THE EFFECTS OF SCIENTIFIC ARGUMENTATION ON STUDENT ATTITUDES
AND UNDERSTANDING OF A CONTROVERSIAL TOPIC

by

Kristin Leigh Combs

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2015
ACKNOWLEDGEMENTS

This paper and the research it describes would absolutely not have been possible without the unconditional and constant, steady support and love from my family, especially my husband Tom and my parents, Tony and Diana Williams. I am forever in their debt and will always be grateful.
### TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND .............................................................. 1

2. CONCEPTUAL FRAMEWORK ........................................................................... 2

3. METHODOLOGY .................................................................................................. 10

4. DATA AND ANALYSIS ....................................................................................... 17

5. INTERPRETATION AND CONCLUSION ............................................................ 28

6. VALUE .................................................................................................................. 31

REFERENCES CITED ............................................................................................. 36

APPENDICES .......................................................................................................... 40

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>MSU Institutional Review Board Memorandum</td>
</tr>
<tr>
<td>B</td>
<td>Gray Wolf Management Research Form</td>
</tr>
<tr>
<td>C</td>
<td>Wolf Management Argumentation Construction Form</td>
</tr>
<tr>
<td>D</td>
<td>Argumentation Session Form</td>
</tr>
<tr>
<td>E</td>
<td>Combs Wolf Biology Pretest and Posttest</td>
</tr>
<tr>
<td>F</td>
<td>Scientific Argumentation Pre-Survey</td>
</tr>
<tr>
<td>G</td>
<td>Pre-treatment Wolf Opinion Survey</td>
</tr>
<tr>
<td>H</td>
<td>Post-treatment Wolf Opinion Survey</td>
</tr>
<tr>
<td>I</td>
<td>Post Scientific Argument Survey</td>
</tr>
<tr>
<td>J</td>
<td>In-Class Observation Form</td>
</tr>
<tr>
<td>K</td>
<td>Post Argumentation Student Interview Form</td>
</tr>
</tbody>
</table>
LIST OF TABLES

1. Data Triangulation Matrix ............................................................16
LIST OF FIGURES

1. Median of Scores from the Pretest and Posttest..................................................18

2. Box-and-Whisker Plot of Pretest and Posttest Scores ........................................19

3. Survey Question: “I would rather have a scientific argument in class
than do any other activity”........................................................................................20

4. Survey Question: “I enjoy arguing with other people”........................................21

5. Survey Questions: “Arguing a topic is the best way to come to an agreement
on a difficult subject”& “Scientific argumentation helps me learn about
both sides of an issue”..............................................................................................21

6. Survey Question: “I sometimes change my opinion when I argue with someone”......22

7. Box-and-Whisker Plot of Positive Attitudes toward Argumentation ....................24

8. Pre and Post Survey Negative Attitudes toward Argumentation............................24

9. Pre and Post Pro-Wolf Attitudes of Students..........................................................26

10. Pre and Post Anti-wolf Attitudes of Students.......................................................27

11. Survey Question: “Predators are an important part of an ecosystem”...............28

12. Example of Student Letter ..................................................................................33

13. Response from Idaho Fish and Game Employee.................................................34
This study implemented scientific argumentation as a learning tool in a science classroom to determine if it would change student opinions about a controversial topic and increase student learning about the topic. Scientific argumentation was introduced in a seventh-grade life science classroom in Idaho on the topic of wolf management. Students were responsible for conducting research about the topic and learning about both sides and then participating in a large group argument and a small group argument about wolf management in Idaho. The study found that student opinions changed to more pro-wolf or became more neutral as a result of the argumentation and that student learning of the topic also increased.
INTRODUCTION AND BACKGROUND

I have taught seventh-grade life science at South Fremont Junior High in St. Anthony, Idaho for the past three years. St. Anthony is a town of 3,542 residents and also serves Fremont County, Idaho, which has a population of 13,128 (United States Census Bureau, 2011). The school is located on the same campus as Henry’s Fork Elementary and South Fremont High School. At the time research was conducted, there were 360 students in the sixth, seventh and eighth-grades. In the 2014-2015 school-year, the seventh-grade had 111 students. The demographics of the town are reflected in the population of students at South Fremont Junior High. The majority of students are Caucasian with Hispanic students comprising twenty-seven percent of the population (A. Hackworth, personal communication, February 10, 2015). The estimated median household income is $35,350 (Onboard Informatics, 2012). St. Anthony has a lower income than surrounding cities and the main source of income for families is from farming and ranching. South Fremont Junior High is a title one school with fifty-two percent of students qualifying for free or reduced lunch and/or breakfast (K. Turner, personal communication, February 10, 2015).

Due to the proximity of St. Anthony, Idaho to Yellowstone National Park, many controversial wildlife issues exist within the community. Controversy surrounds most species and includes wolves, bison, elk, moose and many others. Students often have strong opinions about these topics without knowing any of the biology or ecology behind the species. There are no easy solutions to the problems surrounding these species and I have often tried to teach my students about these issues, but their emotions get in the way. Scientific argumentation provides a special opportunity for students to experience a
topic as an actual scientist would. The student must use the relevant data of the topic to engage in scientific argument with other peers who have also researched the topic. Both parties must come to a consensus for a solution to the issue. Rather than relying on emotion and anecdotes, the students must face a difficult topic with reason and logic based on fact. I wondered if I could encourage students to see both sides of an issue by incorporating scientific argumentation when discussing these topics. I wanted to see if students would change their opinions based on scientific argumentation or if their opinions would remain the same. This led me to my focus question, *What are the effects of scientific argumentation on student attitudes and understanding of a controversial topic?*

CONCEPTUAL FRAMEWORK

The benefits of argumentation and controversy in science education are something that has not always been at the forefront of leading science instruction research. In the past, controversy has been avoided in the science classroom because it might lead to conflict and resentment between students (Johnson & Johnson, 2009). More recently, the value of argumentation and controversy to spark student interest and provide deep understanding has become a new priority in science instruction (Johnson, Johnson & Smith, 2000). Many states have recently adopted both the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) and the Next Generation Science Standards (NGSS Lead States, 2013). Both of these new standards include specific requirements for scientific argumentation and encourage it as part of a diverse science education curriculum.
Science can be presented to students as a static collection of facts that does not change, is not argued against and has specific boundaries. This method of teaching science has given students little skill in dealing with the socioscientific issues that they will most certainly face as adults (Driver, Newton & Osborne, 2000; Osborne, 2010). One of the main reasons that argumentation and controversy are not part of the science classroom is that teachers feel unequipped to implement this lesson format. There is often no training in teacher preparation programs as to how to lead a group of students through a successful argument. Therefore, teachers may avoid this teaching method because they are afraid of losing control of classroom management if conflicts arise between students (Johnson & Johnson, 2009; Osborne, 2009). However, with proper preparation and a little confidence in the concept, controversy and argumentation can be integrated into any science classroom by any teacher.

