EFFECTS OF EXPLICIT TEACHING AND SCAFFOLDED SCIENTIFIC ARGUMENTATION ACTIVITIES ON STUDENTS' UNDERSTANDINGS OF THE NATURE OF SCIENCE, CONTENT KNOWLEDGE AND ITS APPLICATION, AND ARGUMENTATION SKILL IN AN 8TH GRADE PHYSICAL SCIENCE CLASSROOM.

by

JEREMY SCOTT EDGE

(Under the Direction of Cory Buxton)

ABSTRACT

The purpose of this research was to study the overall effects of teaching scientific argumentation in conjunction with content knowledge in an 8th grade science classroom. The goals were to determine if students could: a) learn argumentation as a concept, b) learn to argue well at the same time as they learned new content knowledge, and c) improve how they applied that knowledge to situations that required science understandings. The study made use of explicit instruction in argumentation, scaffolds that helped students develop their arguments, and oppositional groupings to aid students in learning to argue and in developing higher level and complete arguments. Students participated in four main argumentative sessions spanning electricity and magnetism content-knowledge-related topics. Three of these arguments were strictly science-based, while the final argument made use of a socially relevant scientific topic. The arguments that students developed were rated quantitatively based on their structure and level of content knowledge included. The arguments were analyzed qualitatively based on argument and reasoning patterns. Students completed an interview that was analyzed for themes regarding student perceptions regarding argument and the learning experiences.

The findings from the data indicate that over the course of the unit, students developed greater skill in the construction of their arguments. Students developed more complete products, used more content knowledge in a meritorious manner, and reasoned more effectively. Students progressed in their arguments as a result of explicit teaching of argumentation coupled with scaffolding sheets to help them produce quality arguments. Statistically significant improvements were made in almost every case. The thematic nature of the argument and reasoning patterns showed that students were reasoning more effectively and thinking critically about what they were doing and about the science that supported their efforts to support their claims. The student perception interviews showed that students appreciated the way using argumentation as a learning tool, as well as a specific part of science, helped them to develop a deeper understanding of the content. The participants enjoyed convincing others that they were right while they used information they developed in class and through research to make persuasive arguments.

INDEX WORDS: Argument, Argumentation, Science Literacy, Science, Physical Science

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CHAPTER 1

THE PROBLEM

Introduction

Scientific argumentation has become a topic of intensified research interest in the past decade. This research becomes increasingly important in light of the Next Generation Science Standards (NGSS, Achieve, 2013) and their inclusion of argumentation as a conceptual and practical part of science understanding and learning. Argumentation is commonly accepted as being a part of what scientists do in order to create, detail, and defend what science knowledge is. Kuhn (1962) expounds on the idea of knowledge creation through experimentation, development of theory, argumentation to determine the most agreed upon theory, and the process therein, that scientists go through in order to develop the knowledge base that is currently accepted in the science community. Argumentation amongst competing theories generates better science and more competent scientists.

The communication of science results has always been a part of the scientific method in schools, while the higher level and critical thinking that takes place in argumentative discussions has not. Researchers in the area of argumentation have been, and are currently, seeking to find argumentative aspects of current teaching and at the same time to determine not only how to integrate argumentation in science education, but also how to measure the results of that inclusion.

Once again, Kuhn (1962) details the idea of a scientific concept is something that is proven through debate and the arguments created, supported by observations and experimentation. Science is one of the only fields in which the knowledge that has been acquired must be constantly examined and proven over and over again. Facts are derived from the discussion that surrounds observation and experimentation while there is an attempt to disprove those facts or prove alternate theories. With time, theories can be altered through further experimentation and debate centered on observation until at some points the entire concept may be revamped. The discourse surrounding scientific thought and fact is pivotal. The act of argumentation is where science consensus knowledge comes from. Osborne (2000) notes that science itself is created through discursive practices that propagate and promote what culminates into scientific knowledge. For a person to be scientifically literate, in what he describes as the derived sense, it is necessary for him or her to know how to conduct a scientific argument and participate in discourse. Otherwise, a person is merely memorizing the knowledge that has been derived from other's argumentation and experience.

A basic premise of an argument is presenting a claim and also supporting that claim with evidence and information (Osborne, 2000; Erduran, Simon, & Osborne, 2004; Hand et al., 2003; Buxton et.al., 2012; Wang et al., 2011; Cavgnetto, Hand, & Norton-Meir, 2010; Hand, Wallace, & Yang, 2004). Scientific thought and practice provides the means for a person to construct a claim and defend it with observation, previous scientific facts and justification from others' previous experiences and writings. As one creates a claim, he or she must, at the same time, be able to articulate reasons for supporting that claim, consider alternate positions, relate it to other events, and understand why it is important (Osborne, 2000). The structure of the argument rests on the basis of experience and knowledge. The claim is supported and detailed as well as defended. Within the practice of science, there is also the construction of the counterclaim by others in the stream of discourse surrounding the original presentation of a claim. The idea is to create knowledge based on experience, communication, and defense of claims. The counterclaim is an alternative way to look at the facts presented and the discourse that ensues is to determine the best way to interpret and derive knowledge from the data presented (Osborne, 2000; Osborne, Erduran, and Simon, 2004; Erduran, Simon, and Osborne, 2004). Turner and Broemmel (2006) note that there is a specific cognitive challenge in the construction of the claim and the counterclaim that is based in the writing, construction, and organization of the discourse involved. Through the use of argumentation, a deeper understanding of the concept is attained through reading, writing, thinking, and examining of experiences, all in a critical manner.

The focus of research in the field of argumentation in science education has evolved from wondering if there is argumentation in the classroom and whether there are conditions that promote the basis for argumentation to the development of complex frameworks for analyzing both the structure and the level of reasoning involved within the arguments and argumentative sequences themselves. The issues at hand are still to identify the benefits of using argumentation in the process of teaching science, the best way to teach the argumentative processes to the students, and how to measure the results of using argumentation in the classroom. Teaching argumentation cannot truly be left out of the field of science education, as it has been shown to be an integral part of science itself, and an education in the sciences that teaches the basis of scientific knowledge must therefore include argumentation. It is now up to researchers to develop methodology for teaching and determine the results therein. In this dissertation, I set out to design a methodology that would examine the effect of teaching both scientific argumentation explicitly, and electricity and magnetism content during one unit of study in an eighth grade classroom. The goal of this study was to ascertain the overall effects on students' skills of creating argument, developing and understanding content knowledge, and applying content knowledge in order to solve problems.

Research in the Field

Research performed in recent decades traverses a variety of approaches and outcomes. Fundamental principles are present that aid in categorizing this research. Essentially, one can look at current research to understand: a) the presence of argumentative qualities in general classroom discourse; b) benefits to argumentation learning through explicit teaching; c) results of argumentative abilities that students gain through the scaffolded practice of argumentation; d) relationships between argument quality and topical selection with regard to the difference of science based topics and socio-scientific topics; and e) to what level students are internalizing the content and reasoning skills constructed in social argumentative environments.

Argumentative in General Classroom Discourse

Many researchers pursue evidence of argumentative discourse in the classroom. Frequently, they analyze dialogue of whole class, small group, and dyadic exchanges for the presence of argumentative style knowledge claims without any instruction or scaffolding concerning argumentation. Newton, Driver, and Osborne (1999) find that classroom discourse is primarily directed by the teacher with the focus on a discovery model of science consisting of presenting information or leading students directly toward what is considered scientific fact. Without classroom discourse and a constructivist stance, the true nature of science learning is not encouraged. In a high school classroom, Jimenez-Aleixandre, Rodriguez, & Duschl (2000) find that with groups of students who are comfortable working in discussion groups and where discussion based education has been carried out in the past, students are able to create basic arguments. These researchers perceive the traditional positivist teacher-led classroom as the greatest barrier to argumentation. Studies such as these show that in order to foster argumentation, classroom environments should be student centered and involve discourse among students.

With regard to discourse that takes place in the classroom and its relation to the construction of knowledge, multiple studies seek to examine the kinds of discourse and specific patterns that lead to quality argument development. Kelly and Chen (1999) specifically set out to do an ethnographic study in which they examined the oral and written discourse of a cycle of activity in a college classroom. They examined class discussions to generate an understanding of how knowledge was constructed. Their results showed that a classroom environment with a predisposition to open discussion as well as teacher framing of concepts helped students develop the use of evidence to make and support claims. Osborne, Erduran, and Simon (2004) found similar results with junior high school students, while Kuhn, Shaw, and Felton (1997), when examining both adolescents and adults, saw improvements in reasoning and quality of argument through a variety of interactive forms. However, Felton (2003) found, in a study of middle school students, that discussion followed by reflection on the argumentative discourse is most effective.

Maloney and Simon (2006) find that the kinds of talk engaged in by groups are pivotal to creation of quality arguments. What they call “exploratory talk” is deemed vital for students to engage in, as it involves critical examination of each other’s ideas in a constructive way. Chin and Osborne (2010) and Evangorou and Osborne (2013) confirm the use of exploratory talk as important to constructing quality arguments and note the importance of questioning during that talk. Nevertheless, Sampson and Clark (2008) and Albe (2007) noticed some specific problems with the group dynamic and discussion in a group of high school students. Groups often focused on procedural steps and less on reasoning. Students sometimes ignored contributions of group members and there was sometimes an authoritative presence from one or more group members. These issues could lead to reliance on inappropriate evidence and a lack of constructive exploratory discourse.

Interesting work has been done in discovering how improvements are made in argumentative understanding, ability, and reasoning. Schwarz, Neuman, and Biezuner (2000) and Schwarz et al. (2003) developed ways to examine arguments as to the level of skills needed to argue, comprehension of the opposing side and reasoning to support argument. Through scaffolding, they lead students through discussion to create arguments.   They suggested that to best create arguments and knowledge, students should be involved with disparate ideas and thoughts that lead to others' arguments, specific argumentative operations (such as challenging opponents and conceding supports), testing hypotheses, and scaffolds that help to internalize the operations of argumentation. Clark and Sampson (2007) and Albe (2007) also noted that best results in reasoning and creating support for claims come from higher levels of opposition within discussions.

This research reveals that argumentation can happen naturally, at a basic level, in specific classroom environments. Environments that foster discussion and discourse are essential to developing dialogical and argumentative discourse. Within this context, discussion is defined as a more open and freely participated in group or paired interaction to convey thoughts and ideas. Discourse here is used to identify an interaction that is specifically topical in the realm of a more specified ideology, such as argumentative discourse or scientific discourse. The idea of discourse here also contains a quality of rhetoric.   In discourse within the classroom, better results come from confronting disparate viewpoints and questioning those positions. Exploratory talk, in which students are engaged in constructive critiquing of each other's ideas, leads to more thorough conceptual understandings of content and learning.   Researchers recommend explicit teaching about communication and cooperation in group work, and providing explicit scaffolding and support for effective collaboration practices and communication, as well as monitoring, in a supportive way, how students are progressing in developing collaborative and communication skills.

Explicit and Scaffolded Teaching

Research examples of scaffolded production of arguments are necessary to develop an understanding of how student's natural propensity to argue their positions can be guided. Bell (2010) notes increased understanding of the nature of science and better arguments with a computer assisted scaffolding program, while Simon, Johnson, Cavellt, and Parsons (2011) see only a slight increase in content knowledge understanding. Sandoval and Millwood (2005) note that although the scaffolds allow students to create arguments, in some cases students follow the scaffold with little knowledge as to what they are actually doing conceptually. In these cases students rarely interpret data with regard to its connection to theoretical argumentative support.

