remember details of the stories over the short and long terms?

CONCEPTUAL FRAMEWORK

Storytelling is an essential human trait. Anthropologists have found evidence of folklore in all cultures around the world throughout all periods of human history. From the oral traditions of bygone eras to the array of multimedia forms of the modern day, narratives have always been an integral part of the human experience. That this characteristic is so pervasive across the cultural landscape has attracted the interest of researchers in various fields who seek to discover what our predilection for stories might tell us about human nature (Hsu, 2008).

Cognitive psychologist Jerome Bruner (1986, 1990, 1996) suggests that stories are the primary means by which we make sense of things in our everyday thinking and living. From early infancy, we have an innate ability to assimilate understanding through stories. So basic is a narrative organization of thinking that it influences concept formation and understanding in humans more than any other kind of mental functioning. However, educators have largely failed to capitalize on the innate disposition students have to narrative thinking.

Over the past few decades, one of the most ardent supporters of the use of stories in education has been Kieran Egan. He is interested in examining the ways in which children use imagination in the process of learning. Stories foster imagination in children which helps them to remember things better and makes knowledge more engaging (Egan 1997, 2005).

In contemporary education, inquiry-based instruction has been widely embraced by science educators. Hands-on experiences with scientific phenomena have been demonstrated to have a positive effect on students' understanding of the nature of science (Minner, Levy, & Century, 2009) and on improvements in attitudes and motivation (Foley & McPhee, 2008). Yet despite such promising possibilities, studies show that schools at large have been slow to respond. Among the challenges cited by science teachers was lack of available resources and sufficient time to plan appropriate activities. (Weiss, Pasley, Smith, Banilower, & Heck, 2003).

Stories are a suitable alternative when time constraints or lack of resources restrict inquiry-based lab activities (Kirchoff, 2008). Stories can be used as a creative tool to both generate hypothesis and test them through experiments. The coupling of stories and hands-on inquiry activities can be approached in two ways. The story can be told first and concepts can be identified within the narrative that relate to the topic at hand. Conversely, an experiment can be undertaken and the story can be used to support the findings. Selecting stories that contain problem solving elements or that highlight change or growth are especially appropriate for this approach. After students have finished hypothesizing and experimenting, the whole experience can be tied back into the story (Sima, 1998).

Along with an emphasis on inquiry, the National Science Education Standards also emphasizes the importance of "history in school science programs to clarify different aspects of scientific inquiry [and] the human aspects of science" (National Research Council 1996, p. 107). Both students in the classroom as well as scientists operating in the field have a predisposition to think in story-like sequences. Every scientist starts out as an amateur. They become skilled practitioners as they immerse themselves in their field of study take on a narrative mode of thinking about the varied and subtle senses of a situation (Martin & Brower, 1993). Their quest usually starts with a vague hunch. This hunch leads them to investigate further and collect more data. All the while, they make records of their journey in the form of diaries and field journals. By being exposed to these kinds of narratives, students can put themselves in the shoes of the great scientists and appreciate the struggle that led up to the celebrated moments of discovery (Kirchoff, 2008).

Scientific knowledge is dependent both on making careful observations of phenomena and on confirming these observations through experimentation. This process inevitably leads to the occasional discarding of theories as new knowledge becomes available (National Science Teachers Association, 1997). This process is reflected in the evolution of the storylines that emanate from the scientific community. Aristotle, Copernicus, Kepler, Galileo, Newton, and Einstein each saw the world from unique vantage points and constructed new narratives based on their observations (Martin & Miller, 1998).

Exposing students to a diverse collection of biographies as well as current event articles, books, and websites can help them to not only embrace the complexity of science, but also shed light on the significant contributions to science that have been made by people in traditionally underrepresented minority groups (Kirchoff, 2008).

Middle school textbooks are filled with vocabulary that is strange and abstract and students are reluctant to talk about the text (Fang, 2000). Narratives use language that is more common and accessible to students. This is important, because learning works best when students are involved in active listening and thoughtful participation in class discussions. They need to be able to share ideas with one another and give each other constructive feedback. A review of more than a dozen studies on this kind of reflective learning suggests that this approach increases comprehension, achievement, and standardized test scores (Rosenshine & Meiser, 1994). Stories emanate from reflection, and storytelling is a powerful tool for inducing reflection (McDrury & Alterio, 2003; Schön, 1988).

The extent to which stories should be used in favor of science textbooks is debatable. While acknowledging the value of judicious use of storytelling in the classroom, some researchers would argue that the practice is not a replacement for the use of texts. This is because texts are necessary for building the kind of science literacy students will need to meet the strenuous demands of contemporary science. As a consequence of being highly symbolic and specialized, it cannot be adequately conveyed in the common language of storytelling (Fang, 2006).

Reading aloud is a normative practice in elementary school classrooms, but not prevalent middle school. A review of extensive research that has been conducted on reading aloud in middle school and secondary classrooms suggests that the practice can be beneficial. Increased motivation and improved vocabulary acquisition are two outgrowths that have relevance in science classrooms. Research in this area relating specifically to core content areas such as science is thin (Braun, 2000).

Stories are an integral part of the psychological life of all people (Hsu, 2008), and students have a natural inclination towards narrative organization of thinking (Egan, 2005). Using stories in the classroom can evoke motivation and interest and can improve comprehension, memory, and vocabulary (Braun, 2000). The nature of scientific investigation is mirrored by stories (Martin & Miller, 1998). Through a storytelling mode, scientific knowledge, principles, and values can be effectively conveyed to students (Kirchoff, 2008). Storytelling fits well with the purposes and practices of inquiry education and can be blended into other learning activities such as reflective dialogue (McDrury & Alterio, 2003) and hands-on activities (Sima, 1998).

METHODOLOGY

During the first twelve weeks of school, five major topics from the sixth grade life science curriculum were taught; the characteristics of living things, the chemistry and organization of life, the structure and function of cells, and DNA. At this point, the curriculum was taught through lectures, class discussions, textbook reading, and hands-on activities. The students worked both individually and in groups.

Due to the fact that my study involved normal educational practices and relatively unobtrusive research methods, my principal gave me an exemption regarding informed consent (Appendix K). Also, the research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The treatment period lasted three months, during which time storytelling and related inquiry activities were used as the primary mode of delivering instruction. The project spanned five major units of study including, respectively, DNA, bacteria, plants, protists and fungi, and invertebrates. In the first two units, I used stories about the work of two significant scientists – Alphonse Bertillon and Joseph Lister. My source for these stories was the *Childcraft* anthology of children's books, published by World Book, Inc. The next three units involved everyday science mysteries. These stories, having to do with seed germination, lichens, and earthworms, were from the NSTA Press book series *Everyday Science Mysteries: Stories for Inquiry-Based Science Teaching.* In order to facilitate the triangulation of data, multiple research methodologies were used throughout the course of the project.