There is a noticeable difference between debate and argumentation. In a debate, each side argues their point and a winner is declared. In scientific argumentation, two sides are argued with scientific evidence in support of each, and the interested parties must come to an agreement (Johnson & Johnson, 1985). “[Scientific argumentation] occurs when one student’s reasoning influences that of another, and, in return, a reciprocal relationship is forged” (Zeidler & Kahn, 2014, p. 14). There is research to show that debate can be a valuable experience for students (Budesheim & Lundquist, 1999; Kennedy, 2009). However, a debate implies that there are winners and losers, and a student may find themselves in either one of these categories. While students who see themselves as winners will have a decidedly more positive view of themselves, the losers will experience quite the contrary. Self-esteem is often times lowered because of a
debate thereby leaving students unhappy with their peers, as well as the lesson. Controversy and the resulting argumentation that does not define winners and losers can leave a more positive impact on all of the students involved, therefore making the learning more meaningful and lasting (Johnson & Johnson, 2010).

Scientific argumentation provides students with improved scientific reasoning skills. When an educator specifically instructs students in argumentation skills, the students’ ability to think rationally and logically increases significantly (Osborne, 2009). “Argumentation is a pattern of reasoning that allows students to organize findings, advance claims, and identify alternatives” (Zeidler & Kahn, 2014, p. 34) which are skills that help develop students’ ability to think critically. Additionally, students who perform better in scientific reasoning also perform better in other subjects as well (Johnson & Johnson, 1985; Osborne, 2010; Shayer & Adey, 1993).

There has been a push by the National Research Council and the Common Core State Standards to better equip students with twenty-first century skills. When human resource managers were asked what the most necessary and desirable skills are for future workers, the National Resource Council (2008) found that the best candidates should have “oral communication skills, collaboration skills, professional and work ethics, written communication, and critical thinking and problem solving [skills].” Introducing scientific argumentation and controversy in middle school will provide students with a foundation in these skills and better prepare them for the workplace (Osborne, 2009).

Social identity can also be developed during scientific argumentation. Oliveira, Akerson and Oldfield (2012) found that giving middle school students three environmental dilemmas provided the students with an opportunity to build skills around
distinct types of argumentation. One situation involved whether or not students would take the initiative to turn off the lights in the classroom when going to lunch. Another situation was whether or not students would give up a pet iguana after getting tired of caring for it. The final situation was whether or not students would do anything about a fawn left alone in the woods. The students had a chance in each situation to be adversarial or non-contradictory while providing evidence for their side. This led students to help construct their social identity during the argument. It is noted however, that “an appropriate and productive sociocultural classroom context needs to be fostered in order for rational and reasoned environmental argumentation to take place” (Oliveira, Akerson & Oldfield, 2012, p. 891). Therefore, teachers must provide a solid structure for their students when implementing conflict in their classroom (Johnson, Johnson & Smith, 2000; Zeidler & Kahn, 2014). “For the purposes of the classroom practice, a focus on tolerance, mutual respect, and sensitivity must be modeled and expected” (Zeidler & Kahn, 2014, p. 15).

Science seeks to be completely objective, but when controversy is introduced, objectivity becomes more difficult to maintain. Scientific argumentation holds that some subjectivity is always present in any argumentation situation regardless of the attempts to preclude it. Therefore careful consideration of fact versus opinion must be taken by any teacher who is introducing conflict into the classroom. It is difficult to truly extinguish any bias from argument because we are human. Social context provides a background for any controversy and must be considered when controversy is presented to students. Helping students work through their own bias and cultural context is one of the main roles of the teacher when leading students through scientific argumentation (Ericsson &
Heberlein, 2003; Kuhn, 2010; Oliveira, Akerson & Oldfield, 2012). The teacher must also lead the students through their moral and ethical feelings and how those match up with the scientific evidence. This is especially true when a topic has a deep personal meaning for a student “as they instinctually rely on emotional responses without consideration of evidence” (Zeidler & Kuhn, 2014, p. 34).

Values of an individual are also important when considering argumentation. A diverse population of people, such as is present in the United States, have differing values on what is important. If a student has no cultural background with a topic of study, they may show little interest in participating in argumentation of that topic (Evagorou & Osborne, 2013). Therefore, a topic that is culturally significant should be used in order to pique student interest in argumentation. For example, when discussing conservation biology, there are many different values present, especially in students of differing backgrounds (Grace & Ratcliffe, 2002). Some students may be unsure, some students may have strong values tied to their previous knowledge, and others may be ambivalent about it.

There are a variety of topics that can be explored using scientific argumentation. Some of the best topics are environmental issues such as offshore oil drilling, climate change, farm-raised versus wild-caught salmon, and hydraulic fracturing (Zeidler & Kuhn, 2014). These topics provide a good platform for argumentation because in real-life there is no clear answer. Scientists that currently study these topics have to evaluate the evidence in order to present a quality argument. Usually the solution to these problems must incorporate values and views from all stakeholders as no perfect answer exists. Scientists must come to an agreement as to which solution is best based on the
evidence presented. Students arguing about these topics must also evaluate the evidence and come to an acceptable agreement that both parties agree upon (Oliveria, Akerson & Oldfield, 2012).

An environmental issue that is prevalent in the background of students of eastern Idaho is the controversy surrounding the reintroduction of the gray wolf (*Canis lupus*). This is a suitable topic for students to engage in scientific argumentation because it is an issue that is common in their community and one in which most students feel they have ownership. Students’ values and backgrounds pointedly have a direct bearing on their attitudes toward the wolf (Grace & Ratcliffe, 2002; Hermann & Menzel, 2013; Prokop & Kubiatko, 2008). Grace & Ratcliffe (2002) have shown that when students think about conservation issues, more weight is given to personal values than to scientific concepts. A teacher introducing scientific argumentation into the classroom must keep this in mind and know how to incorporate both values and scientific knowledge at the same time. Both are equally important when engaging in scientific argumentation. Science has tended to discredit values as a legitimate facet of controversy. However, new research has shown that values are an important aspect to consider when argumentation is being conducted (Evagorou & Osborne, 2013).