The Science Writing Heuristic (SWH) is one specific kind of scaffold. Research in elementary grades (Hand et al., 2004; Cavgnetto et al., 2010) and with year 5, 7, and 10 students (Choi, Noteburt, Diaz, & Hand 2008) for levels of reasoning, argument creation, and engagement with knowledge creation produced positive results. The scaffolded techniques of the SWH leads students through exploratory laboratory interactions that allow for more engagement, an understanding that knowledge claims must be coordinated with evidence for support, and an understanding of the nature of science as the construction of knowledge through discourse. Sandoval and Reiser (2004) notice similar results with a computer program similar in function to the SWH. Kind, Kind, Hofstein, and Wilson (2011) find that without a scaffold like the SWH, it is difficult to change the nature of students' approach to laboratory activities from following a discovery-style pre-manufactured experience, to the inquiry style of learning that supports argumentation.

A number of research studies have examined interventions that involve explicit teaching of argumentation, its purpose, and its structure. Zohar and Nemet (2002), while working with biology students in Israel, denoted that an intervention with explicit teaching of general reasoning patterns and argumentation skills in a genetics unit sees students develop both greater skill in argumentation and a greater conceptualization of the content knowledge involved. Kuhn and Udell (2003) show that explicit instruction of argument techniques in combination with specifically disparate discussion groups, in which opposing sides are specifically grouped together, leads to significant changes in ability to construct counterarguments and examine opposing positions.

McNeil (2008) postulates that teacher affect is high with teaching argumentation. Teachers need a thorough understanding of argumentation as well as knowledge of classroom practices that support discussion. Teachers also need to model, provide feedback, and build background knowledge frameworks for students to connect to scientific issues. Kuhn, Wang, and Li (2011) identify higher levels of student achievement when a fundamental understanding of the purpose of argument is present. Bulgren, Ellis, and Marquis (2013) see that explicitly teaching the analysis of claims and construction of an argument to support a claim leads to increased confidence in the students regarding their abilities to follow lines of reasoning and identify an argument in a real world scientific article.

Studies that use intervention help to derive best practices for the teaching of argumentative discourse. Kaya, Erduran, and Cetin (2012) find that without explicit instruction in argumentation, their high school students are not sure of the different types of justifications used in arguments, are unclear as to whether they are doing argumentation or not, and show a lack of metacognition as to what they are doing in science classes. Kelly and Takao (2002), Takao, Prothero, and Kelly (2002), and Takao and Kelly (2003) saw low levels of argumentative ability, poorly constructed arguments, low levels of reasoning, and a general lack of understanding of the bases for argumentative support when examining written essays from college students who were not explicitly taught argumentative techniques.

The need for both scaffolded and explicit instruction in teaching argumentation is shown through positive results stemming from using both approaches. Using scaffolding as well as explicit teaching produces more conceptual understandings concerning the basis for argumentation, better content knowledge in the science field, and an enhanced level of productive discourse. Without the added explicit instruction, students do not develop as much theoretical understanding of why they are arguing and what they are learning through the argumentative process. Overall, interventions are necessary to aid in students' construction of arguments and their understandings of argumentation and its place in the world of science education.

Scientific Versus Socio-Scientific Topics

Topics of argument construction are generally either science based or socio-scientific. Sadler (2004) finds, in analysis of an argumentation intervention, students' levels of content knowledge with regard to scientific assertions influences the level of reasoning they are able to use. Kolsto (2006) and Sadler and Donnely (2007) determine that when confronted with socio-scientific issues, their students do not find textbook or expert evidence to be crucial to the arguments created. They focus instead on values and social knowledge. Interestingly, Jimenez-Aleixandre (2002) finds that in an issue combining scientific and socio-scientific aspects, a professional in the field of science can show similar value-based arguments as her eleventh grade students. Arvola and Lundergard (2011) see that using a socio-scientific issue does not often encourage construction or use of scientific knowledge.

With topics centered in science, Von Aufschnaiter, Erduran, Osborne, and Simon (2007) notice students require foundational knowledge about the topic in order to create quality arguments with support for claims and reasoning. Students with less background knowledge not only do not make use of given information on the topic, but incorporate social understandings in its place. Students do not appear to create new knowledge, but they do solidify understanding they already possess.

The use of socio-scientific topics does appear to help improve students' reasoning in argumentative discourse. If that is the goal, then these kinds of topics are generally helpful. However it is pivotal for students to understand the difference between a constructed argument with claims and reasoning, and an opinion that is based on values and possibly emotions. An argument should undoubtedly have support based in facts and theories that are a part of the scientific canon and community. Constructing arguments when the topic is science has proven to be difficult for students without high levels of background and content knowledge in the area. However, significantly higher gains in content knowledge and understanding have come from these discussions. The purpose of the lesson should guide the choice of topics.

Internalizing Argumentation, Content, and Reasoning Skills

Multiple studies examine the levels to which students internalize group discussions and arguments to transfer them into their own work. Kuhn and Crowell (2011), when studying sixth grade students, noted that students participating in computer chat with similar and opposing viewpoints transferred argumentation skills to their individual essays better than students who merely participated in whole class discussions. Argumentative discourse increased the transfer of socially acquired knowledge to the individual personal level. Mason (1998) examined fifth graders through their small and large group discussions to gauge group cognition and argument construction while also studying the level to which her students appropriate knowledge developed by the group. She saw that students made strides in their refinement of the information and showed precision in their writing after discussions. Fenton (2003) noticed that the group dynamic allowed for lower achieving peers to gain more insight and develop higher quality arguments after discussions. Schwarz et al. (2003) saw only a partial internalization of collectively constructed arguments, while Sampson and Clark (2008) noticed that only some students were able to transfer knowledge.

The internalization of operations that take place in groups is necessary for each individual student to take away what they need and apply it to their own knowledge base. Research shows a level of transfer from the group to the individual, however research in the area is scarce and thus it is not conclusive as to whether students involved in argumentative group discussions do internalize what happens in those groups. This is an area open for further research with regard to transfer, the level of engagement of students who do and do not exhibit that transfer, and levels of reasoning in those transferred arguments.

Moving Forward

In the field of argumentation in education, multiple facets of the processes and environmental conditions that produce argumentation in the classroom and the results of those arguments on students' learning have been examined. One concern from the research is the low level of repeated research designs. Many of these studies target a small sample size and similar groups generally have few studies directed at them. In the sixty or so studies examined for this work, the age range was from elementary school students (Shelly et al., 2012; Cavgnetto et al.,2010) through secondary schools (Bulgren et al.,2013; Simonneaux , 2001), and into college and adult years (Kelly and Takao, 2002; Kuhn et al., 2011; Felton and Kuhn, 2001). In very few cases was the same population in the same country examined multiple times while examining the same basic premises. Generalizing results is therefore difficult. The studies performed are helping us to understand argumentation and its practice in science education, yet there is not a large group of studies that support each other with multiple examples of the same occurrences. There is a need for much more research in the field.

Also, the studies in the field at this time take place across multiple countries, with the bulk of the scholarship coming from the United Kingdom. Although educational systems around the world share similar qualities, differences in the culture of education exist across countries. The scholarship emitting from the UK is of great quality, but when the bulk of studies are done in one general geographic location, culturally specific qualities may lead to results only applicable in particular contexts. Currently very little research has been done in the United States, Eastern Europe, and South America. The body of research must grow in order to create a concrete basis supporting educational theory that is being developed.

One area that is underdeveloped is that of longitudinal studies. With a large proportion of studies in the field focusing their attention on timeframes from one to two days up to a little more than a week or two, there is not a significant body of research examining timeframes of more than a few weeks. Currently research shows good but limited results in short term interventions (Sadler, 2004; Kuhn & Udell, 2003). Scaffolding in a small number of lessons has also yielded improvements, but they are incremental in nature (Sandoval & Reiser, 2004; Bulgre et al.,2013). Results garnered from studies that examine a timeframe of a complete unit of teaching or a timeframe lasting more than a month may show greater improvements and aid researchers in pinpointing particular scaffolds and interventions that provide results. Longer term application of argumentative thinking in science classes would also lead to a greater understanding of the reasoning and discursive capabilities that students develop and use. How students develop argumentative practices is a gap in the knowledge in the field at this point.

Research in precise pieces of discursive interactions has helped educators to see what kind of talk helps an argument progress, but there is little knowledge as to the ways in which students develop and internalize the argumentative process and the reasoning that it cultivates. Longitudinal studies can provide the opportunity to examine an incremental development of argumentative processes in students. Introducing argument with its conceptual basis and then proceeding to fine tune students' usage structurally, as well as their reasoning and epistemic levels of argument, would allow students to better understand all facets of argument. At the same time, researchers would see how the parts fit together in argumentation development in the classroom.

Research in developing argumentation has focused somewhat on the structure and lines of reasoning students use. Different kinds of talk have been shown to lead to better reasoning and support in an argument (Evagorou & Osborn, 2013; Chin & Osborne, 2010), however it is still unclear how a particular discourse can be cultured in students. What kind of talk is needed and the level of students who generally produce this kind of talk is shown in various studies. However, if argumentation is to be used as a tool for teaching science and at the same time as a part of scientific knowledge, the development of exploratory talk must be examined so that all levels of students may be aided in developing reasoning and discourse in this manner.

Students can solidify their knowledge (Von Aufschnaiter, Erduran, Osborne, & Simon, 2007) through argumentative discourse and practices, but how students might acquire understanding of the extensive body of theory and knowledge currently held as scientific understanding has not been examined. Osborne et al. (2004) show that when arguing about scientific topics, students need more background knowledge in the content in order to produce a quality argument; however, there is little research designed to understand if students can develop background or content knowledge through engaging in argumentation activities.

To push the study of argumentation and its usefulness in the science classroom I am proposing research to examine the use of argumentation specifically as a teaching tool for the conveyance of the specific laws and theories as accepted by the science community as basic knowledge and understanding necessary to do scientific work. Argumentation is a part of scientific practice in the science community and should thus be taught in the science classroom. However, with the growing amount of content knowledge expected to be taught in the science classroom, it is important to devise ways to teach multiple concepts and practices at the same time. If scientific argumentation could be taught as a part of science and at the same time be used as a method of teaching and learning, this combination would be beneficial to science teachers and students.

Although it has been shown that using oppositional development of arguments brings about decidedly more complex and complete outcomes, this process has not been fully examined in the online context that students are continually finding themselves in both their educational and personal lives. Here I am proposing to forward this part of argumentation research by examining the results of student participation in an online discussion format with oppositional groupings. The online forum may prove to be more comfortable for the students and allow them to present arguments that they may not be as comfortable doing in person. In this way, they may allow themselves to delve more deeply and oppose with more vigor their classmates' ideas. At the same time, they will have access to a written record of their counterparts' arguments and the claims, reasoning, counterarguments, and rebuttals. This computerized record could help in the construction of their arguments.

In a world with an increasing need for problem solvers in every aspect of science it is important to also gauge the effect that teaching scientific argumentation practices has on students' abilities to solve problems that involve the application of their knowledge in new and unique situations. It is possible that the critical thinking involved in constructing arguments that are complex and complete through their oppositional groupings will lead students to a greater ability to apply their knowledge outside of school. Examining this and previously mentioned expanding fields of research in argumentation will help to determine the effectiveness and benefits of pursuing scientific argumentation in the classroom.