Before beginning my study, I collected baseline data from two sources. One source was student interviews which were conducted with twelve randomly selected students using the Pre-treatment Interview Questions (Appendix H). The other source was the Student Beliefs and Attitudes about the Nature of Science and Doing Science Survey (Appendix J). On the day that this survey was conducted, two students were absent (N=29). When I administered the same survey at the end of the treatment period I did not report data from these students.

The Students Beliefs and Attitudes about the Nature of Science and Doing

Science Survey gathered information in two distinct categories. The first category was *doing science*. The reference here was to the everyday practices and procedures involved in classroom learning. The second category was the *nature of science*. Here the focus was on key features of scientific knowledge and the science profession. The survey consisted of 21 questions rated on a four point Likert-type scale (1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Disagree.) For purposes of simplification I combined the four response categories (e.g., *strongly agree, agree, disagree, strongly disagree*) into two categories: *agree* and *disagree*.

After each storytelling session, students were given an opportunity to discuss various aspects of the story. The class discussions originated from responses to the Story Dialogue/Discussion Prompts (Appendix A). The ideas, statements, and questions generated by students during these sessions were recorded on the white board. Using this list for reference, each inquiry group then proceeded to design and conduct an experiment to answer a question raised by the story. Science notebooks were used continuously by students for recording experimental designs, thinking, vocabulary, and questions. To ensure that students had recurrent exposure to the language of science, I kept a “Working Words” bulletin board which was an ongoing collection scientifically significant graphics, words, and background information from the unit.

My strategy for the implementation of the inquiry investigations was based on the essential features of inquiry based learning where the investigations are primarily student-directed and teacher guidance is held to a minimum (NCR 2000). Unique to the purposes of this study was the specification that the investigations needed to be not only scientifically relevant but also story related. Possible answers to these questions were investigated by collecting and analyzing data, drawing conclusions, justifying results, and debate. To begin with, group members collaborated together on a question to investigate. They then created a materials list and decided on procedures. As students moved along, they used their science notebooks to draw and label pictures of their experiments and record their findings. The final step was having each group explain and support ideas orally. Individual members of the group took responsibility for at least one aspect of their group's presentation. A plenary discussion followed to evaluate the merits and deficiencies in the experimental designs and results. As a wrap-up, students were asked to reflect on the ways in which the investigations had deepened their understanding or broadened their perspectives about various aspects of the storytelling. Throughout the course of the project, the effectiveness of the storytelling and inquiry activities were assessed by the students using the Self-Assessment of Storytelling and Related Activities (Appendix F).

In order to assess students' ability to remember the details and concepts related to the storytelling sessions, I used the Story Retelling rubric (Appendix G). I used a three point scoring scheme to capture the quality of recall with 1 representing a "poor" recollection, 2 representing a "good" recollection, and 3 representing and "excellent" recollection.

Student portfolios were used during each unit to provide a snapshot of the ways in which students had internalized the concepts from storytelling, discussions, and experiments. Options for portfolio submissions included writing an alternative ending to a science mystery story, writing a unique story, providing a detailed explanation of an experimental design, or using graphic visualizations to develop new insights into the topic. These rubrics, with regards to the aforementioned options, were as follows: Story Writing Self Reflection Questions (Appendix B), Experimental Design Self Reflection Questions (Appendix C), and Graphic Visualizations Self Reflection Questions (Appendix D). Students were required to give a short oral presentation of each of their portfolio items. The final portfolios were graded using the Student Portfolio Scoring Rubric (Appendix E).

To determine students' ability to remember key concepts and details two weeks after the stories had been told, I used the Story Retelling Rubric (Appendix G). My daily observations of students' reactions, questions, participation, and recollection of story details were recorded in a research journal. In order to provide data necessary for comparison with the pre-treatment interview data, I interviewed the same twelve students at the end of the project using the Post-treatment Interview Questions (Appendix I).

To illustrate the various aspects of the methodology as they were actually applied, I will refer to the first story that I used in my treatment which is titled, "The Mean, Heartless Detective" by A.D. Lewis. This short story is based on a particular event in the life of Alphonse Bertillon, an anthropologist who more than a hundred years ago discovered that some things about a person never change – the size of his head, the length of his ear and of his fingers. By recording these measurements of criminals in files kept at the Paris police station, Bertillon could identify them as long as they lived.

In the story, an elderly man was caught in possession of stolen property. At the police station he tried to convince Bertillon that he was merely a poor, hungry farmer who had stolen out of desperation so that he could sell the items and purchase food for himself and his wife. Bertillon was skeptical. He began the rigorous process of recording the man's body measurements. All the while, the man sorrowfully pleaded his case and complained of physical weakness. The police officers in attendance, believing that the man was telling the truth, had misgivings about Bertillon's handling of the hapless man. Bertillon stubbornly pressed forward. On this occasion he experienced some minor glitches in his system that initially caused him to come up empty handed. But then, after making some quick adjustments, he found what he was looking for. From a file box he extracted a card that contained the police record and photograph of a criminal. Bertillon triumphantly held the card up to the man's face. Upon seeing his own image on display, the man exploded with rage. He was not the poor farmer he had claimed to be. He was a common crook, and Bertillon's scientific methods had proven it.

During student discussion about the story a few themes surfaced. Students noted that (1) the practice of science isn't always fun, sometimes it is just plain hard work (2) although Bertillon could be stubborn and mean he was very good at his job and (3) by today's standards, Bertillon's system for identifying criminals seemed to be quite primitive.

The final aspect of the discussion focused on the accuracy of the Bertillon system in correctly identifying a person. This provided a springboard for students to design and carrying out an experiment. The consensus among the students was that they wanted to test Bertillon's system for themselves by obtaining the prescribed measurements from each member of the class. Before they began the experiment, students were asked to establish a criterion that would ensure that the measurements were collected in a scientific manner (i.e. uniformly and consistently). Once the experiment had been completed, students presented their findings and shared their observations about the experiment.

At this point, students were asked to use their previous learning about heredity to explain the connection between the inheritance of traits and the physical characteristics under consideration in the experiment. Students were then introduced to the structure of the DNA molecule with discussion focusing on how the unique ordering of its nucleotides serves to define the unique construction of each individual’s body. Further discussion contrasted the relative ease of use and accuracy of Bertillon’s system in comparison to modern day examinations of fingerprinting and DNA evidence. Student portfolio submissions related to the story included detailed drawings of a segment of the DNA molecule, short stories about DNA samples being used to identify the perpetrator of a crime, and redesigns of the class experiment that might minimize experimental errors.

The data collection methods that were used are shown in Table 1.