After being exterminated from the western United States in the early 1900s, wolves were reintroduced into Yellowstone National Park, Wyoming and the central mountains of Idaho in 1995 (Bangs & Fritts, 1996). The political firestorm and controversy that surrounded the reintroduction is still very much alive, especially in regions directly affected by the reintroduction. The governors and lawmakers of Idaho, Montana and Wyoming, along with the residents of these states, are involved almost on a
daily basis with the issue of wolf reintroduction. It is not so much the actual effect of the wolves on one’s personal life, but the perception of the wolves’ impact that causes the controversy (Bangs & Fritts, 1996; Ericsson & Heberlein, 2003). Attitudes of the general public toward wolves depend on their interaction with nature and their values of species. Often times, people have a negative view of animals if that animal is threatening or scary (bats, spiders, etc.). However, animals that are more widely accepted (dogs, cats, etc.) are usually positively viewed. (Decker, Bath, Simms, Lindner & Reisinger, 2010; Ericsson & Heberlein, 2003; Johansson & Karlsson, 2011; Prokop & Kubiatko, 2008; Shelton & Rogers, 1981). Most often, the wolf is viewed in a negative light because of childhood fairy tales, the perception of the wolf being capable of bodily harm, and the perception that wolves routinely kill people (Ericsson & Heberlein, 2003; Hermann & Menzel, 2013; Johansson & Karlsson, 2011; Prokop, & Kubiatko, 2008).

Students living in the wolf reintroduction areas are often exposed to vast media coverage of this debated topic. Therefore, students’ backgrounds and values will be affected by the media coverage, as well as values instilled upon them by their parents and the community in which they live. As previously stated, the use of values in scientific argumentation is important because values will inherently influence students’ attitudes toward a topic. Research that has been conducted on student attitudes before and after scientific argumentation and decision-making has shown that students will use both values and scientific knowledge in their arguments (Driver, Newton & Osborne, 2000; Evagorou & Osborne, 2013; Grace & Ratcliffe, 2002; Kolst, 2006; Osborne, 2010). Also, after argumentation, it has been shown that “participation in controversies…promotes the open-minded incorporation of opposing information into
one’s position and changing one’s attitudes toward the issue” (Johnson & Johnson, 1985, p.253). Offering students the opportunity to engage in scientific argumentation gives the students a platform for more discourse which stimulates higher-order thinking (Osborne, 2009). Therefore it can be presumed that scientific argumentation about wolves will provide students with a broader knowledge and context with which to base their future decisions.

Teachers must be well-equipped to mediate the arguments set forth by students. Osborne, Erduran & Simon (2004) have developed “DVD-based materials (the IDEAS pack) that support teaching about ideas, evidence, and argument in science education” (p. 64). Additionally, The National Science Teachers Association has also published several books that aim to help teachers implement scientific argumentation into their classrooms. Materials such as these should be used by a teacher who is introducing scientific argumentation in their curriculum to help students see the value of a solid, fact-based argument versus an opinionated, value-driven response. One of these books is Scientific Argumentation in Biology: 30 Classroom Activities by Sampson and Schleigh (2013). Sampson and Schleigh (2013) outline a specific format to follow when engaging students in scientific argumentation. They propose that students develop a claim, evidence to support the claim and then justification of the evidence that explains the importance of the evidence. This format will help students to use a system to develop an argument and then provide solid background to support their argument. The activities that are provided in Scientific Argumentation in Biology: 30 Classroom Activities (Sampson & Schleigh, 2013) are to “help students learn how to generate a convincing scientific argument and to evaluate the validity or acceptability of an explanation or argument in science” (p. xii).
Another one of these books is *It’s Debatable: Using Socioscientific Issues to Develop Scientific Literacy* (Zeidler & Kahn, 2014). The authors of this book have developed practice curriculum, rubrics, ideas for development of skills, key classroom strategies and reflections by teachers who have implemented scientific argumentation into their classrooms. These materials are to help teachers incorporate scientific argumentation of socioscientific issues into their curriculum. This gives the teacher a platform and direction to introduce argumentation into their classrooms with guidance and confidence as well as improve their skills with it for future use.

**METHODOLOGY**

The focus of this research was to determine if scientific argumentation had an impact on student attitudes toward a topic. The sub-question investigated was whether or not scientific argumentation increased student understanding of a topic. 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 (Appendix A).

Data was collected at South Fremont Junior High during March of 2015. Participants consisted of 76 seventh-grade life science students from five separate class periods. Data came from pretests and posttests, student responses on two Likert-scale surveys, student interviews and my journal entries which all contributed to assisting me in answering my research focus question and sub-question. The non-treatment group was represented by student scores on a pretest and posttest on wolf management and scientific argumentation.
In order to introduce scientific argumentation to students, short, pre-trials of scientific argumentation were conducted using activities from two different books, *Scientific Argumentation in Biology: 30 Classroom Activities* (Sampson & Schleigh, 2013) and *It’s Debatable: Using Socioscientific Issues to Develop Scientific Literacy K-12* (Zeidler & Kahn, 2014). This gave the students a chance to become familiar with the practice of scientific argumentation. It also gave me a chance to model expectations of the classroom environment during arguments. I wanted the students to know that talking over each other or making others feel inferior because of their ideas would not be tolerated. The topics for the activities from these books ranged from whether or not a virus should be classified as a living thing to how to allocate resources to get through the winter during the Dust Bowl.

Wolves are a highly contested and debated topic in eastern Idaho. Often overheard in my classroom are students stating vehemently how much they dislike wolves. Therefore, wolf management was chosen as a topic in which students could use to engage in scientific argumentation during the treatment unit. The argument that often surrounds wolves is that there are either too many or not enough of these animals. I introduced the concept of wolf management to the students by showing them three different videos that showcased the different sides of the issue. The first video was from Big Game Forever, an organization that values wilderness as well as hunting, and large populations of big game animals such as deer and elk. This organization advocates for strict regulation and management of all predators, including the wolf. They also advocate for states’ rights to monitor and control the population of wildlife as they see fit. The video highlighted why hunters are opposed to federal regulation of wolf populations in
the Northern Rocky Mountain region. It also outlined that elk populations are significantly declining in many areas where wolves are found therefore supporting the need for strict wolf control and lower numbers of wolves in these areas (Big Game Forever, 2015).

The second video was posted by a social issues support group known as Sustainable Human. Sustainable Human is an advocacy group that supports the reconnection of humans to the biosphere and uses videography to transmit their message (Agnos, 2015). This video, called *How Wolves Change Rivers*, outlined how wolves changed the ecosystem in Yellowstone when they were reintroduced. It highlighted how the reintroduction of the wolf ultimately resulted in rivers becoming healthier and many other species feeling the effects of a more balanced ecosystem (Agnos, 2014). This group supports large numbers of wolves and a more natural balance to ecosystems with less human intervention.

The third video I showed the students was a documentary by the Public Broadcasting System. This video told both sides of the issue of wolf management and stressed to students why it is so difficult for either side to compromise on this issue (PBS, 2010).

Following the videos, students conducted their own independent research on the Internet using the Gray Wolf Management Research Form that I prepared and provided to them (Appendix B). Also provided to students was a list of websites posted on the school’s internal server that could be used to find reliable information such as the Idaho Fish and Game website (Idaho Fish and Game, 2015). Students were then required to complete the Wolf Management Argument Construction form to help them gather their
thoughts about wolf management and construct their claims (Appendix C). Students were required to have evidence and a source to support each claim they made. They then had to anticipate an opposing viewpoint and how they would rebut a counter-argument.