CHAPTER 2

CONCEPTUAL/THEORETICAL FRAMEWORK

The researchers involved in examining argumentation within the field of science have a multitude of underlying theoretical concepts and frameworks that drive and structure their thinking and experimentation. The frameworks that underlie the art of argumentation in science education deal with how students learn, how scientists go about their work, and argument itself. These theoretical and conceptual frameworks span a range that encapsulates such things as the ideas of the cognitive development of children; the sociological dimensions of learning and knowledge; the epistemological concepts of knowledge; the philosophical ideologies surrounding scientific inquiry, learning, and discovery; the uses of language in learning and communication; socio-linguistic contributions to learning; and the structure and process of argumentation itself. When examining or venturing into the field of scientific argumentation and how this is used to drive instruction in the science classroom, it is necessary to understand and detail these frameworks in order to understand how they inform the structure of educational experimentation as it has evolved through the recent decades.

How Students Learn

Inquiry

Learning theories are fundamental to developing an understanding of research on argumentation in science education. Dewey (1929, 1938, 1984, 1986, 1998) and Vygotsky (1962, 1978) lay the foundation for the place of scientific argumentation in the science classroom. The use of argument and its associated techniques are part of the greater concept of inquiry learning as a pedagogical theme.

Inquiry provides a basic foundation on which argumentation in the classroom is based (e.g., Duschl, 2008; Sampson & Clark, 2008; Sandoval & Reiser, 2004; Osborne, Erduran, & Simon, 2004). In an inquiry-based classroom, students are afforded time and space to ask questions and derive answers through practices that involve acquisition of evidence. This acquisition occurs in association with a framework that drives and encourages students to understand the concepts that will answer their questions about the world. Students are engaged in what is considered authentic learning because they direct learning through their own curiosity while developing skills necessary to quench their thirst for knowledge. Osborne, Erduran, & Simon (2004) point out that fundamentally, inquiry based leaning through the use of argumentation allows students to distill their processes and thinking through social interaction and inquiry, thus developing a holistic cognitive understanding of how the physical world works and of the epistemic underpinnings of science. When students holistically approach these processes and guidelines, they can be acculturated into the science community by using and internalizing concepts central to the culture of science.

Inquiry presents students with a method of learning and knowing that is derived from experience and allows students to live their education. This form of learning prevents students from uncritically inheriting assumptions others have made about the physical world. As Dewey (1986) notes, “If we see that knowing is not the act of outside spectator but of participator inside the natural and social scene, then the true object of knowledge resides in the consequences of directed action,” (p.157). Inquiry is at the heart of scientific understanding, whether it be in the laboratory, where the direction of scientists that came before leads the way to new action, or in the classroom, where the teacher facilitates participation in inquiry activities in which scientific epistemologies are used to create knowledge. Each experience allows the learner to see the world in a new way and to build on what has come before. As Dewey (1938, 1998) stated, “Every experience enacted and undergone modifies the one who acts and undergoes, while this modification affects…the quality of subsequent experiences,” (p. 26).

Dewey (1897) also spoke of the social nature of learning when he stated that, “the only true education comes though the stimulation of the child’s powers by the demands of the social situations in which he finds himself,” (p. 77). Dewey relates this to two sides in education: the psychological and the sociological. Learning and knowledge are contextualized as a product of social and cultural environments in which education occurs. The values of society influence the terms of accepted knowledge. Vygotsky also approaches the social nature of learning as he detailed it to be a culturally mediated process in which social learning leads to higher order thinking skills.

Newton, Driver, & Osborne (2010) point out that science itself is a specific way of doing things and thinking about the physical world. They suggest a theoretical point of view that places argumentation, and the inquiry that must accompany it, in the center of the science curriculum. Using inquiry to create a holistic learning environment, Newton, Driver, & Osborne (2010) propose that argument and argumentation are the best way for students to approach science in order to actualize an authentic scientific experience. As stated, “Argument is central to the philosophy of science,” and “At an institutional level, argument is manifest in the establishment of scientific knowledge,” (p. 555). The way to learn science is to do science; and the way that science is done is through argumentation. In science we seek empirical evidence through experimentation and observation, but the real work of building understanding and explanation of the physical world is done through argumentation.

It is in physical exploration through experience that mental acuity is attained in a way most similar to the authentic practice of science. Experiential education gives students some power over their own education, an idea that is reminiscent of Foucault's (1980) ideas about power and knowledge. Power relationships are important in education. Classrooms in which the teacher has the power and children are agents to receive knowledge, lack authentic learning. When students develop power and interest while sharing in education, they are engaged and ready knowledge creators. Argumentation in education has the potential to give students power while promoting the idea of experience in education. Research has shown that students who actively participate in experiential science learning, such as argumentation, reach higher levels of cognition of the methodologies and content of the argument (Cavagnetto, 2010; Kuhn & Crowell, 2011; Kuhn & Udell, 2003).

Limitations in actualizing inquiry approaches in science include the constraints of the extended time and amounts materials this type of education requires. Ford (2008) posits that it is not plausible to teach all content through the practice of argumentation. When inquiry is distilled to its essence one might argue that practice in thinking could increase abilities at such tasks and that all of the time and materials are not necessary in a multiple learning situations. Research shows that greater time spent thinking about the same things does not necessarily lead to mastery and instead can lead to misconceptions (Kuhn, Shaw, & Felton, 1997). In order to combat these possible limitations, I will set up as many argumentative situations as possible during the single unit in which students will be learning about argument. Students will work with multiple hands-on lab sessions, and will watch instructional lecture based videos at home as homework in order to allow for more time for activities in class.

Social Interaction and Language

The socio-cultural/socio-linguistic view of knowledge creation is another framework that buttresses research in science learning. Argumentation is a social activity and seeing it as such, and therefore valuable for learning, supports scientific argumentation and its use in the science classroom. Vygotsky's ideas have helped up to better understand the social aspects of learning and social construction of knowledge.

Vygotsky (1978) saw the idea of social interaction as key to the learning process. He detailed the Zone of Proximal Development (ZPD) in which the learner should be working and experiencing education at a level that is just above where they are cognitively at the time. He explained that students, when learning tasks and functions, "can perform under guidance, in groups, and in collaboration with one another that which they have not mastered independently," (Vygotsky, 1978, p. 87). The concept of the ZPD is linked to key notions prominent in science education and research. One practice, scaffolding techniques, is seen in many examples of science education research (e.g. Schwarz, Neuman, & Ilya, 2003; Hand, Wallace, & Yang, 2004; Chin & Osborn, 2010; Evagorou & Osborn, 2013). In scaffolding, students are assisted using worksheets, teacher assistance, peer assistance, or computer programs to complete tasks that they might not be cognitively ready to complete. Scaffolding gives students practical experience in completing tasks and is a commonly accepted way to assist the learner in: becoming independent, learning concepts that underlie tasks, and relating ideas cognitively to what they already know. Scaffolding is used by researchers and in the teaching of argumentation to assist students in taking part on argumentative practices as they learn on a holistic level through social interaction.

According to Lemke (1990), “Any particular concept or idea makes sense only in terms of the relationships it has to other concepts or ideas,” (p. ix). In order to learn something new, students need something to relate it to. Scaffolding can help students to use the background that they have and connect it to new learning. Piaget (1952) suggested that learners develop schema when they internalize new conceptual understandings. It is schema that allows them to make sense of other new ideas. This relates to the concept of background knowledge, although schema is a more complex idea concerning frameworks for understanding, which some researchers posit is necessary in order to create suitable arguments (Osborne et al., 2004; Cavgnetto, Hand, & Norton-Meier, 2010). Lemke (1990) shows that the continued acquisition of thematic understandings in a “family” of concepts allows students to understand more of the language of science that they are using. The relationships between different semantic relationships can be highlighted more quickly as students understand the familial connections between concepts. The development of these understandings is the background knowledge and schema that students need in order to understand scientific theories and laws in their appropriate context. Asserting the fundamental social nature of learning, Vygotsky (1978) elucidated that, “human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them,” (p. 88). Group discussions in argumentation are social learning activities where students exhibit intellectual growth (Albe, 2007; Mason 1998; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Felton 2003; Evagorou & Osborn, 2013). The concept of the social nature of learning supports the use of group discussion and dyadic conversation related to constructing argument and detailing ideas. As part of the ZPD, members of groups can help elevate each other to higher levels of learning, as some members will be at different levels of cognition of the material of study.

In order to structure research that engages development of argumentation and science knowledge, scaffolds afford the researcher a shorter time table in which to implement small scale research. The social nature of the ZPD supports the influence of sociolinguistic thought and practice in learning, thereby opening doors for researchers to evaluate how students internalize what they experience through external speech and activity. Some research, however, has raised concerns about social learning as students do not always seem to transfer group understandings into their own conceptual knowledge (Sampson & Clark, 2008; Kuhn & Crowell, 2011). Also, the students who work through scaffolded research lessons may not be internalizing the processes and their underlying concepts as much as may be hoped, an aspect that needs to be considered in examining research results. Sandoval and Millwood (2005) noticed in their research that students seemed to follow the scaffolds somewhat mechanically, not necessarily comprehending what they were doing. Research results must be considered in light of the challenge of really not knowing whether or not students are internalizing the conceptual nature of argumentation.

With a socio-linguistic framework, learning is viewed as not only a social activity, but also as one that is predicated on language use and understanding (Lemke, 1990; Cavagnetto 2010; Kelly & Takao, 2002). Vygotsky (1962) framed the basis for a socio-linguistic view of learning as he outlined links between development of language and concurrent internalization of conceptual understandings. The formation of a concept in the mind is a collective task of which language is pivotal. “This operation is guided by the use of words as the means of actively centering attention, of abstracting certain traits, synthesizing them, symbolizing them by a sign,” (Vygotsky, 1962, p. 81). Students' active use of language and its symbolic nature allows them to create new schema and conceptual understanding. In focusing more on language, Lemke (1990) examines the meaning-making processes people go through when learning new concepts. Language is a basic means for learning and constructing of knowledge. Language promotes the negotiation of meaning by facilitating exploration of the relation between symbols and concepts. Symbols permit us to manipulate concepts in a way they can be understood. Discourse among humans allows ideas to be internalized through both external and internal language. Language and its use are integral parts of the learning process, as language, thought, and knowledge are inseparable (Osborne, 2010). In argumentation and science research, the study of language and its relation to science understanding and argumentative discourse has become increasingly popular (Cavgnetto et al., 2010; Osborne et al., 2004; Mason, 1998).

Language, and its integral relation to learning, is fundamental to argumentation. The idea that argumentation is a process through which language is used to construct competing stances and their supportive evidence, uses language as a learning practice. Lemke (1990) links the specific language of science to the meaning making that takes place in scientific discourse. In order to understand science, one must speak science. Argumentation is a significant part of the language of science and to argue a science topic or concept, one must use specific scientific language. As that scientific language is used through the social interaction of scientific argumentation, deeper meaning and understanding takes place. The internalization of content and the semantics of science progress as one argues a scientific claim. The arguer is immersed in the attitude of science, the social interaction of science, and the values that scientists hold.

An analysis of the specific language of argumentative discourse offers researchers understanding of thought processes of the learner while it allows structural analysis of arguments and reasoning patterns. I will facilitate the class discussions and monitor small group and paired discourse to focus on language as a descriptor of reasoning within the arguments. I will guide students to use specific scientific language and detail in their speech. I will ensure the inclusion of the language of science within the practice of scientific argumentation. The use of the scaffolds and constant explanation by students will also highlight their level of understanding of topics and argument and show if they are "following the scaffold" or thinking for themselves.