Table 1
Data Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
1. How well can students recall the details of the storytelling?	Instructor observations and journaling	Student surveys, journal writes, and reflections	Post-treatment interviews
2. Does student participation in discussion about science improve as a result of the storytelling?	Instructor observations and journaling	Student self-reflection surveys	Post-treatment interviews
3. Can students effectively design and carry out experiments related to the storytelling?	Instructor observations and journaling	Student portfolio submissions	Student self-reflection rubrics
4. Does student understanding of science concepts and vocabulary improve as a result of the storytelling?	Formal assessments	Student self-reflection surveys and portfolio submissions	Post-treatment interviews
5. How does the storytelling affect students' understanding of the nature of science and doing science?	Instructor observations and journaling	Student journal writes and reflections	Pre and post-treatment attitude and beliefs surveys

DATA AND ANALYSIS

Pre-survey data from the Students Beliefs and Attitudes about the Nature of Science and Doing Science Survey (Appendix J) revealed that 51.7% of the students had a preference for open-ended investigations rather than worksheet activities (*N*=29). One student reported that she liked to do experiments, "especially when we have the worksheets that go with them." Favorability towards open-ended investigations had increased to 79.3% in the post survey. "I like science more," commented one student. "You let us respond to it ourselves. You do give us help…but we get to explore." The number of students who *agreed* with the position that they would prefer being able to help design an experiment of their own decreased by almost 7% in the post-survey.

Evidence suggests that students' motivation to engage with science outside of the school context was improved. This trend is illustrated by an increase of about 20% in the number of students who claimed that they read science articles or books for personal enjoyment. As one student said, "For some reason when I get bored I've been reading science textbooks. I feel like I'm getting better and better every day." Another student recalled, "One time, when I was at Sophia's house, I noticed that she wanted to talk about what we're learning in science class. She is interested in science and enjoys it."

There was an increase of about 17% in the number of students who agreed with the position that they make useful contributions in class discussions. The same percent increase was seen with regards to students' perception that in class we engage in talk and debate about science concepts. "We're kids. Talking about concepts together, using words we understand, gives us a better idea about what we are learning rather than a very, very, very scientific explanation.

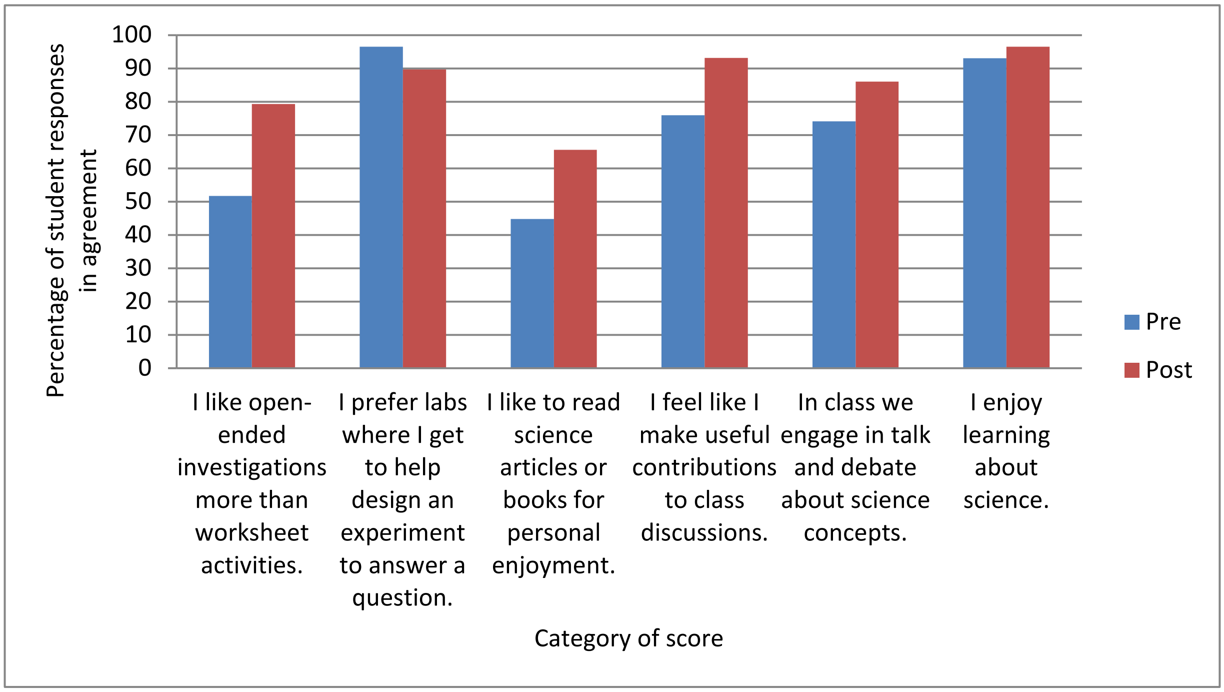

Figure 1. Doing Science, (*N*=29).

With regards to the nature of science, the pre survey data from the Students Beliefs and Attitudes about Doing Science and the Nature of Science Survey (Appendix J) indicated that 72.4% of the respondents agreed that learning science affects the way that they view the world around them (*N*=29). In the post survey, 93.1% of the responses in agreed with this position. A heightened awareness of connections that exist between school science and "regular life" was reported by many students. "We get to discover and go more into depth, like not just going outside and seeing a leaf and saying it's green, but understanding why it's green." In a similar vein, the post-survey data indicated an increase of about 11% in favor of the belief that science will be useful in real life. One student commented, "These concepts will be in my life later. Through the story of Joseph Lister, I learned why it's important not to put a dirty rag on a wound."

Student responses showed a decrease of about 24% in the number of students who agreed with the position that in science logic is more important than imagination. One student commented, “To me, science is the study of anything you can imagine.”

Modifications in beliefs and attitudes towards the practitioners of science were also evident. Before participating in this study, one student couched her description of science professionals in rather mundane terms. “The first thing that comes to mind is lab coats and goggles. Scientific experiments. Looking in microscopes. Lots of notes and writing.” Biases of this nature were echoed numerous times throughout the pre-treatment interviews. The post survey data from the Student Beliefs and Attitudes about Doing Science and the Nature of Science (Appendix J) indicates a decrease of about 14% in the number of students who believed that being a professional scientist seems boring. One student described his personal experience. “I used to think scientists just studied things like planets. Now I know it has to do with everything we do in life. I used to think it was boring, but now I think it is fun.”

Analysis of the data suggests that students gained a greater appreciation of the transitory nature of scientific theory. There was an increase of about 31% in the number of the responses in agreement with the position that as scientists learn more many ideas they have will be proven wrong. This theme was underscored by the comments such as, “I have learned that in science class you have to listen a lot, being open to all ideas, open to everyone’s point of view. You might have a lot of knowledge about a subject, but you need to put that aside and look for what new thing you can learn.” This finding is curious when viewed in juxtaposition to survey data revealing that there was no change in the belief that the main point of science is to learn what others have already discovered.