Once students had completed these two forms, they were divided into three large groups of opposing viewpoints. I led the groups through a large classroom argumentation session about wolf management. I used a talking stick to provide structure for who could speak and when they would be permitted to talk. Students understood that they would only be allowed to talk when they were holding the talking stick. Once they felt as though they had said everything they wanted to, they handed the stick off to another person. I supervised the passing of the talking stick and the discussion and intervened when necessary. After the large group discussion, the students were divided into smaller groups of three to five students ensuring there were a variety of viewpoints within each group. Students then had to conduct arguments within their smaller groups and come to a consensus on a wolf management plan for Idaho. The groups were provided the Argumentation Session Form in order to guide their arguments and help them in the development of a plan (Appendix D).

Following the small group argumentation, students were required to write a letter to an organization that has a stake in wolf management in Idaho. The students stated their opinion of how best to manage wolves in Idaho. Their choices of who to write to consisted of Defenders of Wildlife, Predator Defense, Idaho Farm Bureau Federation, U.S. Fish and Wildlife Service, Idaho Fish and Game or United States Senator Mike Simpson of Idaho. Students could choose to write to an organization that agreed with
them or had an opposing viewpoint. The letters were then mailed out to each organization.

The Wolf Management and Scientific Argumentation Pretest was administered to the students before the treatment unit was started to gather baseline data on their knowledge of wolves and scientific argumentation (Appendix E). This same test was again administered at the end of the treatment unit to determine if student learning of the topic of wolf management and scientific argumentation had changed. Student scores on the Wolf Management and Scientific Argumentation Posttest were totaled and the mean, median and mode of scores were calculated. These were compared to the Wolf Management and Scientific Argumentation Pretest scores. A box-and-whisker plot of the scores and a bar graph of the median of pre and post scores were constructed to show any differences between the scores. Normalized gains for each student were calculated for the posttest to see if there was an appreciable difference in student learning from the treatment unit.

The Scientific Argumentation Pre-Survey was introduced to the students before the treatment unit began to gain an understanding of how students felt about participating in scientific argumentation (Appendix F). The survey was given to the students at the beginning of the unit after the pretest was given on wolf management and scientific argumentation. Data collected from the Scientific Argumentation Pre-Survey was classified as negative, neutral or positive. A box-and-whisker plot was made to look for trends. The Post-Scientific Argument Survey was given to students after the treatment unit (Appendix G). The responses of this survey were categorized as negative, positive
Students’ opinions of wolves were collected in the Pre-Treatment Wolf Opinion Survey (Appendix H). The responses of this survey were tabulated and categorized as negative, positive or neutral. A pie chart was produced to determine if there were any trends in the responses and a two-tailed t-test was performed to check for any statistical significance. After the treatment, the Post-Treatment Wolf Opinion Survey was administered to the students to see if changes in their opinions had occurred during the treatment unit (Appendix I). The same pie chart and two-tailed t-test was made on the post data to check for statistical differences of means and any trends of students’ opinions.

During the treatment, I kept detailed records of student demeanor and statements made. These were recorded on the In-Class Observation Form (Appendix J). I carefully observed students and then wrote down any pertinent information to scientific argumentation or the topic of wolves. I also kept a teacher journal during the treatment unit to record my general observations of the implementation of scientific argumentation or if I thought students’ opinions were changing.

Student interviews were conducted after students received the Wolf Biology Posttest and responses were recorded on the Post-Argumentation Student Interview Responses Form (Appendix K). Student interviews were recorded on an iPhone and then digitally transcribed for data analysis. Interview data was analyzed for themes and used to support evidence from the Pre and Post Treatment Wolf Opinion Survey.

Data was collected from multiple sources to help validate the reliability of the data. By collecting data from multiple sources and looking for themes and trends across the data, I was able to gather evidence to back up my claims. A list of the data used to help answer the focus question and sub-questions is listed in Table 1.

Table 1
Data Triangulation Matrix

<table>
<thead>
<tr>
<th>Focus Questions</th>
<th>Data Source 1</th>
<th>Data Source 2</th>
<th>Data Source 3</th>
<th>Data Source 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Question:</strong> 1. Does participation in scientific argumentation change student attitudes toward a topic?</td>
<td>Pre and Post Treatment Wolf Opinion Survey</td>
<td>In-class Observations</td>
<td>Post Argumentation Student Interview Responses</td>
<td>Teacher journal</td>
</tr>
<tr>
<td><strong>Secondary Questions:</strong> 2. What are student attitudes toward wolves?</td>
<td>Pre and Post Treatment Wolf Opinion Survey</td>
<td>In-class Observations</td>
<td>Post Argumentation Student Interview Responses</td>
<td>Teacher journal</td>
</tr>
<tr>
<td>3. Do students prefer to learn by scientific argumentation?</td>
<td>Pre and Post Scientific Argumentation Survey</td>
<td>In-class Observations</td>
<td>Post Argumentation Student Interview Responses</td>
<td>Teacher journal</td>
</tr>
<tr>
<td>4. Is student learning increased by scientific argumentation?</td>
<td>Wolf Biology Pre and Posttest</td>
<td>In-class Observations</td>
<td>Post Argumentation Student Interview Responses</td>
<td>Teacher journal</td>
</tr>
</tbody>
</table>
DATA AND ANALYSIS

The results of the Wolf Management and Scientific Argumentation Pretest and Posttest indicated that there was an average normalized gain of 23% (N=73). According to Hake (1998), an average normalized gain of 20% or lower is considered in the low category, 20-50% is medium gain and 50% and higher is high gain. Therefore, the students in this study had a medium level of normalized gain. When asked if they were more motivated to learn a topic when conducting a scientific argument during the final student interviews, one student commented, “Yes because when you have a scientific argument you have to figure out more stuff about [the topic] in order to argue your point.”

The median scores from the Wolf Management and Scientific Argumentation Pretest to Posttest increased from 67% to 80%, a gain of 13 percentage points. In a box-and-whisker plot of the pre and posttest scores, the upper quartile boundary increased from 72 to 85 with the minimum score remaining the same at 33%. When asked if after the argument students felt that they better understood the topic, one student commented, “I honestly didn’t know much about [wolves] but I like learning about new things like this. Honestly I did learn a lot about this.” The mode for the Wolf Management and Scientific Argumentation Pretest and Posttest scores increased 20 points from 67% to 87% (Figures 1 & 2).