The Work of Scientists (Constructivism)

A fundamental belief in the field of argumentation research is that acts of critical discourse along with dialectic (argumentative logic) and dialogic (discourse or discussion) interactions are the ways in which scientists create knowledge. Kuhn (1962) detailed scientific knowledge creation and its use of argumentation. Science is a particular culture and to truly know how to work, think, and learn as scientists do, it is necessary to be acculturated into the community (Ford 2008, Driver, Newton, & Osborn, 2000). Research done about argumentation in science education is based on a framework stating scientists construct knowledge through social interaction and argumentation within the science community.

Acculturation into the constructivist methodologies of scientists is seen as the best way to teach science processes and understandings to students. Jimenez-Aleixandre and Erduran (2008) refer to a cognitive apprenticeship in which the student learns the epistemic nature and processes of the scientific world through experiencing it. This methodology develops critical thinking and metacognitive skills for students in the same manner they are developed and used by scientists (Bottcher & Meisart, 2010; Cavagnetto, 2010).   Thus, researchers use frameworks consisting of the social construction of knowledge modified for their specific cases. Some methods used to promote social interaction and qualities of scientific discourse include: large or small group discussion, computer assisted discussion, paired discussion, or the creation of argument on an individual basis for the purpose of convincing others.

The framework of social constructivism is not disputed in current research and allows for those in the field to observe development of true scientific discourse and monitor understanding of the culture of science. However, Ford (2008) suggests constructivist methods may not be plausible for teaching large amounts of science content knowledge within the school setting. He theorizes that it is not possible to learn all that is needed strictly through inquiry methods and argumentation as they are not a complete match to how scientists learn all they know about science. Scientists read and learn what those who have come before them have determined through the techniques of constructivism described here, and as such, teaching through wholly constructivist methods is not a thoroughly truthful representation of scientific learning. It is because of the culture of the scientific community, the trust that they place in their methods, and the fact that they are accountable to each other and their community, that previous theories are accepted and used as a basis for further work (Ford 2008).

Structure and Processes of Argumentation

The basic frameworks used to analyze the structure of arguments come from two fundamental sources. Toulmin (1958, 2003) makes a case for the environment in which an argument is generated and the mental state of the arguer. He makes reference to the power of words and the ways in which language is used in argumentation to allow for the structure and force of an argument. He is also clear that one must admit to the possibility of alternatives in order for it to be considered an argument. This is an important point for defining the argumentation process at its basis, especially with regard to scientific argumentation (Driver, Newton, and Osborn, 2000). The details of specific structural pieces that make up an argument are the most used portions of Toulmin's conceptual framework for argument. Multiple researchers use Toulmin's argumentation structure in order to analyze the quality of arguments created by students (Zohar & Nemet 2002; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Maloney & Simon, 2006). Toulmin espouses the structure of an argument to include: an assertion that gives a position, a claim that supports that assertion, data to support the claim, warrants to show how the data can lead to the claim, backing to the warrants that show why they are legitimate, and qualifiers that may be necessary to express what situations and conclusions the argument is valid with. Qualifiers may contain rebuttals that would show cases and situations where the claim itself would not be warranted.

The framework as outlined by Toulmin is one that is good for looking solely at the structure of the argument. Arguments can be evaluated with regard to the way they are put together and the inclusion of their necessary parts. The ability to create an argument and the presence of arguments in dialogical interaction can be measured within a framework drawing on Toulmin's conceptual basis. Some researchers (Kelly & Takao 2002; Takao & Kelly 2003; Duschl, 2007; Erduran, Simon, & Osborne, 2004) have concerns with how to examine counterclaims and lines of reasoning within an argumentation analysis based solely on structure. An analysis using a Toulmin-based framework is quantitative in nature as it seeks to locate the presence of certain structural parts of an argument and their prevalence therein. Toulmin's framework exhibits weaknesses in examining the reasoning and critical nature of the arguments formed.

Walton (1996) asserts a framework that looks at the presumptive reasoning patterns that comprise arguments. He is concerned with the reasonable nature and effectiveness of arguments. Researchers must be able to assess the reasoning through which an argument accomplishes its goal of persuasion. Walton outlines twenty-five main argument schemes and provides critical questions in order to aid in deriving an argument's purpose, reasoning, and effective premises. A researcher using Walton's reasoning bases for arguments can elucidate lines of reasoning and justifications students use in their arguments (Kelly & Takao, 2002; Takao & Kelly, 2003; Kuhn & Crowell, 2011). Kelly and Takao (2002) have developed a framework that deals with the epistemic levels of argument that rates the support an argument has and its scientific basis as its justification for reasoning. Epistemic levels begin with what are considered low quality arguments containing only data as support for claims, and continue to high epistemic level claims that use predominantly theory as their basis.

There are benefits to the use of reasoning as a basis for analyzing arguments. If the argumentative process is meant to instill the art of reasoning and critical thinking in students, then this framework will highlight those qualities. Walton's theories underpin the basis for frameworks that can detect and evaluate those skills as a main focus of science education. However, the nature of reasoning is qualitative at its base and could lead to difficulties in the analysis of arguments among different researchers and across different projects. Interrater reliability can be an issue in the analysis of reasoning. With more than one person conducting analysis, it is necessary to discuss differences in rating and come to a consensus based on argumentative theory and an understanding of argumentative reasoning as well as argumentation as a concept. Another issue is the need to construct individual frameworks for each study rather than having a basic outline for use across multiple sets of research that could yield more comparable results. The need to make the framework fit the unique reasoning warranted for each argumentative situation makes this a tedious style of analysis that is not universal in nature.

Some researchers, in an attempt to analyze arguments more thoroughly, have developed frameworks that include pieces of both main conceptual frameworks (Schwartz et al., 2003). In situations where the competence and growth of argumentation skill is the focus of research, a combined framework that includes the conceptual bases from both Toulmin and Walton would allow a researcher to highlight specific gains in total argumentative competence and ability and would give the researcher a more complete view of how the learner progresses, and the full nature of the augments produced. The fundamental issues with an examination of the presumptive reasoning qualities of an argument and the individual nature of each argumentative situation would still be relevant within a combination framework.

My Theoretical Framework

I situate myself in a theoretical framework that seeks to further understand argumentation not only as the practical methodology of scientists as they work to create knowledge in the scientific community, but both as a reasoning tool and a pedagogical tool for the science classroom. Teaching argumentation in the science classroom begins with accepting the ideas of Kuhn (1962) as he outlines the tenets of how scientific knowledge is created. There is a culture of scientific thought and practice that promotes social creation of knowledge through empirical research, followed by theory development, and then communication and argument through which theories are altered and made more precise until the best possible explanation of the natural world is decided upon. In order to teach scientific thought, reasoning, and process to students, the practice of argumentation and the acculturation of students into scientific epistemology must take place (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Driver et al., 2000; Duschl & Osborne, 2002; Erduran et.al., 2004; Ford, 2008; Cavagnetto, 2010). There is no reason to dispute the bases for these ideas within accepted theoretical frameworks that have been used within the community of research on the ideas of argumentation in science education.

Defining and Evaluating Argument and Argumentation

Foremost in the discussion of arguments and argumentation is a distinction that must be made between the ideas of argument and opinion. Kuhn (1991) succinctly illustrates the fact that an argument and an opinion are not the same thing. In fact, essentially, the morals, and belief systems of an opinion should be separate from the reasoning and fact basis of a scientific argument. When these are not separated, the scientific argument is less valid and cannot be supported by reasoning. This is why the support for a claim, based in data, observation, and scientific theory, is pivotal to a scientific argument's progression throughout the act of argumentation.

Scientific arguments created in the classroom must be assessed through a holistic view based on both structure and reasoning. As Toulmin (1958) posits, the structure of an argument has multiple salient features that should be examined. Walton (1996) suggests that the lines of reasoning and whether they create a valid argument regarding the science must also be examined. These both must be made very clear and concise. An argument can be examined based on its claims, supporting data and theory, structure of presentation, and lines of reasoning that connect these ideas together (Berland & Reiser, 2008; McNeill , 2008; Sampson & Clark, 2008). Sampson and Clark (2008) label reasoning as a combination of warrants and backing from a Toulmin based scheme. These should be considered at the epistemic level. An argument evaluated on this level should be scrutinized as to the ways in which data are used alone or in conjunction with theory in order to support the claim. Kelly and Takao (2002) have a quantitative scheme evaluating arguments on this level through a hierarchical model that places basic data used in support at the bottom and theory-based support at the top. A model that places more emphasis on theory interwoven with the data in order to make the argument more concrete would align better with the goal of persuasion. Therefore, a refinement of this idea should include data alone at the bottom, theory alone in a higher position, and a combination of the two near the top as this is a more analytical level of thinking. The inclusion of both theory and data shows an understanding of how they fit together within science. Knowledge construction in science is based on support from proven theories but also grounded in the data that can be observed empirically.

There is a difference between the argument as a construct and argumentation as the process in which arguments are constructed (Jimenez-Aleixandre & Erduran, 2008; Bottcher & Meisert, 2010; Nielson, 2011). Argumentation itself is the creation of the argument, as in the above, however it includes the presence of a counterargument as an opposing viewpoint and the social actions of counterclaims and rebuttals. Without the presence of these elements, there has merely been a presentation of views or perhaps a discussion. These ingredients are definitive parts of argumentation. Walton (1989) noted the idea of an argument is to bolster a position by getting an opponent to agree that some parts of the position are valid and at the same time to undermine the other position. It is through rebuttals and counterclaims that this happens. The process of argumentation can be followed through utterances that make up this dialogical scenario and thus purposeful remarks made should be analyzed and scrutinized both for effectiveness and improvement in methodology over time.

The process of argumentation adds an element to the reasoning that is involved in creating arguments. In order to develop quality rebuttals and counterclaims, one must evaluate the opposing viewpoint. For this, one must examine the basis of the argument, its reasoning, and support. Knowledge is fashioned and scrutinized through the examination of opposing argument and construction of each individual argument. Thinking and reasoning used to develop argument along with the argumentative process are practiced simultaneously so those skills and mental acuities see greater development. The power of argumentation as an educative tool lies in thinking and reasoning skills, the acculturation of students into the world of science, and knowledge that can be produced and solidified therein.

Argumentation in School

The classroom environment must be conducive to discussion for argumentative practices to flourish (Mercer, 1999; Osborne et.al., 2004; Jimenez-Aleixandre, 2002).   Multiple approaches to teaching and learning argumentation, the content that helps this process, and the content that can be gained exist. To move forward with the use of argumentation in school, one must further develop ideas that have been successful with educational practices and benefits. The ways in which scientific argumentation is taught, the knowledge it seeks to impart, and the separation of social and rhetorical development are areas critical for these changes.

Teaching argumentation has been approached both using scaffolding techniques (Schwarz et.al., 2003; Sandoval & Reiser, 2004; Sandoval & Millwood,2005; Evagorou & Osborn, 2013) and explicit teaching (Zohar & Nemet 2002; Schwarz et al., 2003; Chin & Osborne, 2010). Although each strategy has been shown to create some increase in argumentative practice and understanding, it seems clear that a combination of the two in a holistic process would lead to greater gains.

Dewey (1902, 2010) saw education as a process of holistic learning experiences in which the child is engulfed into a process and thereby learns the pieces as they fit together rather than learning individual pieces and later fitting them together. At the same time, Newton, Driver, &

Osborne (1999) assert that argument is fundamental to the very essence of science and scientific thought. As a scientist, the understanding that one has affects every action in the process of marrying observation, theory, evidence, and argument. Science can be understood and taught best through the immersion in scientific thought and practice through the process of argumentation. Teaching argumentation can proceed through immersion in which scaffolds allow for the development of arguments and lessons are designed in a way that elicits questions as to the purpose and culture of argumentation, science, and knowledge creation. . This can also be accomplished by developing lessons that reproduce the methods, arguments, and cultural situations surrounding the acceptance of trusted theories and ideas. Experiencing the historical versions of scientific argumentation and being acculturated into its processes would take place through the reading of non-fictional accounts, teacher modeling, and also through whole class or small group role play.