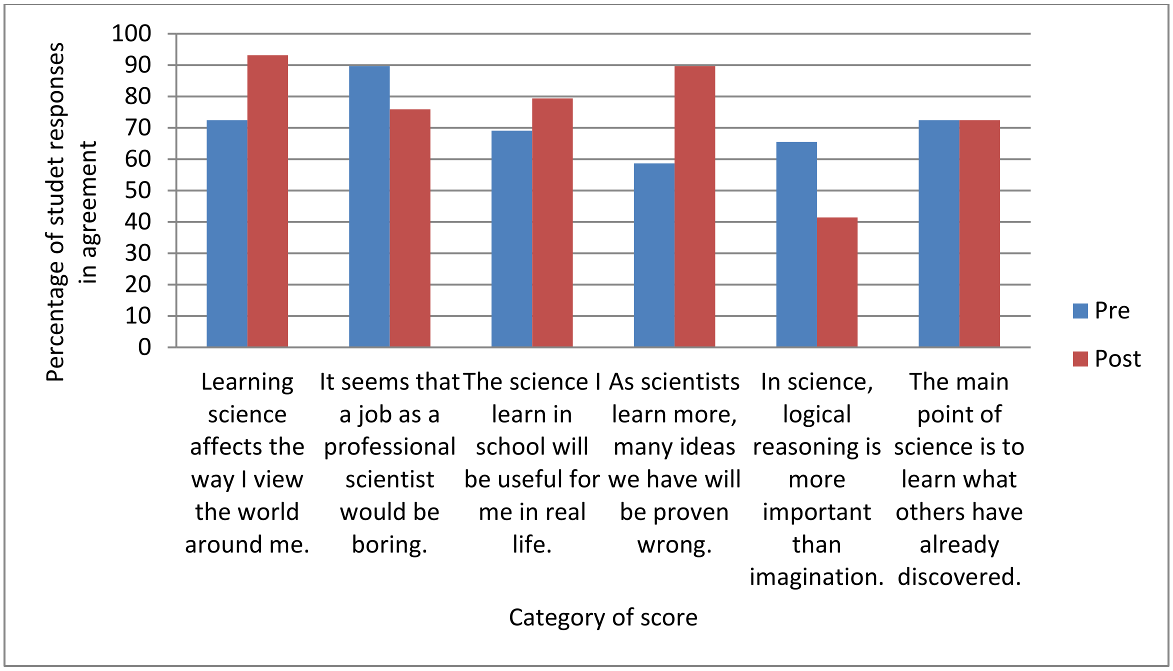

Figure 2. The Nature of Science, (*N*=29).

Among students surveyed in the Self-Reflection on the Storytelling and Related Inquiry Activities (Appendix F) there was overwhelming agreement that the dialogue sessions helped with concept understanding and recall (*N*=31). At the same time, students were fairly divided about whether the sessions improved their speaking and listening skills.

There was strong agreement among the respondents that the dialogue sessions helped with making connections with previous learning. This particular finding was corroborated by the high frequency with which students recruited previously acquired knowledge in order to address various issues that were raised. For instance, in a story related discussion about seed germination, a show of hands indicated that most of the students believed that soil was essential for the process. "Seeds do NOT need dirt to grow," asserted one student. "I know they don't because we did an experiment in fourth grade where my teacher grew plants out of a paper towel."

Table 2
Combined Student Responses to Survey Questions (N=31)

Student Assessment of Dialogue	Agree and Strongly Agree (%)	Disagree and Strongly Disagree (%)
Gaining understanding of concepts	86.5	13.5
Making connections to previous learning	72.9	27.1
Improved speaking and listening skills	55.5	45.5
Remember what you have learned	81.8	18.2

Themes identified in a review of the dialogue sessions were that (1) many students were excited by the prospect of responding to the storytelling by telling stories from their own life (2) discourse among the students was fairly equitable, and (3) students often arrived at understandings by responding to questions rather than being given answers. These themes are exemplified in the following excerpt from a dialogue session that followed a storytelling about an incident in the life of with Sir Joseph Lister, inventor of the Antiseptic Technique.

Shane: One time when I was on vacation in Mexico, I skinned my knee really bad when I fell when I was chasing my brother. A few days later the sore hurt so bad that I couldn't sleep, and when we looked at it there was a red line going up my leg. My parents totally freaked, and I had to go and see a doctor down there.

Sophia: I just wanted to ask Shane, what do you mean there was a red line on your leg?

Shane: The sore was all red and swollen and there was, I don't know, just a red line in my skin that you could see going out from the sore. My mom said it's a sign of a bad infection.

Me: That's right. When you think back on today's storytelling, what might have prevented Shane's wound from getting infected?

Chloe: Just like with the doctor in the story, he could've put antiseptic on it.

Me: What kinds of antiseptics do you have at your houses?

Nick: We have like alcohol that's a kind of antiseptic, and it stings really, really bad.

Shane: My mom has ointment in a kit at my house, but that time I just washed it off with a wet paper towel and kept playing.

Me: So, what was the cause of Shane's infection?

Tristan: There were bacteria in the dirt that got into his knee when he scraped it.

During the course of each study unit, students often referenced the "Working Words" bulletin board as they attempted to respond more coherently to the topic at hand. One student said, "I've been able to bump up my vocab and use the word 'germinate' and know what I'm talking about."

Figure 3. "Working Words" bulletin board.

The task of generating story related questions for investigation through experimentation really stretched the students. An instance that illustrates the point occurred following a storytelling about the behavior of earthworms. When consideration was given to questions that might be worthy of investigation, the discussion stalled. At first the only suggestions being put forth were untestable or just plain silly. What kinds of bugs do worms like to hang out with? How long can worms hold their breath underwater?

To stress the fundamentals of sound investigative thinking, I reread the questions that characters in the story had come up with after observing earthworm behavior first hand. In an attempt to provide students with a somewhat comparable experience, I distributed paper plates and gave each student a live earthworm. Of course, everyone became very excited and there were a lot of squeals, laughter, and chatter. I let out the reigns and allowed students to savor the moment. After bringing them back to attention, I asked them to imagine that they had switched places with the worm on the plate. I challenged them to consider, from that perspective, what they might want students to know about them so they could stay healthy and happy. The lines of questioning soon got on track. What kinds of dirt do worms prefer? Do they like it hot or cold? Can they smell? Do they like to stay together or spread apart? Inquiry groups designed their investigations based on these and other questions that are not enumerated.