Student responses during the Final Student Interview Questions support the analysis of the Wolf Management and Scientific Argumentation Pretest and Posttest scores. When asked if they would like to say anything about their experience with scientific argumentation, one student commented, “I thought it was a lot of fun learning
about this topic because I got to learn about new things. And I think learning about new things is important because you never know when in life you will run into things you need to know about. Another student commented, “It was fun and I think it was a good way to figure out ways to figure out what to do.” From my observations, I noticed that the students were able to talk about wolf management with each other much more easily after the argumentation session than before. They asked what my opinion was and if I thought the state of Idaho was doing a good job managing the population.

Figure 1. Median of scores from the wolf management and scientific argumentation pretest and posttest, (N=74).
Figure 2. Exam scores comparison for wolf management and scientific argumentation pretest and posttest, (N=74).

The Scientific Argumentation Survey results indicated that student attitudes about argumentation as a learning activity increased (Figure 3). In the final student interviews, two students commented that they learn best by engaging in argumentation. One student commented, “I learned a lot during the argumentation because I was able to see facts that other people found.” Another student said, “I liked the argumentation because we don’t have to write a lot and because I got to see other people’s viewpoints.”
Figure 3. Scientific argumentation survey results: “I would rather have a scientific argument in class than do any other activity,” (N=76). Note: -2=Strongly Disagree, -1=Disagree, 0=Neutral/Undecided, 1=Agree, 2=Strongly Agree.

The number of students who enjoy argumentation increased with the number of students who felt negatively about argumentation dropping from 26 to 20. The number of students who felt neutral about it increased from 30 to 35 and the number of students that felt positively about it increased from 20 to 21 (Figure 4). The number of positive responses from two survey questions on how students felt about argumentation as the best way to learn about issues increased from 94 to 102 (Figure 5).
Figure 4. Scientific argumentation survey results: “I enjoy arguing with other people,” (N=76). *Note:* -2=Strongly Disagree, -1=Disagree, 0=Neutral/Undecided, 1=Agree, 2=Strongly Agree.

Figure 5. Scientific argumentation survey results: “Arguing a topic is the best way to come to an agreement on a difficult subject & Scientific argumentation helps me learn about both sides of an issue,” (N=76). *Note:* -2=Strongly Disagree, -1=Disagree, 0=Neutral/Undecided, 1=Agree, 2=Strongly Agree.
The Scientific Argumentation Survey results indicated that when asked if arguing with someone made students change their opinion, negative responses stayed the same, neutral responses increased by three and positive responses decreased by three, however the amount of students who strongly agreed increased by five (Figure 6). However, in the interview responses, seven out of eight students interviewed commented that the argument session did change their opinions of wolves. One student stated, “I feel a little bit different. At first I didn’t really care. I used to think that we shouldn’t have any wolves because all they do is kill but now I see that it helps balance the ecosystem.” Another student commented, “I feel different because now I realize that they help the ecosystem and they make people worry. Those are the people that don’t want them and the people who see they help the ecosystem do want them.” Additionally, a student said, “At first I didn’t care about them but now I do because they give more life to other animals.”

Figure 6. Scientific argumentation survey results: “I sometimes change my opinion when I argue with someone,” (N=76). Note: -2=Strongly Disagree, -1=Disagree, 0=Neutral/Undecided, 1=Agree, 2=Strongly Agree.
A box-and-whisker plot of the results from the Scientific Argumentation Survey indicated that the scores that were in support of scientific argumentation from the survey increased positively from pre-survey to post-survey. The median decreased, but the boundary of the upper quartile increased from 18 to 23 (Figure 7). This indicated that the overall responses increased from pre-survey to post-survey. Additionally, the amount of students who felt negatively about argumentation also decreased. More students disagreed that they felt frustrated when they argue with another person and more students disagreed that they would just rather agree with someone than argue with them (Figure 8). In the final interviews, when asked if the students would like to have another scientific argument in class, one of the students stated, “It can help us to see why it is valuable to see both sides and understand that there are two sides to every argument.” Another student said, “Yeah, it was a pretty fun experience. I would like to have it where we could pick the topic and research what we want.” Furthermore, another student stated, “Yes, because it is easier and active.” Additionally, a student commented that they liked the argument in class, “because I can talk more than I’m supposed to and start to make people think what I’m thinking. Like kind of start to change their minds.”
Figure 7. Survey response comparison for pre-survey and post-survey positive attitudes toward argumentation responses, (N=76).

Figure 8. Survey response comparison for pre-survey and post-survey negative attitudes toward argumentation responses, (N=76). Note: -2=Strongly Disagree, -1=Disagree, 0=Neutral/U ndecided, 1=Agree, 2=Strongly Agree.
During both the large group and small group argumentation sessions, the students showed critical thinking skills. They used statements, “In my opinion,” “To what you and you said,” “I know what you’re saying,” “What you said doesn’t make sense because,” “I see your point but,” “Let’s agree that,” and “I’m going to argue against both points.” I heard students using facts that they had learned to back up their claims and arguments. Students said things such as, “I think wolves change the whole ecosystem for the better,” and “We kill things and wolves kill things, it’s not that different.” Another student remarked, “When wolves were gone [from Yellowstone] everything was dying. Once the wolves came back, the ecosystem was back in balance.” This indicated the students were taking the information they had learned and were synthesizing it to either support their own opinion or refute another student’s opinion.

The Wolf Opinion Survey results indicated that student opinions changed from the argumentation session. The number of student responses that strongly agree to the survey questions that were pro-wolf increased from 39 to 66 and the number of student responses that were neutral to the pro-wolf survey questions decreased from 77 to 61. However, the number of student responses who answered strongly disagree to the pro-wolf survey questions also increased from 21 to 36 (Figure 9).

In my observations, I noticed that many students that had strong anti-wolf sentiments were reluctant to change their opinions. When asked if their opinion had changed after the argumentation, one student who remained strongly anti-wolf throughout commented, “I still feel the same. I don’t understand why people don’t want them to be hunted or have fewer numbers.” However, another student who was mostly anti-wolf stated that they “feel a little bit differently because I understand that we do need
some wolves because if we don’t have enough we won’t have enough to control the elk population.” In what I witnessed, many students moved more toward the neutral position of having some wolves to help control the elk population but also having a hunting season on wolves to help control their populations. A two-tailed t-test found no statistical significance between the pre and post pro-wolf survey responses with a p-value of 0.61. However this could be a result of a small sample size.

![Figure 9](image)

*Figure 9. Pro-wolf responses to the wolf opinion survey. (N=76). Note: -2=Strongly Disagree, -1=Disagree, 0=Neutral/Undecided, 1=Agree, 2=Strongly Agree.*

The amount of student responses to the anti-wolf survey questions decreased greatly after the argumentation. The number of students who answered strongly disagree to the anti-wolf questions increased from 37 to 63, a change of 17% (Figure 10). I had students sit on the side of the room that indicated their opinion about wolf management. Students shifted positions frequently when a new point was made by another student and they thought about it for a while. During the large group argument, one student commented, “We are not as split as we thought. We pretty much all agree that there should be some wolves with some hunting of wolves allowed.” When trying to determine just where a student stood on the issue one student asked another, “You’re in
the middle but which way do you lean more to?” A two-tailed t-test of the pre and post anti-wolf responses to the Wolf Opinion Survey showed statistical significance in the means of the data with a p-value of 0.01.