Within this framework, scientific argumentation is not only taught as a process used in the culture of science and creation of knowledge, but teaching itself is used to help develop content of scientific theory and understanding which can then be used for argumentation. Content knowledge of scientific theory and understanding is necessary to create quality arguments when science is the topic (Osborn, Erduran & Simon, 2004). The holistic teaching of scientific argumentation perpetuates itself and provides structure and support for the learner to acquire multiple aspects of science and argumentation concurrently. This immersion would lead to more positive outcomes and be more indicative of how scientists learn their craft. Also, content of science standards and the argumentative process can be taught synchronously. Therefore, time that might have previously been devoted to the sole teaching of argumentation or the use of argument to solidify content knowledge can be used to create content knowledge and learn epistemic scientific concepts.

It is necessary to take a different approach to qualitatively assessing the internal processes of social interactions and rhetorical creation of arguments than that which has dominated the research to date in the area. Developments in the socio-linguistic area of analyzing students' speech patterns within discussion and writing are thorough and reflect sound theoretical foundation. . In order to understand students' motivation, as well as the level of comprehension of scientific ideas they are developing through the argumentative sessions, it is necessary to look at the language used in the construction of those arguments. Lemke (1990) posits that the basis of understanding and communication within a field centers on the language of that field. The process of using specific scientific language and translating it back and forth from the scientific language necessary to communicate specific science understandings to the colloquial language of the student can elucidate the process of internalizing content. This can be done through a scaffolded worksheet that would serve two purposes. First, it would allow for the students to help themselves to develop the kinds of talk that are needed to create quality arguments. Second, this would give the researcher insight into motivations of students' speech and where they see themselves within the learning process of argumentation. This will offer a glimpse into the workings of the student mind and how well they are internalizing the argument, content, and acculturation into scientific thinking.

Using this theoretical framework in conjunction with and in opposition to frameworks and processes already being incorporated into research within the field will allow further steps to be taken towards understanding the place, development, and student views of argumentation in the science classroom. The theoretical framework can be used to guide the construction of research and the development of analytical frameworks to discern the learning of students and the practice of the research techniques in the field.

Building on the theoretical ideas I have presented in this chapter, I developed a study that used explicit instruction in the concept of argument to help develop argumentative skill. In addition, the study focused on developing specific scientific knowledge and understanding through argumentative discourse, which took place through multiple opportunities to research specific electricity and magnetism topic and create an argument based on a claim relating to that topic. Students had opportunities to think critically, speak and write using scientific knowledge and understanding, and apply what they learned to solving problems. In the following chapter, I provide a detailed description of the methodology I used to conduct this study.

CHAPTER 3

METHOD

In the realm of research in the field of argumentation in science education, there have been the aforementioned theoretical approaches developed by researchers and philosophers working in the field of argumentation as well as in education. Working within those theoretical guidelines and bases, researchers have developed multiple methodological approaches in order to further the knowledge in the field and at the same time, to develop the idea of argumentation as it can be used within science education. In examining these methodological approaches to researching argumentation, there are some parts of the field that are accepted and used by multiple researchers and there are parts of the research and analysis process which are still being developed in order to obtain results that can be informative and move the field forward. In the following, a systematic analysis will highlight both positive aspects of methods used in the field and some drawbacks or room for improvement. This examination spans the context of the research, the subject matter in which argumentation is researched, the ways in which argumentation is presented, student groupings, materials used, data collection, and analysis methods. Along with this I detail a methodological approach that suggests ways to move forward in the field.

Methodological Approaches to Research In Argumentation Education

Context of Experiments

The context of a research experiment in education is very important to knowledge that it can provide to other researchers, educators, and to the body of knowledge to which research is contributing. For the purposes here, context includes the institution in which research takes place, participants, sample choices, length of study, and structure of intervention. A complex picture appears when looking at such a large group of factors, however many factors relate to each other and there are few variances in some.

Institution

In the past, research was often conducted in "controlled" environments, such as Dewey's learning labs. More recent research has been conducted in informal settings, which are more like real-world situations. These newer style studies develop a clearer picture of how interventions work in a regular environment. Most current research in the field takes place in formal learning environments where the subjects of research have been enrolled for at least some period of time preceding the research study. Research that takes place within the child's normal school activities is optimal for specific reasons. Glaser and Strauss (2008) state that conditions in which research takes place are pivotal to its results. This is due to the emotional actions, interactions, and reactions that will take place in the environment. The learning environment in which students have been accustomed is important to keeping their actions and reactions normative. Mason (2002) asserts that the conditions of research and the subjects therein should be relative to the research questions and practical in terms of the environment for which the knowledge created will serve. A normalized environment in which students are comfortable with both the people and setting lowers the risk of new environmental influences. Work in this normalized environment is a necessity.

The necessity of keeping the child in their natural learning environment also leads to inhibiting factors for researchers. When in the regular classroom, multiple influences that impact participants are out of researchers' control. Many of these factors include: other students creating off-task behavior (Cavgnetto, Hand, & Norton-Meier 2010; Osborne, Erduran, & Simon, 2004), scheduling conflicts in the school day, standardized testing, school holidays/vacations that inhibit lessons and continuity of interventions (Kuhn & Udell, 2003), and differences in the way teachers approach teaching and learning pedagogy (Osborne, Erduran, & Simon, 2004). Factors that are out of the control of researchers can make it difficult to examine results and indicate with confidence those results which can be attributed to and what factors outside the observed variables could account for results. One way to mitigate those factors could be for teacher-researchers to conduct action research within their own classrooms. Although this is not a common occurrence in the field currently, a teacher in their own classroom understands both the environment and the students and can thus design research that accounts for many circumstances and would have a better chance of measuring what the researcher desires to measure.

In my study, I addressed this issue of institutional setting by conducting research in my own classroom. This classroom was a regular education classroom in an average Title I school. As the research was conducted late in the school year, the students were comfortable with the environment and with me as their teacher, and thus could be expected to perform as they usually would on their assignments.

Participants

All scholastic levels are represented in current research on argumentation. Each grade level has benefits and drawbacks for research design. Research done in elementary schools has focused on fifth grade students, who are ten to eleven years old, and typically has questions about natural instincts for arguing and developing these through scaffolding techniques (Cavgnetto et al., 2010; Mason, 1998; Simon, Johnson, Cavellt, & Parsons, 2012). Benefits of working with this age group include: students are not enculturated completely into a specific experience of school and their ideas about school and the way they learn can be more easily molded. At the elementary level, students may see changes in teaching as more fun and could follow these changes with less trepidation. However, attempts to develop more abstract concepts surrounding the nature of science may not be suitable at this age.

Research in middle grades tends to center on interventions designed to teach the art of scientific argumentation specifically (Osborne et al., 2004). This is either done with explicit instruction of scientific argumentation or with the use of scaffolding (Chin & Osborne, 2010; Kuhn & Udell, 2003). There is minimal research on teaching the nature of science. These students are able to comprehend and internalize functions of argument in relation to science and can begin to think about justification and evidence through more abstract theory. Examining this context allows researchers to see the emergence of abstract thought.

Research done with high school and college students deals with scaffolding techniques and some explicit instruction to aid students in developing arguments and promote discourse (Sampson & Clark, 2008; Cross, Taasoobshirazi, Hendricks, & Hickey, 2008), production of argumentation and epistemologically sound scientific inquiry through immersion in authentic inquiry situations (Jimenez-Aleixandre , 2002; Sandoval & Millwood, 2005), and assessments of arguments students produce without intervention and only the knowledge base they have acquired through their schooling (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Kelly and Takao 2002). This level of student is advanced enough cognitively to embrace the full nature of scientific argumentation at its epistemological basis. Issues that arise with research in these age groups concern students trying to get work done and “Doing the Lesson” (Jimenez-Aleixandre et al., 2000) as they usually do rather than participating whole-heartedly in the argumentative task and interventions.

In my study, I addressed this issue of the age of participants by using my own middle grades classroom. Students in this level have not fully developed their approach to persuasive and argumentative writing, so I can have a greater effect on their development in those fields. These students are becoming capable of abstract thought and thus can use and develop critical thinking and argumentative prowess. My students can use scaffolds, yet still look to me for explanation and assistance, so I can be more confident that they will develop the understandings that I want them to and not just "do the lesson."

Sampling

Size and makeup of samples involved in research projects have influence on validity, reproducibility, and generalizability of knowledge gained from the work (Corbin & Strauss, 2008; Mason, 2002; Wertz, Charmaz, McMullen, Josselson, Anderson, & McSpadden, 2011). Demographics researched in the field include multiple countries with a focus in Western Europe (Jimenez-Aleixandre et.al., 2000; Osborne, Erduran, & Simon, 2004) and the United States (Cavgnetto et al., 2010; Kelly and Takao, 2002). Classrooms are often diverse in middle to low socio-economic communities (Kuhn & Crowell, 2011; Zohar & Nemet, 2001). There is a focus on the average child in a diverse world. There are some examples of homogenous classrooms (Mason, 1998) and private schools with higher SES students (Evagorou & Osborn, 2013). Variations in demographics are necessary to generalize results to the larger population which is the focus of the research (Mason, 2002).

Size of the samples used in research is not normative. Samples range from a group or two within a classroom to whole grade levels at a school, and even venturing to multiple classrooms from multiple schools. Corbin and Strauss (2008) and Mason (2002) hypothesize that the size of the sample is related to information that is to be ascertained, analysis that will be done, resources of the researcher, and ability of the sample to be representative of the greater population. In cases when the goal is to analyze in-depth the practices of a group and their specific products without comparison with other groups, sample size can be small and in a multitude of cases, it is (Evagorou & Osborn, 2013; Kelly & Chen, 1999; Jimenez-Aleixandre et.al., 2000; Mason, 1998). Small sample sizes are a good methodological choice when seeking to look deeply into the practices of students in an environment to determine their motivations and practices. In these cases, the results of scaffolds and interventions on a small scale can be more closely examined with regard to what they produce from individuals and small groups. Issues with this size of sample are: this sampling size does not generalize to a larger population easily and results can easily be skewed by the performance of a few participants.

In examples of comparative research, larger sample sizes including multiple classrooms (Zohar & Nemet, 2001), multiple schools (Kuhn & Udell, 2003; McNeill, 2008), and entire grade levels are more common (Hand, Wallace, & Yang, 2004). These larger sample sizes incorporate more students into the sample to make it more representative of the average student, make it easier to compare groups of students receiving different treatments within interventions and studies, and to determine causality (Mason, 1998). Analysis is often more difficult when greater numbers are present. The amount of data that is generated can be overwhelming, as exhaustive data is desirable for sufficiently developed theory and knowledge (Corbin & Strauss, 2008). Large amounts of data often take more time to analyze, and may also require more complex analysis schemes to derive causality from multitudes of sources.

In the current study, I addressed the issue of sampling by using my entire team of students as a participant pool. I was able to teach all students in the same way without regard to their participation in the research. Students were not specifically selected, but were given the opportunity to have their products used as data for the research. The team of students was representative of the school itself and much of the school system. The sample was somewhat diverse with regard to gender and ethnicity. The participant group contained 4 boys and 12 girls. The ethnic breakdown was 5 African-American, 8 Hispanic, 1 White, and 2 Bosnian.