The degree of difficulty that students had with generating appropriate question for investigation varied among the five different storytelling modules. I viewed the first module as somewhat of a practice session, so I distilled this component down to having students agree on a single question that everyone investigated together. In the next module, a historical narrative, students were initially able to come up with just four viable questions. Each of the next three modules involved science mysteries which generated between five and ten questions apiece.

It bears noting as a caveat to the findings above that while the initial investigations were ongoing students were often struck by tangential questions that led to even more investigations. Over the course the project it became common for students to drop by before and after school and during break times to check on experiments or set up new ones. Towards the end of a unit on plant germination I wrote in my journal, "Students' appetite for experimentation seems to be insatiable and the learning seems effortless."

Transition from the dialogue sessions into the inquiry phase of each module didn't always flow smoothly. In one case, a student became loudly argumentative with other members of his group. When I interjected myself into the situation, the boy immediately asked, "Can I work alone on a project? No one is listening to me." The dispute was about which kind of seeds, bean or corn, would be used in the investigation. I didn't want to allow this student to jump ship and give the message that when conflict arises we just avoid it. So, I asked the group members sit and listen to each other's ideas without interrupting. Eventually it was decided that the boy would work with on the project with his classmates using bean seeds, but he would be allowed to conduct an experiment on the side using corn seeds. To a greater or lesser extent, such conflicts arose during each unit of study.

Inquiry related data from the Self-Reflection on the Storytelling and Related Inquiry Activities is summarized in Table 3. Students showed strong agreement that the inquiry activities were helpful in each of the targeted learning areas (*N*=31). The findings of this survey were substantiated by interview data indicating that there had been a boost in students' ability to explore and inquire about science. In the words of one student, "I have learned to be as detailed as possible when explaining an experiment. You need a control in an experiment, and you can't get off topic. I didn't know that before." Another said, "We've gone a lot deeper into science. It's not just about facts. You need to discover what makes up the facts." A correlation between the inquiry activities and improvement in student attitudes was also evident. One student described her experiences by saying, "I'm very happy to learn science. I'm more of a hands-on learner. It's nice to be in this class because we do a lot of hands-on."

Table 3
Combined Student Responses to Survey Questions (*N=31)*

Student Assessment of Inquiry Investigations	Agree and Strongly Agree (%)	Disagree and Strongly Disagree (%)
Gain understanding of concepts	90.4	9.6
Gain interest in the topic	85.3	14.7
Make real world connections	86.7	13.3
Remember what you have learned	86.3	13.7

A further elaboration of changes in students' beliefs can be seen in a comparison of the terms students used to describe a successful science student. Previous to the treatment period, students most often identified perfunctory qualities such as "getting good grades" and "turning work in on time," as being important. Note taking was mentioned at least six times. An assessment of student attitudes and beliefs following the completion of the project emphasized a different theme. "Go deeper." "Have fun." "Be interested." "Find the truth," were typical phrases used by students.

The palpability of students' enthusiasm about science during the study period caught the attention of my school's administrators. Before the third storytelling, our vice principal, Scott Rockney, sent me the following email which was forwarded to the entire administration team: "Thanks for the invitation. I'll be there at 8:35. Fellow administrators – I have been twice before, and this is a real treat. I encourage you to come by and see Dale in storytelling action." Both principal, Becky Nibecker, and associate headmaster, Scott Lisea, attended the next storytelling.

On this occasion, as was common throughout the study period, many students did not stroll in for class. Rather they fast walked from the doorway to the back counter eager to check on experiments that were still ongoing from the previous unit of study. Within minutes the room was buzzing with chatter and activity. "I can't believe the level of excitement around here," remarked principal Nibecker. "This is wonderful!" She walked over to where a group of students were taking measurements and recording observations. "So, what do we have going on here?" she asked. For the next few minutes students exclaimed "over here" and "check this out" as they clamored for her attention.

Prior to implementing my study, some students expressed a belief that storytelling in the classroom had positive potential. But many seemed to have a sense of uncertainty that was conveyed through their use of such phrases as, "Yes and no." "There are pros and cons." "It depends on what the story is." "What do you mean by stories?" "Just don't make it too silly."

The first really tangible clue about how this component was being received by students came from an unexpected source. On the day that we concluded our first unit of study, one of my students, Rose, was leaving the classroom when a document on my desk caught her eye. She stopped, glanced at the cover page for a moment, and then inquired if that was the story that I would be telling next. I told her that it was. “Oh, good,” she said smiling. “I can hardly wait.” At face value this episode may seem to be of little consequence. Yet its significance can be appreciated if you know a little bit about Rose. She is a very reserved student who, until that moment, had never let on that she was excited about anything in science class. Furthermore, this marked the first instance in which she initiated a casual conversation with me. Later that afternoon I recorded the following reflections in my journal. “Rose had a breakthrough day! The stories really seem to be connecting with her. I am encouraged.”

Not every student expressed such positive feelings towards storytelling. “I don’t like the stories,” remarked one student. “Everybody has different things they like, but the storytelling doesn’t connect with me.” Another commented, “I think I like to do hands-on activities more than the stories.” Such comments, however, represented a minor though certainly noteworthy footnote in relation to the prevailing sentiment. Perhaps one student captured it best when she said, “Keep telling the stories. I love to hear them. They stir up my imagination, make me think about things differently, and help me to remember.” Data collected from the Student Self-Reflection on Storytelling and Related Activities Rubric (Appendix F) related to the storytelling sessions is shown in Table 4. Students gave their strongest endorsement of storytelling in terms of its ability to promote comprehension, while there was substantially less agreement that it helped with remembering what had been learned (*N*=31).

Table 4
Combined Student Responses to Survey Questions (*N=31)*

Student Assessment of Storytelling	Agree and Strongly Agree (%)	Disagree and Strongly Disagree (%)
Gain Understanding of concepts	78.5	21.5
Gain interest in the topic	73.7	26.3
Make real world connections	73.8	26.2
Remember what you have learned	66.4	33.6

When the percentage scores for *just* the historical narratives are compared to those for *just* the science mysteries, a different perspective emerges. In that light, it can be seen that the historical narratives scored much higher in each category on the survey. For example, 96.5% of the respondents agreed or strongly agreed that the historical narratives helped with conceptual understanding. "I really enjoy the storytelling," commented one student. "The stories with plots are interesting. They catch my attention and relate to everyday life." In terms of whether the stories helped them remember what they had learned, 93.0% of the respondents agreed or strongly agreed that the historical narratives did so.

Examination of the data from the Story Retelling Rubric (Appendix G) shows that students earned higher scores on their ability to remember story details and concepts from the historical narratives than the science mysteries. One student noted, "I like more historical stories. I couldn't remember the ones that didn't have a plot and characters." This finding is consistent with the post-treatment interviews during which 100% of the students mentioned one or both of the historical narratives as being stories that they will remember for a long time. Overall, 55.4% of retellings from the historical narratives were rated as being *excellent*, while the same was true of just 19.1% of the science mysteries. A rating of *poor* was given to 38.2% of the science mysteries while only 4.2% of the historical narratives earned this rating.