Students’ opinions of predators as an important part of an ecosystem increased. The amount of students who were neutral about predators decreased by three and the amount of students who strongly agreed predators were an important part of the ecosystem increased by five (Figure 11). This is not a large gain, however it does indicate that students opinions did change before and after the argumentation.

*Figure 10.* Anti-wolf responses to the wolf opinion survey. (N=76). *Note:* -2=Strongly Disagree, -1=Disagree, 0=Neutral/Undecided, 1=Agree, 2=Strongly Agree.
INTERPRETATION AND CONCLUSION

This study provided evidence that scientific argumentation changed student opinions about a controversial topic and it also increased student knowledge of a topic. It furthermore indicated that scientific argumentation increased critical thinking skills in students and that some students enjoyed argumentation as a classroom activity.

The primary research question aimed to see if participation in scientific argumentation changes student attitudes toward a topic. The study results demonstrated that student attitudes changed greatly in some areas and more subtly in other areas. Students’ attitudes toward wolves became more positive and more understanding. Pro-wolf sentiments increased with more students agreeing that wolves are a valuable component of an ecosystem. Even though the survey results don’t indicate this, as stated
previously, I witnessed many more students’ opinions moved away from the more extreme positions and moved toward the neutral positions. However, there were a handful of students that remained either pro-wolf or anti-wolf regardless of the argumentation and facts presented. More students increased in pro-wolf sentiments and strongly agreed that it was a good thing that wolves were reintroduced to Idaho.

Student learning and understanding of wolf management was reflected greatly in their letters. Students presented both sides of the issue and stated their opinion on the subject in an articulate manner. In the responses received by the letters’ recipients, many of them stated that they were impressed with the quality of the students’ knowledge on the topic and how well-rounded their thoughts were. The recipient of the letter sent to Idaho Fish and Game was pleased to see that these students would be well-informed about this issue when they become voting citizens later in life. Students did much better on the pre and posttest indicating that they knew more about wolf management issues specifically as well as how scientific argumentation should include facts and values instead of just emotion.

Even though the responses to the Scientific Argumentation Survey did not indicate that students enjoyed the argumentation session we had in class, many of the responses in the interviews indicated just that. When I spoke with students afterward, they realized after talking with me about it that they did enjoy the argumentation and that it gave them a chance for their opinion to be heard. Sixty-four percent of students indicated on the Scientific Argumentation Post Survey that they enjoyed the argument that we had in class. Students agreed that they, “liked to see other people’s viewpoints,” as well as talk about their own opinions. One student really enjoyed the argumentation
saying, “The argumentation helped me to learn because I was able to see facts that other people found.” Another student exclaimed that scientific argumentation made them more motivated to learn about a topic because, “you have a goal to look forward to because you are trying to understand your side more and the other side more.”

Scientific argumentation also gave the students experience with developing a consensus with other people who may disagree with them. Students were forced to at least consider the other side of the issue and look at facts to come up with a management plan which all in the group could agree was adequate. As I circulated around the room, I heard students going back and forth about limits on hunting and whether or not wolves were valuable to the ecosystem. The majority of students were pleased with the outcomes of their group’s management plan and realized that they could not get their way entirely. When asked about if they were happy with the management plan their group decided upon, one student commented, “Yes because it balanced out how both sides of the group thought and both sides had a happy agreeable solution.” Another student said, “I realize there needs to be a compromise. They get what they want and I get what I want.”

The argumentation session gave almost all students the chance to build confidence in their opinions. It gave them real world experience where they learned about what makes issues like wolf management such a controversial topic that is difficult for the public to decide upon a solution. One of the students that was strongly pro-wolf agreed that, “I don’t understand why people are so stubborn. I am stubborn too though and I can kind of see why people are and that’s why we are where we are. In Wyoming, I feel that’s why they haven’t come to a consensus. A person’s opinion is based on how
you grow up. We don’t usually buy meat, I don’t hunt. Those people who grew up hunting it is just a part of what they do.” After this experience with argumentation, the students have a better idea of how to properly argue their point with someone. They learned that they need facts and evidence on which to base their claims and cannot use emotion alone to argue a point successfully. This skill is part of the 21st century values that are a part of the new generation of science standards and will be expected of students in the future (NGSS Lead States, 2013).

The Likert survey responses did not always match the student interview responses. This provides some uncertainty of the data. Survey data may provide the students a more anonymous platform on which to voice their opinions about something but the interview data seemed more authentic. In future studies, I would like to use more interviews pre and post argumentation to affirm the efficacy of the argumentation. It seems like students were able to comfortably voice their opinions to me during the interviews and told me how they truly felt about the questions. I would also make the Likert surveys shorter. I collected some data that was more background noise than useful data and may have exhausted the students’ truthful responses to other more useful survey questions.

VALUE

The value of this research project on my teaching and the students cannot be overstated. I am a better science educator because of it because I see the value of providing students with skills that they will use in their lives as adults. The value of argumentation is that students are required to see the facts of an issue and look at arguments on both sides. Students must also come to a consensus and be willing to
consider the alternatives to their opinion. I found myself using argumentation both
before this study and after this study because it was such a valuable method of teaching a
topic. Scientific argumentation allows students to have an opinion but they still need to
have the facts to back up their claims. Scientific argumentation should be used multiple
times throughout the year in every science classroom. It is a better representation of how
actual scientists perform their jobs on a daily basis. Furthermore, it more accurately
depicts science as a process than the recipe-type experiments that I usually use to teach
the scientific method. Scientific argumentation requires students to confront ethical real-
life issues and try to think about the proper course of action. My students and I had great
conversations about ethics and how science isn’t always black and white. We covered
genetics after the wolf argumentation and the students were able to have a small
argumentation about transgenic research. They wanted to know what both sides of the
issue were and why some people might be against transgenics, especially when it comes
to use on humans. I was proud that my students were able to have an opinion but also
were willing to hear about the opposite side of the issue.

The additional value to my students was that they felt that their voice was being
heard by policy-makers and advocates in their letters. The students’ writing was better
than I normally see from them and they were diplomatic in the way they presented their
opinions. The letters revealed how students were able to articulate that they understood
both sides of the issue but that they could also state their opinion along with their claims
(Figure 12). The students were excited about the responses they received from the
officials we sent letters to and were surprised that their opinions were valued by someone
in the “real world” (Figure 13).