Student Grouping

Student grouping for discourse events is a varied area of methodology in the research. There are instances of whole class discussions and also small groups. In small groupings, there is a tendency to examine dyads, triads, and groups of four, while whole-class discussions usually take place afterwards to debrief and compare what has happened in small groups (Evagorou & Osborn, 2013; Jimenez-Aleixandre et al., 2000; Osborne et al., 2004). Grouping of students in dyads is good because of the ability to pair students with a person of an opposite position to fuel argument and opposition (Felton & Kuhn, 2001), as opposition has been shown to create higher quality argument (Clark & Sampson, 2007). Dyads also allow the researcher to better trace contributions of each student more efficiently. Also, pairs can be combined into groups of four to further the discussion (Cross et al., 2008). A downfall of using two person groupings is that sometimes the amount of discourse is limited because of limited amounts of input available from only two people (Albe, 2007). Triads make sure everyone is either discussing or listening to what is being discussed (Schwarz, Neuman & Ilya, 2003). Three person groups can have issues sustaining a discussion in similar fashion to the pairs and one member may feel outnumbered. Maloney and Simon (2006) detail that in four person groups, the expectation is that all students will have a chance to discuss and there is a likelihood that multiple points of view will be represented. Groups are not too big so everyone's voice can be heard and it allows for equal representation of two sides or two demographics. A downside to this grouping is the group may split into two separate conversations and lose focus.

Grouping students by gender has been shown to affect productivity (Sampson & Clark, 2008). Homogenous teams may be better for the comfort level of students involved in some cases. Many studies group students in mixed ability levels as it is indicative of students who make up classes (Zohar & Nemet, 2001). However, homogenous ability groups examine the specific ability ranges (Maloney & Simon, 2006) and determine if all students can be successful at argumentation practices and use high levels of reasoning. Use of homogeneous groupings is rare and generally serves a specific purpose, as with these groups some normal interactions of a classroom and a society are missed.

In considering the question of student grouping in the current study, I decided to use multiple grouping arrangements to get as many benefits as possible for the students. Students worked individually at first so they could see where they stood on their own. Then they progressed into pairs or groups of three. Students participated in class discussions and they also worked in small oppositional based groups to see multiple sides of an argument and develop counterarguments with their associated rebuttals.

Subject Matter

There are two main contexts of research regarding the subject matter of argumentation: scientific subject matter and socio-scientific subject matter. Methodologies performed in the context of science knowledge (Kelly & Chen, 1999) and using scientific content (Jimenez-Aleixandre, 2002), teaching materials (Osborne, Erduran, & Simon, 2004), and laboratory work

(Cavgnetto et al., 2010; Kind, Kind, Hofstein, & Wilson, 2011) are a significant portion of the research available. There are strengths to examining argumentation using science as its basis. Scientific argumentation takes place in the context of science, therefore it is preferred to study it therein (Bottcher & Meisart, 2010; Driver, Newton, & Osborn, 2000; Ford, 2008). This context helps to gain an understanding of students' perceptions of the nature of science (Hand et al., 2004; Kaya, Erduran, & Cetin, 2012) and scientific epistemology (Duschl, 2008), that may not otherwise be seen outside of the context. A downfall develops when students with less scientific knowledge have difficulties constructing scientific arguments even while using scaffolding materials (Lawson, 2003; Von Aufschnaiter, Erduran, Osborne, & Simon, 2007). This can hinder the development of argumentation skills and skew results.

Problems eliciting quality argument and teaching argument in the context of science content knowledge are often circumvented by using socio-scientific subject matter. Questions here do not have a factual conclusive answer and thus are well-suited for discussion and argumentation to decide on an outcome or decision (Evagorou & Osborn, 2013). Arguments can be created out of social knowledge and value judgments which students already hold (Albe, 2007; Kolsto, 2006). A benefit to researching in the context of a socio-scientific issue is an increased ability of students to participate in argumentative sequences. Students with little understanding of science content and with little tutelage in the art of argumentation can construct arguments that can be measured according to their adherence to schemes designed to measure argument content and reasoning ability of those arguing (Maloney & Simon, 2006; Osborne et.al., 2004). Without the need for scientific knowledge, argumentation can be studied in a context that is similar to science but does not require the same amount of background teaching to prepare for argument. Downfalls to researching in socio-scientific contexts relate to possible misunderstandings of scientific epistemologies and understandings required to perform true scientific argumentation leading to misconceptions about the nature of science.

When considering the subject matter focus of my student, I decided to focus almost exclusively on specific scientific content. I wanted to gauge whether content can be taught, understood, and applied through the practice of argumentation. Although it has been detailed that socio-scientific topics allow students to argue more effectively, there is often little or no content knowledge applied. This was an unacceptable option for me. There is one scenario in my study that was socio-scientific, but students were required to use electricity and magnetism knowledge in their arguments.

Length of Study

The main periods of time for studies in this field range between one or two units or experiences (Mason, 1998; Zohar & Nemet, 2001) and a year of work (Simon et al., 2006). The shortest of studies is often a non-intervention study in which students are surveyed or observed as they use reasoning ability and discourse practices that they already know (Chin & Osborn, 2010) to gauge the skills that students have. A drawback here is that no materials, teaching methods, or interventions for use in the classroom are examined. Longer studies allow for intervention to have some effect on students' performances. A benefit here is that results are clear sooner and allow researchers to make assertions and influence further research. An issue is that significant changes to thinking and reasoning abilities may not be drastic and thus not easy to determine.

In long term studies materials can be developed, tested, and implemented to develop results. Students can be followed to trace effects of interventions on their modes of thinking and reasoning (Kelly & Chen, 1999; Kuhn & Crowell, 2011). Long studies allow researchers to gather more data over a longer time period. They can implement the same intervention to multiple groups of students as one group leaves for the next grade and a new group comes in (Osborne et al., 2004). Changes can be made and implemented immediately to track their benefits. Obstacles are the time commitment for the researcher and teachers involved and multitudes of data for analysis which can be overwhelming.

In planning the length of study for the current project, I decided to use a unit of study that was particularly long. The unit on electricity and magnetism is generally one of the longest of the year and can last up to six weeks. I wanted to give the students an extended period of time to learn argument and to apply what they learned to the study of electricity and magnetism.

Nature of Intervention

The nature of the intervention used in the classroom to encourage argumentation, teach argumentation, or develop discourse amongst students is important to consider in designing research. Two main categories of interventions occur in the research: scaffolding and explicit teaching. In scaffolding, students are assisted using worksheets (Schwarz et al., 2003), teacher assistance (Osborne et.al., 2004), peer assistance (Evagorou & Osborn, 2013), or computer programs (Sandoval & Millwood, 2005) to work on and complete tasks that they may not have training or full understandings to complete on their own. Scaffolding gives students experience in completing arguments and is used to help students create and sustain discourse. Using scaffolding as an intervention benefits both the students and the researcher. As a researcher is developing materials and practices to help students learn argumentation skills, the examination of benefits from those materials creates desired knowledge. Scaffolds also allow the researcher to examine reasoning levels of students and their argumentative abilities without devoting time to explicit instruction. A downside to using scaffolds as an intervention is that students may depend on them heavily to perform and may not be using as much of their own skill and expertise, providing data that may not show what students are learning about augmentation and the nature of science (Jimenez-Aleixandre et al. 2000). Further, it may not be clear if students can perform without the scaffolds and whether they retain the abilities they gain (Jimenez-Aleixandre, 2002).

Interventions involving explicit teaching of argumentation and reasoning pattern are not as well represented in the field. Explicitly teaching vocabulary along with processes and epistemological considerations can allow students to understand more deeply what they should be doing in the science classroom and why (Chin & Osborne, 2010). Explicit teaching can also involve modeling argumentative discourse. Benefits of explicit teaching as intervention are that students can develop more of a nature of science and epistemology based conceptual foundation for argumentation. Zohar and Nemet (2002), state that an intervention with explicit teaching of general reasoning patterns and argumentation skills allows students to develop both greater skill in argumentation and a greater conceptualization of content knowledge involved. Kuhn and Udell (2003) notice a greater increase in oppositional discussions, which are beneficial in creating better justified arguments with higher levels of reasoning after explicit instruction. A downfall of using explicit teaching of argumentation can be the time it takes to implement lessons that focus less on content and more on technique, taking time away from practice and immersion.

When considering the questions of scaffolding and explicit teaching of argumentation as I designed the current study, I included both explicit teaching of argument and a set of scaffolds that students could use to aid them as they constructed their arguments. The explicit teaching of argument was to help guide students to an understanding of the parts of argument, where they fit, and what their connection to the whole of an argument was. The scaffolds were designed to make use of my expertise when I was not constantly present with an individual or a group of students. These students had used scaffolds before and thus could make good use of the argument scaffolds as they constructed their arguments.

Data Collection Practices in the Research

Data collection practices in the argumentation research to date center on the written works produced by students and the recorded discursive interactions including discussions, argumentative discourse, and group interactions. Each is generally straightforward and most researchers collect their data in similar ways, although there is some variation. In the following paragraphs, I review the different approaches used for data collection and provide a rationale for the research design decisions I made about how I would collect data in the classroom during the study, and which artifacts I would collect. One of the most common forms of written work collected in previous research are pretests and posttests given to students to determine effects of interventions (Cross et al., 2008; Felton, 2003; Kuhn & Udell, 2003; Kuhn, Shaw & Felton, 1997; Zohar & Nemet, 2001). With regard to other written works produced during research sessions, these often consist of scaffolding worksheets (Hand et al., 2004), graphic organizers (Bulgren, Ellis, & Marquis, 2013), argument diagrams (Chin & Osborne, 2010) or graphic representations of students' written arguments (Evagorou & Osborn, 2013; Sampson & Clark, 2008), and essays (Choi, Notebaert, Diaz & Hand, 2008). Most in the field collect all written work to be sorted out and analyzed. There are occasions when only work done on scaffolding sheets or the final argument is collected, but more often all work is gathered.

The benefits to collecting all artifacts, documents, and other written work from an intervention is that a timeline of argument creation, beginning and ending skill of those involved in an intervention, and the full picture of how scaffolds help produce a final argument can be examined. Corbin and Strauss (2008) stress that the quality of materials used in data collection and research determines the quality of results and analysis. To ensure that nothing is missed during analysis, collecting all data is necessary. A downfall to collecting all data from an intervention is the time that it often takes to sort and analyze a multitude of information. This is clearly not a concern for many in the field, as the common practice is to collect all artifacts possible.

Discursive data is transcribed after being audio recorded, video recorded, or both. Overwhelmingly in the field, both whole class and small group discussions are audio recorded and later transcribed. Video-taping can add nuanced interactions, body language, and non-verbal communications not heard on audio. A benefit of collecting audio and video recordings of discourse is the ability to transcribe and keep what happened fresh for researchers. Having a written record of discursive interactions also allows the researcher to more meticulously analyze what has happened in the classroom and allows comparison of multiple discussions they could never witness at the same time on their own. Essentially, audio and videotaping allows the researcher to be in multiple places for longer periods of time and to collect all data that is produced. A downfall of audio and video taping students during research is that subjects may not behave or contribute in that same ways with audio-visual equipment present as they would without it. There could be a negative effect for some students who are not comfortable with such things. In addition, the time commitments involved in transcribing group discussions is great. To transcribe multiple groups could take a tremendous amount of time and thus push back the timetable for research results.