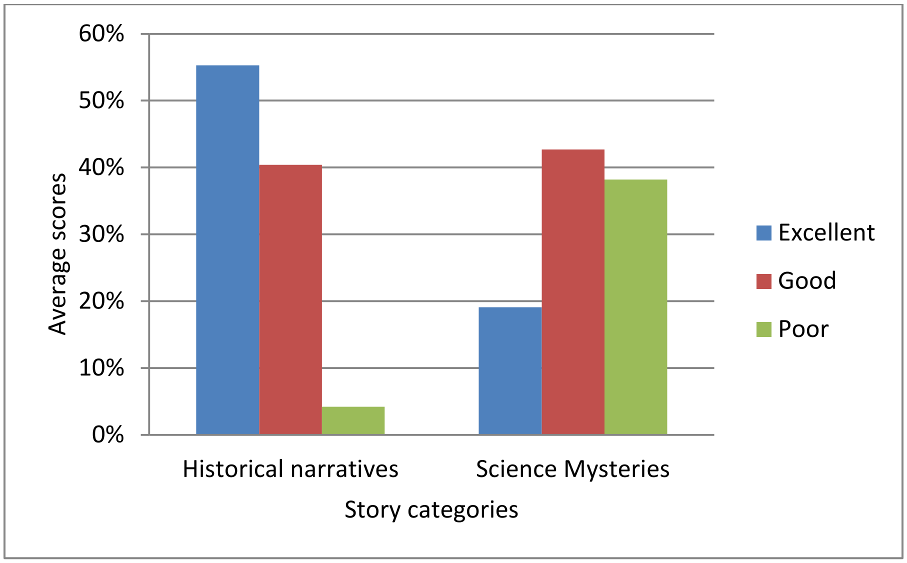

Figure 4. Student recall of story details and concepts.

In the first three storytelling units as well as the fifth unit, students were given freedom to choose the kind of portfolio item they would submit. The most popular choices were graphic visualization (83.9%) followed by story writing (11.3%) and experimental design (4.8%). When I inquired as to why so few students were chosing the experimental design option, they responded that it seemed to be too "hard" or not as "fun" as the others. In the fourth unit of study, I required that everyone submit a formal lab write-up.

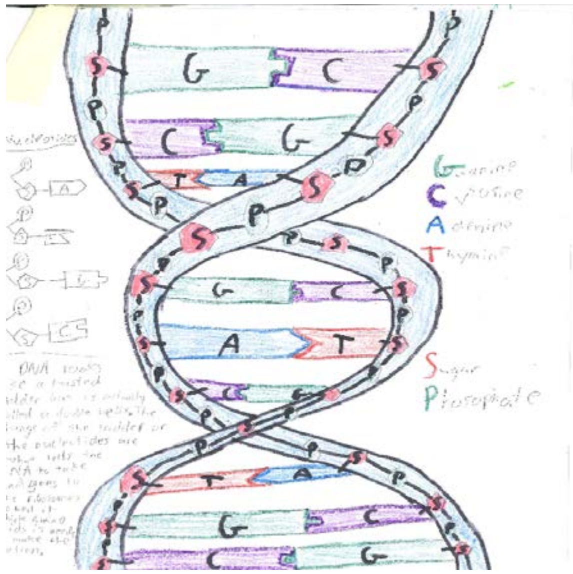

Figure 5. Sample Student Portfolio Item – Graphic Visualization.

Most of my students did not demonstrate a natural proficiency when it came to reflecting on their own work. For example, the student who produced the illustration seen in Figure 5 initially responded to the Graphic Visualization Self-Reflection Questions (Appendix D) by writing, “I showed that DNA looks like a twisted ladder.” After I provided feedback for improvement and extended class time for processing, he eventually submitted the following self-reflection piece:

“The scientist in the story knew that everyone looks different. What he didn’t know is that everyone looks different because their DNA is different. In my drawing, I used more than one color to show how adenine always matches with thymine and that guanine always matches with cytosine. You can also see how the DNA backbone is twisted around to make a helix. One thing I could have done better is to make the DNA molecule look more 3-D like to show what shape it really is in.”

Discussions about the purpose and goals of the self-reflection activities became a mainstay throughout the project. “I really absolutely love science,” reported one student.

"I can always come up to you and ask you something. I also like the feedback you give. It helps us to think about what we are learning and lets you know if we really get it."

Several students enjoyed creating portfolio items so much that during the last three units they asked permission to submit more than one. I told them that they were free to do so but that it would not be given extra credit on the individual assignments. Still, they proceed as they desired, with one student turning in five different items during the unit on lichens.

Many students used the oral presentations of their portfolio items as an opportunity to do some storytelling of their own. For example, one student recounted the adventure that he and his mom had as they "trail-blazed" across the chaparral in search of lichens to be photographed for his portfolio project. On another occasion, a student shared a very funny and educational story she had written about a family of earthworms.

I provided recommendations for revision of each portfolio item as they were submitted. All students submitted at least the minimum number of items for their final portfolios, many of which had been revised. Most of the final portfolios were of high quality.

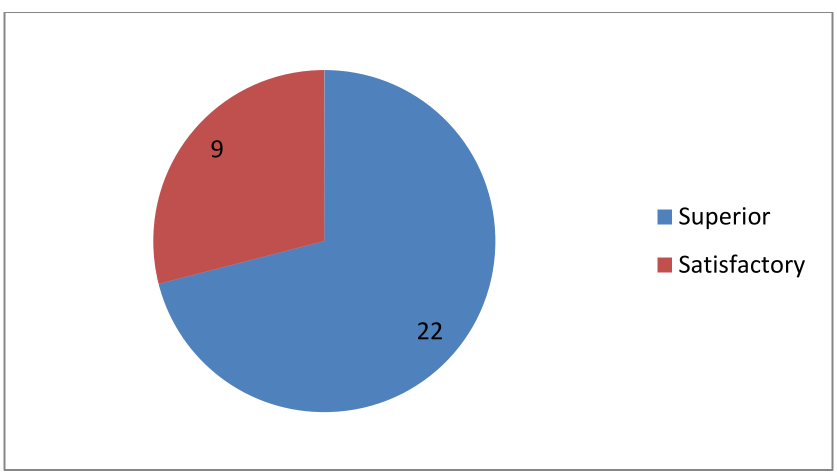

Figure 6. Final portfolio scores, (*N*=31).

Data from the Self-Assessment of Storytelling and Related Activities (Appendix F) revealed that an average of 92.3% of the students agreed or strongly agreed with the position that the overall leaning experience in each storytelling unit was enjoyable (*N*=31).