March 19, 2015

John Thompson,
Director of Public Relations, Idaho Farm Bureau Federation
PO Box 4248
Pocatello ID 83208-4248

Dear Mr. Thompson:
I would like to start off with that I understand your opinion, and would like to express my own opinion, about wolf reintroduction and management. I have been studying this in my 7th grade life science class. I think that we should have about only 100-200 less wolves than there are deer, because before we reintroduced the wolves the deer and elk were getting rid of all the wildflowers and plants. They even made some animals become less like the fish and birds..... If we have less wolves than there are deer then the deer won't run out and the wolves won't die out. I think that we should have hunting seasons for wolves so we can keep them balanced.

Figure 12. Student letter to Idaho Farm Bureau Federation
Figure 13. Response from Idaho Fish and Game Employee

I was somewhat reluctant to spend a few weeks on this project because I was afraid that I would be missing valuable time teaching about other standards. However, I will now use argumentation as an integral part of my science curriculum due to the critical thinking skills that it provides to students. This project was able to provide the students with a goal and motivation that I believe few other assignments would. I will now have at least one argumentation session per unit topic that we study.

Performing this action research based project provided me an opportunity to closely examine what changed with my students as a result of a classroom learning activity. Rarely as teachers do we get the chance to actually see if what we are doing is truly reaching the students. This project gave me that opportunity and proved to me that argumentation is a valuable learning activity and should be used more frequently in
science classrooms. It is my belief that just lecturing about this issue would have done little to change student opinions. I am excited to see if allowing the students the opportunity to choose their own topic and perform their own research will further increase their motivation to learn about the process of science and the ethical issues that it sometimes raises.


APPENDICIES
APPENDIX A

MSU INSTITUTIONAL REVIEW BOARD MEMORANDUM
INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 0000165

MEMORANDUM

TO: Kristin Combs and John Graves
FROM: Mark Quinn, Chair
DATE: November 19, 2014
RE: "The Effects of Scientific Argumentation on Student Understanding and Attitudes toward a Controversial Issue" [KC111914-EX]

The above research, described in your submission of November 19, 2014, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

(b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

(b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.
APPENDIX B

GRAY WOLF MANAGEMENT RESEARCH FORM
Visit a website such as http://fishandgame.idaho.gov/public/wildlife/wolves/ and answer the following questions. You can visit other websites but they must be CREDIBLE sites that are not Wikipedia or blogs.

1. When and why were wolves exterminated from the lower 48 states?

2. What years were wolves reintroduced to Yellowstone and Idaho?

3. Why were wolves reintroduced to Idaho and Yellowstone?

4. Why were wolves put on the Endangered Species List?

5. When were wolves taken off the Endangered Species List? Why were they removed from the Endangered Species List?

6. How are wolves managed in Idaho right now? What are they listed as? Can they be hunted? Is there a limit on how many you can hunt? What is the limit if there is one?

7. Do a little research and find some organizations/government agencies that are interested in the management of the gray wolf in Idaho. List at least 5 different organizations or government agencies below.

   1.

   2.

   3.

   4.

   5.
8. Choose 3 of the organizations or government agencies and list their viewpoints below:

1. 

2. 

3. 

9. For the 3 organizations or government agencies you chose in question number 8 list some values that they have that influence their viewpoints.

Name of Organization:

Values:

Name of Organization:

Values:

Name of Organization:

Values:

Website 1:
____________________________________________________________________________________________________________

Website 2:
____________________________________________________________________________________________________________

Website 3:
____________________________________________________________________________________________________________

Website 4:
____________________________________________________________________________________________________________

Website 5:
APPENDIX C

WOLF MANAGEMENT ARGUMENT CONSTRUCTION FORM
Name: ____________________________________  Wolf Management Argument Construction

How do wolves impact an ecosystem? Be sure to include some information about food webs and ecology from the unit we just finished. Why is that important to gray wolf reintroduction?

Now that you conducted some research on gray wolf reintroduction, which perspective(s) best represents your position? In other words, which organizations or government agencies do you agree with? Why do you agree with them?

What are some values that you have that influence your views on gray wolves and their management?

Below you will begin to develop your argument. You need to state claims and then use evidence/facts to support those claims. Evidence must be from credible sources. Remember that you are looking for scientific claims to support your argument. You must have at least 3 claims with evidence.

<table>
<thead>
<tr>
<th>Claim</th>
<th>Evidence</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Anticipate 1 or 2 counter arguments to your position. How would you defend against them?
APPENDIX D

ARGUMENTATION SESSION FORM
Wolf Management Argumentation

Names of Group 1 Members:
_____________________________________________________________________

Names of Group 2 Members:
_____________________________________________________________________

Stance of 1st Group:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Stance of 2nd Group:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Claims/Arguments of 1st Group:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Claims/Arguments of 2nd Group:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Rebuttal of 1st Group:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Rebuttal of 2nd Group:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
Consensus as to How Wolves Should be Managed in Idaho:
Are wolves a valuable/necessary part of an ecosystem? How do they benefit an ecosystem? Do both groups agree on this?

Should wolves be allowed to be shot on sight and/or poisoned with no limits on how many can be killed? Why or why not? Both sides must come to an agreed plan.

Should there be hunting of wolves in Idaho?

If Yes, how many should be hunted a year or how many should there be left each year?
Year-round hunting with no seasons: YES NO
This many should be hunted_____________This many should be left_____________

If no hunting of wolves, will there be any control measures?

If no hunting of wolves, what will be done if hunters complain about too few elk in an area of the state?

If wolf numbers become too low, will hunting be suspended or reduced for a while? For how long?

What should happen to a wolf if it is determined that the wolf killed livestock?

Should a farmer be compensated for lost livestock? How?

Idaho has just agreed to spend $400,000 on wolf control measures including shooting and trapping wolves to help boost elk populations. Let’s say that you have $1,000,000 to spend on wolf management. How would you spend it? Wolf control? Habitat restoration? Education of public? Reintroducing more wolves? Relocation of trouble wolves? Other ideas?

Any additional ideas about wolf management in Idaho should be listed here.
APPENDIX E

COMBS WOLF BIOLOGY PRETEST AND POSTTEST
True/False (Circle One)

1. A predator is an animal that hunts another animal for food.
   - True  False

2. A prey is an animal that is hunted by another animal.
   - True  False

3. Predators will eat all the food in an area and will have nothing left to eat.
   - True  False

4. Too many animals in one area will cause starvation of some animals.
   - True  False

5. Humans are an example of an apex predator.
   - True  False

6. Without apex predators, prey numbers will decline.
   - True  False

7. Apex predators do not affect an ecosystem.
   - True  False

8. When predator numbers increase, prey numbers will decrease.
   - True  False

9. Historically, wolves once roamed across most of the United States.
   - True  False

10. Wolves are an apex predator.
    - True  False
Multiple Choice (Write the letter on the line next to the number)

1. Wolves were reintroduced into Idaho in what year?
   a. 1895  c. 1978
   b. 1995  d. 2002

2. What species has benefited greatly from wolf reintroduction?
   a. Moose  c. Beaver
   b. Western Newt  d. Elk

3. During scientific argumentation the goal is to:
   a. Come to a consensus
   b. Argue your point until someone sees your way
   c. Refuse to see any other side
   d. Agree to everything

4. Scientists argue because:
   a. They can come up with new ideas
   b. They can see other viewpoints
   c. They can begin to solve problems
   d. All the above

5. It is best to use _________________ when engaging in scientific argumentation.
   a. Emotion
   b. Facts
   c. Both a and b
   d. Neither
APPENDIX F

SCIENTIFIC ARGUMENTATION PRE-SURVEY
Participation is voluntary and will not affect a student’s grade or class standing in any way.