In interviews, data is collected about how students feel concerning discourse and learning (Mason, 1998), motivations and understandings of socio-scientific argument (Jimenez-Aleixandre, 2002), effects of scaffolds on the student's thinking and learning (Hand et al., 2004), to determine ideas and thoughts on the subject matter both before and after argumentative discourse (Kolsto, 2006), and to determine the internalization of topics discussed (Sadler & Donnelly, 2007). Interviews are a way to gather data for analysis in ethnographic studies as well as to be coded for patterns in answers and thinking. Interviewing can be complicated, especially with regard to designing questions that not only seek out the information desired, but also do not lead participants in any particular directions (Rubin & Rubin, 2005). Great care must be taken in interviews to make the subject comfortable and create a relationship which allows him or her to be forthright with thoughts and feelings. In addition, interviewing multiple participants and then transcribing that data can once again be time consuming.

Data collection for studies using ethnographic or case study methodologies generally involves collecting field notes and observational notes. Field notes allow the researcher to detail items that may not be caught on video or audio yet seem important, and are a good way to jot down ideas for analysis and remind the researcher of the situation that led to the idea (Corbin & Strauss, 2008). An external observer not directly involved with the project can also take notes and aid in what the researcher perceives by giving a differing point of reference (Jimenez-Aleixandre, 2002). Extra context and thought that field notes add to analysis of data are additional benefits. A particular downfall of this technique is that sometimes while making notes, other information or happenings can be missed. However, with the video and audio recordings, this is less likely.

When planning the data collection strategies for the current study, I considered this full range of possible approaches. Weighing the various strengths and limitations, I decided to collect all of the products for examination and iterative analysis. In collecting all of the written products, I could see more of the patterns in thinking of each student and compare these to the final product. It would allow insight into the development of the argument throughout the entire process, the ways in which students used the scaffolds, and, how each student applied group interactions to their own work. A teaching journal with field notes was planned as well in order to help with remembering specific interactions and occurrences from the classroom. I decided not to collect audio or video recordings of student argumentative discourse due to the constraints of the school system in which I worked.

Data Analysis Practices in the Research

Data analysis approaches for those researching argumentation, discourse, and reasoning patterns have tended to build off previous successful strategies. Arguments and discourse patterns have been examined quantitatively by assigning them a scaled score to gauge their quality and to see the big picture of their development. Many studies have include analysis based on Toulmin's argument structure concerning the quality of arguments, reasoning patterns students use, discursive operations within groups, and epistemic bases for arguments. These methods have been used to determine quality and level of reasoning, using a scaled score in an effort to measure a change in student reasoning. Qualitatively, researchers have analyzed arguments, students' ideas and thoughts, contributions, reasoning moves, discourse patterns, and the entirety of the classroom situation. This has been done through examining specific speech patterns, entire discursive interactions, episodes of speech, and arguments broken into stems and related turns. Overall, the analysis method has been based on the research questions addressed.

Quantitative Analysis Methods

Analyzing an argument based on Toulmin's design describing the features of argument allows researchers to observe and quantify their presence. This analysis method can be modified by individual researchers to fit their research questions. Using this methodology, an argument can generally be classified as such only when there is a claim with some justification (Zohar & Nemet, 2002). Quality can be assessed in multiple ways. Support for the claim can be quantified by assigning a numerical value to the claim's justification level (Simon et al., 2006; Zohar & Nemet, 2002). An argument can generally be rated as to including no justification, one justification, and multiple justifications. One can also scrutinize the level of evidence to support those justifications. Student's general understanding of the purpose of argument and the basis for claims is examined through this methodology. Unfortunately, these analyses do not examine the reasoning patterns, correctness, or scientific quality of the argument.

Sandoval and Millwood (2005) developed a framework that was content specific that examined scientific accuracy of argument justifications and gauges levels of justification based on theories a claim adheres to. A quantitative score of whether a claim was based within a scientifically accepted content framework was given and then the level of warranting and sufficiency of relevant data was assigned. They looked at level of evidence (none, some, key evidence, full support) to gauge sufficiency of data and also examine the contents of the theory adhered to. Thus a score of argument quality within a specific field of science could be determined. This methodology sought to determine the competency of the arguer in specific content and the level to which they could appropriate content knowledge. This framework was excellent for analyzing changes in content knowledge and the reasoning prowess of the participant.

Some researchers have used all of the qualifications that Toulmin suggests (claim, data, warrant, qualifiers, backing, rebuttal, etc.) to identify pieces of the argument developed, how they align (Jimenez-Aleixandre et.al. 2000) and also to identify scientific knowledge used in each argument part (Jimenez-Aleixandre, 2002). Zohar and Nemet (2002) saw problems in separating warrants and backings from new claims and data that support them and made a case for combining the categories of data, warrants, and backing into a single category called reasoning. This is now widely accepted and used (Erduran et al., 2004; McNeil, 2008; Sampson & Clark, 2008) in an effort to develop categories for the scaled scoring of the arguments students produce. This has lead in many cases to the development of four basic ratings of scientific knowledge inclusion in reasoning to observe student's progress. These levels are based on the inclusion or consideration of: no scientific knowledge, incorrect knowledge, non-specific knowledge, and specific knowledge. With regard to argumentation in science and how it is used to create and defend knowledge, the inclusion of the correct specific knowledge to reason an argument is important. Having a way to quantify this allows researchers a clear assessment of gains students might make. Each preceding framework drawn from this previous research could be used to analyze both scientific and socio-scientific arguments; however, to examine the use of specific scientific knowledge, it may be necessary to develop a study-specific framework to accurately assess the scientific basis of answers. Although these frameworks allow the researcher to examine both written and oral arguments, focusing solely on the reasoning regarding scientific knowledge does not fully weigh the quality of an argument within argumentative discourse.

When using a Toulmin-based scheme to analyze argumentation, it is helpful to quantify arguments in accordance with Kuhn's (1991) ideas regarding quality as concerning ability to rebut an opponent's point of view or argument. Erduran et al. (2004) developed a framework which measured arguments regarding the inclusion of claims and counterclaims, reasoning, and rebuttals. This analysis describes five levels of argumentative quality starting with simple claim v. counterclaim or claim v. claim (with non-related claims and counterclaims rated lower than related ones) and continuing through the addition of reasoning (data, warrants, or backing), then adding rebuttals, and finally ending at the highest level of argumentation in which there is an extended argument with multiple rebuttals. This methodology is the most common in the field regarding quantitative analysis of argumentation. Once again, this analysis can track changes in the level of an argument through an intervention and gauge improvements in skill. This framework can be used in both socio-scientific and scientific argument analysis; however, it does not allow the researcher to examine the correctness of the argument or the scientific knowledge used therein. Another issue with the preceding methods is that they can be difficult to use for examining a lengthy argument with multiple positions, claims, counterclaims, justifications and data.

Assessing the structural quality, level of reasoning, or quality of argumentation does not address the epistemic levels of an argument which can identify students' understanding of the nature of science. Quantitatively, Kelly and Takeo (2002) and Takao and Kelly (2003) developed a framework which concentrates on the level of evidence used to support arguments based on the scientifically accepted epistemic level of evidence. This can be used to scrutinize the overall level of conceptual and content knowledge which students use in their argument. Evidence is ranked at the lowest level when it is solely data and observation. Moving up in quality, more conceptual justification is added until the highest level of epistemic understanding includes theoretical basis as well. This can be used as a generic framework to assess epistemic understandings students have regarding scientific knowledge and importance placed on specific areas of knowledge. Changes in the participants' conceptions as to the nature of science can be observed through the use of this framework. These understandings are pivotal to basic epistemic understandings of science as the basis for scientific understandings and knowledge creation.

Multiple combinations of these schemas (Choi et al., 2008; Evagorou & Osborn, 2013; Kind et al., 2011; Okumus & Unal, 2012; Sadler & Donnelly, 2007; Zohar & Nemet, 2001) could be used within the same study to develop understandings of all facets of an argument and how it supports claims, persuades through construction of an accurate argument, rebuts the opposing argument, reasons argumentatively and epistemologically, and how these skills change and relate to each other. Software is used to accomplish the task of exposing and analyzing their correlation regarding participants' arguments and argumentative interactions. The benefit that comes from researchers working with and building off of each other is the development of these frameworks that can be used in conjunction with each other. Non-content specific and content specific frameworks can be combined to assess every angle of researchers' questions.

In the present study, I adapted some aspects of quantitative analysis based on the various frameworks described above. Specifically, I chose to numerically rate the arguments that students produced so that a quantitative analysis would show specifically what improvements students made. Arguments were assessed as to their level of content knowledge and as to the appropriate inclusion of the various parts of an argument. For the examination of content knowledge, the scale I used was the following:

1. no electricity and magnetism knowledge
2. incorrect electricity and magnetism knowledge,
3. non-specific electricity and magnetism knowledge or general science knowledge
4. specific and correct electricity and magnetism knowledge

The scale to determine argumentative quality was:

1. claim v claim or counterclaim
2. claim v claim with data
3. claim v claim with data and reasoning (warrants, or backing)
4. claim with data and reasoning and with the occasional weak rebuttal related to a counterargument
5. Extended argument with specific and accurate rebuttal (s) directly related to stated Counterargument

With a numerical score it was possible to determine average scores, standard deviation, numerical quantitative improvements, and to perform a paired analysis.

Qualitative Analysis Methods

Multiple research studies seek to examine discourse in the classroom as it relates to social interaction within argument construction (Mason, 1998), the specific linguistic episodes that occur within the patterns of speech and their function (Chin and Osborn, 2010), interactions with regard to the kinds of talk within discourse (Evagorou & Osborn, 2013), and overall discourse of argumentation (Cavgnetto et al., 2010). For qualitative methods, transcripts of audiotaped discourse are analyzed, sometimes with the help of observational field notes. Throughout most analyses, the transcripts are broken into argument stems and related turns (Clark & Sampson, 2007; Felton, 2003), episodes of speech or utterances (Arvola & Lundergard, 2011; Chin & Osborne, 2010), or argument interactions (Albe, 2007; Evagorou & Osborn, 2013; Von Aufschnaiter et al., 2007). The choice of the unit for analysis concerns the questions that researchers are seeking to answer.

Analysis of transcript data involves coding to determine patterns. Predetermined codes are often used to classify data with regard to reasoning and purpose of speech. Participation and modes of talk are most often examined with predetermined codes of talk which come from linguistic analysis such as Halliday's (1977) functions of language, argumentative analysis, such as Kuhn's (1991) categories of talk, other fields of research, such as when Jimenez-Aleixandre et.al. (2000) apply codes from history and philosophy of science with regard to epistemic levels of speech, or previous research in the field (Cavgnetto et al., 2010; Felton, 2003) which is often a continuation of the same researcher's work. After coding, data can be analyzed to determine levels and occurrences of factors for which the researcher is looking. Predetermined codes take less time to apply as they do not have to be developed and often other researchers have vetted their validity and worth in practice. In using this method researchers are not always open to new and different patterns that may be relevant but not examined by the coding system, and something could be missed. Predetermined codes are restrictive as to what researchers can find in the data.

Iterative development of codes involves developing categories from analysis of transcripts, going back to code data with those codes, and then determining if there is data that does not fit the coding system. Data that does not fit is used to create new codes and then the process is repeated until no new codes are needed (Denzin and Lincoln, 1994; Kuhn et al., 1997). This process allows for analysis and categorization to develop from the data itself, thus it is specific to the research and questions of each study. This method is good for identifying patterns from participants in thinking, argumentative action, and kinds of talk specific to a study. The benefit of iterative coding is categories of analysis come from the experience of participants. Iterative coding can be very time consuming. With regard to validity, checks must be put into place to make sure there is not undue influence from the coder(s) on the data. The categories developed and the coding should be checked by someone outside of the original process to assess the validity and representational ability of the codes developed for the data they serve.