INTERPRETATION AND CONCLUSION

A starting place to understand students' high level of enthusiasm for doing science is to consider the nature of the student-teacher relationship during the study. Rather than instruction being primarily teacher directed, students themselves had substantial influence in directing the course of learning. The interplay of ideas from the stories and students' personal interests and perspectives resulted in fluctuations that can be traced across the curricular landscape, but only in retrospect. For me and my students alike it was exciting to set sail at the beginning of each study unit not knowing just where we might end up.

In surveying the full range of data factors, a picture emerged of a classroom environment replete with highly active and productive student discourse. It seems evident that storytelling effectively primed the dialogic pump and held sway on discussion throughout each unit of study. The only puzzling aspect of the picture was that the ease and readiness with which students talked did not correlate to widespread agreement that their communication skills were improved. One possible explanation is that the classroom talk tended to be so casual and spontaneous that students had no need to employ skills beyond what is required for everyday conversation.

Evidence shows that many students' views about the nature of science were qualitatively transformed during the study. It could be argued that the inquiry investigations, standing alone, might have brought about similar results. However, it is my assertion that the stories provided much of the impetus for the occurrence of these changes. Furthermore, episodes where documented in which it seems that students were able to more effectively generated investigative questions following the storytellings than they would have been able to achieve otherwise. However, the absence of comparison data from strictly autonomous inquiry investigations limits the conclusions that can be drawn from these results.

The most obvious explanation for why students were so successful in recalling details from the historical narratives is that these stories contained elements of drama that evoked emotional responses. When emotion is attached to information, learning tends to last. By contrast, data clearly showed that students did not make strong connections with the science mysteries. This is actually quite understandable. The characters and events in these stories are not bigger than life. They are you and me simply trying to gain a deeper understanding of everyday situations that we encounter. The main point is to inspire curiosity and questioning. In this regard, the science mysteries proved worthy.

Going forward, my interest is in finding, or possibly developing on my own, stories that incorporate the best aspects of historical narratives and science mysteries. I also plan to use storytelling occasionally just for the sake of the story itself, such as in highlighting the work of scientists in traditionally underrepresented people groups (Kirchoff, 2008).

VALUE

As I called my class to order at the beginning of the first storytelling session, I experienced a rush of sensation that felt much like standing at the edge of a high dive platform. Months of thought and preparation had led to this moment, and I was excited. But I was also apprehensive. I was not as if I was about to test out the effects of a minor tweak in my teaching methodology. Rather, I stood on the precipice of a major reconstruction in the way operate my classroom. This was going to be a jump in at the deep end.

So why take on something so momentous? After all, before I implemented this study my students were experiencing their fair share of those golden “aha” moments and, as indicated by the pre-study data, they really enjoyed learning science. That being said, the risk was definitely worth it. The level of excitement in my students and the satisfaction that I have experienced in my job over the past few months is unparalleled at any time in my sixteen years as an educator.

Doing this classroom research project has shown me that “reflect” is a very important word. It is an essential practice for all learners, teachers not the least. When your attention is fixed on what you have been doing and how you could improve, it brings fresh clarity. It humbles even as it inspires. For me personally has come the realization that many of my past teaching methods while fun and exciting, were, in actuality, “cookbook” type activities that left little room for the practice of real science. At the same time, I have gained many valuable perspectives that hereafter and forever will improve my approach teaching science.

Significantly, I have learned that the practice of storytelling in the classroom has unique instructional value. Consider, for example, the story of Joseph Lister. As stated earlier, he invented the Antiseptic Technique. That is a fact. It is a fact which, if taught by rote memory, would likely be forgotten as soon as it was learned and would amount to a rather useless bit of trivia if it was remembered. Herein lays the power of a narrative. My students did not encounter this scientist strictly in the abstract. Rather, through the gateway of imagination, they came face to face with the man himself. They were invited to walk beside him, to sense his compassion and see him sweat, to relate to him as he really is, very human. That is inspiring.

I plan to continue using the elements of storytelling, dialogue, and inquiry as part of a unified teaching strategy in my classroom. I am convinced that this approach will provide my students with more opportunities to share their thoughts, collaborate, reflect, and embrace the curiosity and imagination required by science. Most importantly, as was borne out through the results of my project, student attitudes and beliefs about science will be improved. A good attitude, if not snuffed out, may lead to a lifelong interest in science.

In thinking about the possible usefulness of my project for other educators, I would say that the best way to appreciate the value of something is to experience it yourself. If you have never tried storytelling, give it a shot. If you do most of the talking in class, try sharing the stage. If all science experiments are generated by you, see what would happen if you gave students a crack. You will quickly find out what works best in your situation. The promise of happier, more engaged students should provide all the motivation you need.

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APPENDICES

APPENDIX A

STORY DIALOGUE/DISCUSSION PROMPTS

Story Dialogue/Discussion Prompts

1) Are there any connections between the story and your own life?

2) What do you know now that you didn't know before?

3) What do you want to remember from this story?

4) What question(s) raised by this story would you like to investigate?

5) Can you think of a test or experiment that we could carry out that might answer your questions?

APPENDIX B

STORY WRITING SELF REFLECTION QUESTIONS

Story Writing Self-Reflection Questions

Story Title: ____ Date: ___________

1. Give a detailed explanation of the scientific idea from the story that you are writing about.

2. What was the most difficult part of writing the process? In what ways did the writing process help to better understand the specific science ideas?

3. Did any part(s) of your writing connect to your real-life experiences? Explain.

APPENDIX C

EXPERIMENTAL DESIGN SELF-REFLECTION QUESTIONS

Experimental Design Self-Reflection Questions

Story Title: ____ Date: ___________

1. Give a detailed explanation of the scientific question or problem from the story that you are investigating in this entry.

2. Describe in detail how you studied the question through the experiment.

3. What answers did you find in the investigation? Were the answers different from what you expected to find? Did the answers give you insights into other real-life experiences?

APPENDIX D

GRAPHIC VISUALIZATION SELF REFLECTION QUESTIONS

Graphic Visualization Self-Reflection Questions

Story Title: ____ Date: ___________

1. Give a detailed explanation of the scientific idea from the story that you are presenting in your visual aid.

2. Identify how the various features of your visual aid communicate your understanding of the scientific idea.

APPENDIX E

STUDENT PORTFOLIO SCORING RUBRIC

Student Portfolio Scoring Rubric

Score	Required items	Concepts	Reflection
4	Number of entries exceeds requirements.	Entries include scientific information that is accurate, complete, and thoughtfully explained.	Reflections illustrate the ability to effectively critique work.
3	Number of entries meets requirements.	Most entries include scientific information that is accurate, complete and thoughtfully explained.	Reflections illustrate the ability to critique work.
2	Fewer entries than required.	Entries demonstrate partial understanding of scientific ideas.	Reflections illustrate an attempt to critique work
1	Significantly fewer entries than required.	Scientific information has some inaccuracies or is simplified.	Reflections illustrate a minimal ability to critique work.
0	No work submitted		

Observations/Comments:

APPENDIX F

STUDENT SELF-REFLECTION ON STORYTELLING AND RELATED ACTIVITIES

Self-Reflection on the Storytelling and Related Inquiry Activities

Please keep in mind that your participation is voluntary. You may skip any question that you do not wish to answer, and you may end the survey at any time. Participation or non-participation will not affect your grade.