Student Name: ____________________________  Hour: ______  Date: ________________

Scientific Argumentation Pre-Survey

Directions: The statements in this survey have to do with your opinions and beliefs. Please read each statement carefully, and select the answer that best expresses your own feelings. Remember this is not a test, and there are no “right” or “wrong” answers. Please circle the answer that best fits your belief.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided/Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I know what scientific argumentation is.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I would rather have a scientific argument in class rather than do any other activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I feel frustrated when I argue with someone.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Arguing a topic is the best way to come to an agreement on a difficult subject.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Scientific argumentation helps me learn about both sides of an issue.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I sometimes change my opinion when I argue with someone.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. I am good at arguing my point with someone.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. I enjoy arguing with other people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. I would rather just agree with someone than argue with them.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. I am open to learning a new way of looking at a subject that I feel passionate about.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
APPENDIX G

PRE-TREATMENT WOLF OPINION SURVEY
Participation is voluntary and will not affect a student’s grade or class standing in any way.

Student Name: ____________________________  Hour: ______  Date: ______________

Pre-Treatment Wolf Opinion Survey

Directions: The statements in this survey have to do with your opinions and beliefs. Please read each statement carefully, and select the answer that best expresses your own feelings. Remember this is not a test, and there are no “right” or “wrong” answers. Please circle the answer that best fits your belief.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided/Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wolves are an important part of an ecosystem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Wolves should have been reintroduced to Idaho in 1995-1996.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. There are enough elk for both wolves and humans to hunt.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Wolves will eat all the elk leaving none left to hunt.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. More livestock are killed each year by wolves than any other thing.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I know at least one benefit of an apex predator.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. Predators are an important part of an ecosystem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Some predators should be protected by law.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. I think we should be allowed to hunt wolves.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. I think wolves should be protected by the Endangered Species Act.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please circle either YES or NO for the following questions. Remember there is no right or wrong answer.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have seen a wolf in the wild.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2. I am a hunter.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3. I have seen a wolf within a mile of my house.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4. I live inside St. Anthony city limits.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. I live on a ranch with livestock (cattle, pigs, sheep, chickens, etc.)</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
APPENDIX H

POST-TREATMENT WOLF OPINION SURVEY
Participation is voluntary and will not affect a student’s grade or class standing in any way.

Student Name: ____________________________  Hour: _______  Date: ________________

Post-Treatment Wolf Opinion Survey

Directions: The statements in this survey have to do with your opinions and beliefs. Please read each statement carefully, and select the answer that best expresses your own feelings. Remember this is not a test, and there are no “right” or “wrong” answers. Please circle the answer that best fits your belief.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided/Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wolves are an important part of an ecosystem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Wolves should have been reintroduced to Idaho in 1995-1996.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. There are enough elk for both wolves and humans to hunt.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Wolves will eat all the elk leaving none left to hunt.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. More livestock are killed each year by wolves than any other thing.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I know at least one benefit of an apex predator.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. Predators are an important part of an ecosystem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Some predators should be protected by law.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. I think we should be allowed to hunt wolves.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. I think wolves should be protected by the Endangered Species Act.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please circle either YES or NO for the following questions. Remember there is no right or wrong answer.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have seen a wolf in the wild.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I am a hunter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I have seen a wolf within a mile of my house.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4. I live inside St. Anthony city limits.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. I live on a ranch with livestock (cattle, pigs, sheep, chickens, etc.)</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
APPENDIX I

POST SCIENTIFIC ARGUMENT SURVEY
Participation is voluntary and will not affect a student’s grade or class standing in any way.

Student Name: ______________________   Hour: _______   Date: _______________

Post-Scientific Scientific Argumentation Opinion Post-Survey

**Directions:** The statements in this survey have to do with your opinions and beliefs. Please read each statement carefully, and select the answer that best expresses your own feelings. Remember this is not a test, and there are no “right” or “wrong” answers. Please circle the answer that best fits your belief.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided/Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I know what scientific argumentation is.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2.</td>
<td>I would rather have a scientific argument in class rather than do any other activity.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3.</td>
<td>I feel frustrated when I argue with someone.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4.</td>
<td>Arguing a topic is the best way to come to an agreement on a difficult subject.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5.</td>
<td>Scientific argumentation helps me learn about both sides of an issue.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6.</td>
<td>I sometimes change my opinion when I argue with someone.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>7.</td>
<td>I am good at arguing my point with someone.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>8.</td>
<td>I enjoy arguing with someone.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>9.</td>
<td>I would rather just agree with someone than argue with them.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>10.</td>
<td>I enjoyed the scientific argumentation that we had in class.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>11.</td>
<td>I am open to learning a new way of looking at a subject that I feel passionate about.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>12.</td>
<td>I felt frustrated during the argumentation in class.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13.</td>
<td>I felt excited during the scientific argumentation in class.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
APPENDIX J

IN-CLASS OBSERVATION FORM
In-Class Observation Form

Date: ________________

Period: ________________

Activity/Topic Being Taught During Observation: ________________________________

<table>
<thead>
<tr>
<th>Student</th>
<th>Observation</th>
<th>Quotes or Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX K

POST ARGUMENTATION STUDENT INTERVIEW FORM
Post Argumentation Student Interview Response Form

Name of student: _______________________________________________________

Period: __________

Date of Interview: _______________________

Interview Start Time: _____________

Interview End Time: _____________

Questions:

1. Did you enjoy the scientific argumentation that we had in class? Why or why not?

2. What activities in class help you to learn best? Why?

3. At any time during the argument did you feel uncomfortable? Did you feel angry? Did you feel excited?

4. Does scientific argumentation make you more motivated to learn a topic? Why or why not?
5. Would you like to have another scientific argument in class? Why or why not? If not, what would you rather do?

6. Are you happy about the agreement that was made at the end of the argumentation? Why or why not?

7. After the argumentation do you feel that you better understand the topic? Is there anything that you still do not understand?

8. Do you feel the same or differently about wolves after the argumentation that we had in class on them? What changed your opinion?

9. Is there anything else you would like to tell me about your experience with scientific argumentation?