Story Title: ____ Date: ___________

1= Strongly Disagree
2= Disagree
3 = Agree
4 = Strongly Disagree

How do you think the storytelling helped you in the following areas?

• Understanding of concepts	1	2	3	4
• Gain interest in the topic	1	2	3	4
• Make real world connections	1	2	3	4
• Remember what you have learned	1	2	3	4

How do you think the dialogue and discussion session helped you in the following areas?

• Understanding of the concepts	1	2	3	4
• Make connections to previous learning or experience	1	2	3	4
• Improved listening and speaking skills	1	2	3	4
• Remember what you have learned	1	2	3	4

How do you think the various inquiry activities help you in the following areas?

• Understanding of concepts	1	2	3	4
• Gain interest in the topic	1	2	3	4
• Make real world connections	1	2	3	4
• Remember what you have learned	1	2	3	4

Overall enjoyment of the story and related activities	1	2	3	4

APPENDIX G

STORY RETELLING RUBRIC

Story Retelling Rubric

Story Title: ____ Date: ___________

To the best of your ability, tell what the story was about.

Key Science Concept/Problem:
Characters/Setting:
Beginning:
Middle:
End:

3 – Retelling is sequential and all major events are included; characters and setting are described with appropriate detail; key science concept/problem is clearly understood.

2 – Retelling omits a few major events or changed their order; some important details are missing; limited understanding of key science concept/problem.

1 – Retelling shows very limited understanding of the story or key science concept/problem.

SCORE _____

Observations/Comments:

APPENDIX H

PRE-TREATMENT INTERVIEW QUESTIONS

Pre-Treatment Interview Questions

Please keep in mind that your participation in this interview is voluntary. You may skip any question that you do not wish to answer, and you may end the interview at any time. Participation or non-participation will not affect your grade.

1) Please finish this statement: Science is about learning…

2) How would you describe what it means to be a successful science student?

3) Do you "care" about the topics we are studying in class? Why or why not?

4) How would you describe your attitude about learning science?

5) If you were presented with an everyday science problem are you confident that you could set up and carry out an investigation that could solve it? Why or why not?

6) Do you think that storytelling in science class might be a good motivator for you learn about science concepts? Explain.

7) Is there anything else that you would like me to know?

APPENDIX I

POST-TREATMENT INTERVIEW QUESTIONS

Post-Treatment Interview Questions

Please keep in mind that your participation in this interview is voluntary. You may skip any question that you do not wish to answer, and you may end the interview at any time. Participation or non-participation will not affect your grade.

1) Please finish this statement: Science is about learning…

2) How would you describe what it means to be a successful science student?

3) Do you “care” about the topics we are studying in class? Why or why not?

4) How have your beliefs about the nature of science changed over the past three months?

5) In what specific ways have you grown as a science student over the past three months?

6) Is there a story that I told in class that you think you will remember for a long time? Please retell the story as best that you can and explain the science concept that it helped you to learn.

7) Is there anything else that you would like me to know?

APPENDIX J

STUDENT BELIEFS AND ATTITUDES ABOUT THE NATURE OF SCIENCE AND DOING SCIENCE

Student Beliefs and Attitudes about the Nature of Science and Doing Science

Please keep in mind that your participation is voluntary. You may skip any question that you do not wish to answer, and you may end the survey at any time. Participation or non-participation will not affect your grade.

Strongly Disagree	Disagree	Agree	Strongly Agree	1.I enjoy learning about science.
Strongly Disagree	Disagree	Agree	Strongly Agree	2. I like work-sheet directed activities rather than open-ended investigations.
Strongly Disagree	Disagree	Agree	Strongly Agree	3. In class we talk about scientific ideas in student friendly language.
Strongly Disagree	Disagree	Agree	Strongly Agree	4. In class we engage in talk and debate about science concepts.
Strongly Disagree	Disagree	Agree	Strongly Agree	5. Learning science helps me separate fact from fiction in everyday life.
Strongly Disagree	Disagree	Agree	Strongly Agree	6. I like to read science articles or stories for personal enjoyment.
Strongly Disagree	Disagree	Agree	Strongly Agree	7. I feel like I make useful contributions in class discussions.
Strongly Disagree	Disagree	Agree	Strongly Agree	8. The science in school will be useful for me in real life.
Strongly Disagree	Disagree	Agree	Strongly Agree	9. I often talk with family members or friends about the science ideas we study in school.

Strongly Disagree	Disagree	Agree	Strongly Agree	10. In class I am encouraged to try new things and take risks.
Strongly Disagree	Disagree	Agree	Strongly Agree	11. The main point of science class is to learn about what others have already discovered.
Strongly Disagree	Disagree	Agree	Strongly Agree	12. I sometimes make connections between school science concepts and real life experiences.
Strongly Disagree	Disagree	Agree	Strongly Agree	13. Being a professional scientist seems like it would be boring.
Strongly Disagree	Disagree	Agree	Strongly Agree	14. In class we respect and value each other's ideas.
Strongly Disagree	Disagree	Agree	Strongly Agree	15. Memorizing facts is more important than understanding scientific ideas.
Strongly Disagree	Disagree	Agree	Strongly Agree	16. It was clear how the lab experiments fit into this course.
Strongly Disagree	Disagree	Agree	Strongly Agree	17. Doing labs in this class is like following a cookbook recipe.
Strongly Disagree	Disagree	Agree	Strongly Agree	18. I prefer labs where I get to help design an experiment to answer a question.
Strongly Disagree	Disagree	Agree	Strongly Agree	19. As scientists learn more, many ideas we have will be proven wrong.

Strongly Disagree	Disagree	Agree	Strongly Agree	20. In science, logical reasoning is much more important than imagination.
Strongly Disagree	Disagree	Agree	Strongly Agree	21. Learning science affects the way that I view the world around me.

APPENDIX K

EXEMPTION REGARDING INFORMED CONSENT

Exemption Regarding Informed Consent

I, Becky Nibecker, Principal of Oaks Christian School, verify that the classroom research conducted by Dale Spady is in accordance with established or commonly accepted educational settings involving normal educational practices. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Dale Spady regarding informed consent.

____

(Signed Name)

____

(Printed Name)

____

(Date)