To recognize patterns in data, a grounded theory approach may be used. In grounded theory, patterns in the data are examined through a process similar to iterative coding, but the development of a theory with relational and causal aspects is desired (Wertz et al., 2011). This method is used when a pattern of action or a relationship between functions of language are thought to cause or determine a result or other actions (Chin & Osborn, 2010). Specifically, more than the existence of patterns is desired. As this is similar to iterative coding, the same benefits and drawbacks apply. This is often used in concurrence with a case study approach and is more specific to an individual situation.

Research also shows the presence of ethnographic methods of analysis. Not only does ethnography include being involved with the participants and taking detailed field notes on observations made in the field, but it also works to create dense descriptions and understandings of experiential context by combining the researcher's experience and understanding with that of the participants (Prasad, 2005). In ethnographic analysis data are analyzed closely in alignment with what is known about the field already, the researchers experience in the field, as well as data collected during the research cycle to develop a conception of motivations and understandings which participants hold and develop throughout the research process (Albe, 2007; Cross et al., 2008). A timeline of participation and development can be traced in this way (Kelly & Chen, 1999). Ethnographic research can develop a more thorough understanding of the interactions and motivation participants go though in the cycle of research. With a well-chosen sample, these results can be generalizable. However, this research is time consuming with regard to length of study and time commitment involved for analysis. Researchers must be careful to not interject too much of themselves into the study and let the participants speak for themselves through the data (Prasad, 2005).

Building on this history of qualitative analysis of argumentation in past research, in the present study I chose to approach the written data from students with an iterative analysis to develop patterns in argument as well as patterns in reasoning. Walton (1996) outlined specific argument patterns that were a starting point. I also sought to develop reasoning patterns students used specifically with regard to electricity and magnetism knowledge that they had gained in class. In addition, I decided on a grounded theory approach to examine student interview questions to look for patterns in what students learned, how they approached the unit, what they enjoyed, what they found difficult, and their overall impressions of scientific argumentation. I wanted to develop an understanding of what worked well and what did not, in order to guide an understanding of how to teach argumentation to middle school students.

Mixed Methods Analysis

Maloney and Simon (2006) distinguish the possibility of combining a semi-ethnographic system which also uses coding to show how students approach discussion and to what ends they participate in that discussion. This tactic may be considered an ethnomethodology, as it focuses on speech patterns and actions in a specific situation (Prasad, 2005). Hand, Wallace, & Yang (2004) incorporated a mixed methods design to their study by using both tests of understanding that were quantitatively based and an interpretive approach that attempted to examine the ways in which their participants made meaning from their participation in argumentation. In this approach, they attempted to connect the students' scientific understanding, as scored on the multiple choice test, with the methods used and pedagogical choices made in the classroom. The connections were made through student responses to interview questions. Sadler & Donnely (2007) used a mixed methods study to associate the understanding and morality of their participants, as measured through a quantitative test, with information derived from interviews to determine the connections between the socio-scientific arguments created and the level of understanding and significance of participants' moral stances.

In each of the mixed methods studies, the level of content knowledge was quantified in order to make connections to the arguments produced by participants. Qualitative approaches were often used to develop understandings of motivations and points of view held by participants. Qualitative analyses were developed to attempt to understand how participants equated their understandings and how they developed those understandings through the analysis of patterns in interview answers. Using a mixed methods approach allows for the qualities of each kind of study to inform the collection and analysis of data. They also make full use of all data collected, which is a wise use of time spent in the field. Mixed methods studies also use multiple methods to counteract limitations of some methodologies. Mixed methods approaches allow adding the human connection of argument to the quantitative analysis of the test scores describing understanding of argument, the nature of science, and content knowledge. Through a mixed methods study, the connection between knowledge and understandings can be better developed. It may be possible to detail how the participants came to learn the necessary content knowledge, apply that content knowledge to meaningful contexts, and see what part argumentation played in the process.

Thus, there are many benefits of a mixed method design. Schulenberg (2007) suggests that mixed methods research is the best way to determine the "what, when, how, why, and to what extent," (p. 99) things are happening in a particular situation or experience. With multiple viewpoints, a more thorough analysis of data and the inherent connections within that data is possible. A mixed method approach does have some drawbacks, though. Frankael and Wallen (2006) note that training in both quantitative and qualitative research is necessary for a mixed methods approach. In addition, the extra time necessary to analyze data using both approaches is certainly more than either one individually. In addition, Christ (2014) notes that sometimes, there are conflicts between what the quantitative and qualitative data are telling us from the same study. The very nature of the approach to each kind of data, one with a distant researcher and blind, unbiased samples, and the other with a more immersed, iterative, and close-to-the-data stance can make bringing them together tough for the researcher.

Looking closer at the epistemological differences between qualitative and quantitative data, the struggle to generate good mixed methods research is plain. As Christ (2014) points out, one of the main epistemological beliefs of quantitative data is an outsider's perspective. The participants should not be known and the analysis attempts to be unbiased. There should be clear separation from the control and the experimental participants and strict guidelines should be followed to ensure validity and reliability. Qualitatively, some points are similar, as there is a sincere need for valid and reliable analysis. There may or may not be a separation into control and experimental groups. There may not even be more than one group. Clearly, in qualitative designs the researchers cannot distance themselves from the participants. It is the connection to the participants that helps the researchers to develop their findings. This is one reason why qualitative research is the usual choice for teachers in their own classrooms. It is possible to meld these two methodologies, though. For example, a researcher who knows the participants well can remove identifying characteristics of students when specific quantitative analyses are done. It is also possible to separate the quantitative and qualitative data and analysis throughout the research and bring them together in the search for meaning and findings.

My Methodological Approach

In order to take the field of research a little further in some specific areas, I used the previously stated theoretical framework to design a mixed methods study for my own classroom that could answer the following research questions:

1. What is the overall effect on students' argument creation after being taught the concepts and processes of argumentation explicitly in an 8th grade physical science classroom using multimodal, multimedia, and computer based activities?

2. What is the overall effect on students' argumentative skill, content knowledge, and overall science concept understanding after using an oppositional based approach to argumentation in paired groupings? (focusing on counterarguments and rebuttals)

3. What is the overall effect on students' abilities to use content knowledge to solve problems in which the application of science knowledge to new scenarios is necessary, after being taught using argumentative based instruction and practice?

The focus of these questions was on the effects of teaching argumentation on multiple important aspects of student learning and application of learning. First, I attempted to determine if there can be an overall benefit to explicit instruction of argumentation as a subject, a method of science inquiry, and scientific work as a process. The explicit teaching of argumentation may lead to better technique for the students and a more concrete understanding of the methods of argumentation and their purpose in science. There was also a continuation of some work done in the field based on the idea that using oppositional experiences and ideologies in teaching and using argumentative scenarios leads to higher development of arguments and higher level thinking in constructing arguments. The explicit teaching and use of counterarguments and rebuttals in all argumentative sessions should build argumentative skill throughout the interventions. Finally, the question of whether this would assist students in applying their knowledge to different situations is important to solving scientific problems. The idea is that using their scientific knowledge in a critical way to create and rebut arguments may lead to a more thorough comprehension of that knowledge. The ability to create arguments, counterarguments, and rebuttals affords the student the skill of examining information and problems from multiple angles and thus should allow for the development of better and higher level problem solving skills.

Context of My Research

This study was in the context of my own eighth grade physical science classroom. This classroom was in a suburban area near a major city in the Southeastern United States. The area is ethnically and socially diverse with a population consisting of 43% African-American, 30% Hispanic, 16% White, 7% Asian, and 4% either mixed or other races. The school was a Title I school in which 80% of the students qualify for free or reduced lunch. The school fell in the median of the Title I schools in the county as far as achievement scores on science standardized tests. Teams were organized into groups of four teachers who each have roughly thirty students in their classes. This equated to a team of one hundred and twenty students. Students for each team were chosen randomly by a computer. The sample consisted of all students who took physical science during their third academic class on the four person team in which I taught who also brought back their signed permission slips. This was 16 out of 29 students.

One of the foremost aspects of this study was the fact that it took place in my own classroom. This was something that had rarely been done in the published research on argumentation to date. The affordances that this gave me were many and were a benefit to the overall understanding that came from this research. Within a teacher's own classroom, they get to know the students well. Within this knowledge is an understanding of the ways in which the students work and the capabilities that they bring to the learning experience. I could thus design teaching materials and classroom scenarios which ultimately benefitted the students and the research. I was also well aware of the extent to which the interventions were executed and the extent to which they were successfully completed immediately rather than during data analysis or reflection. Interventions could be changed or improved on the spot in order to increase the likelihood of quality results, just as any lesson might be in the classroom. Overall it was guaranteed that the interventions were implemented in the way that that I desired and planned.

In the classroom that I had been working in for some time, there was a bond with the students, an understanding of protocols and work expectations, and knowledge of what worked for those particular students. It is possible that when someone that is not a regular teacher comes into a classroom they do not always get the best results possible because they do not have a bond with the students that is developed over the course of the school year. Here, there were already bonds with these students that had been fostered for over a full semester. Those bonds may have led to students giving more effort and trying new things with an open mind. Students generally work harder for those that they like and have bonded with. Also, with time together came an understanding of what was expected as far as effort and protocols in the classroom. In a classroom that I had worked in since the beginning of the year, protocols and an environment that fit the discussion based or a paired work and thinking methodology were set in place early and well before research started. I had a head start fostering an environment that was suitable for the research. I also had an understanding of what worked with the students, what they were good at, and what could be used in order to have them work with more vigor and to try harder. Knowing these attributes of students helped me here to develop materials that were suitable, fitting, and more likely to be successful with this particular group of students. I derived all of these advantages from this exceptional process of completing the research within the confines of my classroom, with the added benefit of contributing current knowledge to a field where research has not often been conducted in this manner.

The subject matter of the intervention was a single unit lasting six weeks on the topic of electricity and magnetism of which students have some prior knowledge, having been exposed to these concepts in the elementary grades within this school system. In addition, electricity and magnetism are commonplace in society and thus the students would have some social and experiential knowledge as well. This was beneficial as background knowledge is an important factor in the performance within argumentative discourse (McNeil, 2008; Osborne et al., 2004). The unit also took place during the second semester so students had experience in a classroom designed to promote discourse and which includes teaching about the nature of science and its epistemological concerns through the design and implementation of a science fair project by all students. During this project, students began to learn about fundamental aspects of creating scientific knowledge, which Latour (1987) sees as pivotal to science education. These practices, included in the science fair project work, were skills such as interpreting evidence, judging scientific claim and hypotheses, reading scientific literature, and using the language of science.

The work done in the first semester on the science fair project included small pieces of basic scientific skill and practice as listed previously. These concepts were taught in two ways. In beginning a conversation with students about the nature of science and the work of scientists, which they undertook in their science fair projects, explicit instruction as to the nature of science and the work of scientists was necessary in order to provide some background to the skills that were obligatory to complete a science fair project. The explicit teaching was followed up by the application of the newly established knowledge through scaffolding used in the development and implementation of a science fair project. This included an experiment of some sort, evidence to support the reasoning of the experiment, research and reading of science related materials in order to develop a hypothesis and experimental procedure, and a conclusion which took into account the results of the experiment and the science behind it. This foray into a portion of real science and the work of scientists helped these students with regard to their foundational knowledge used later in the year during the electricity and magnetism unit.

In the implementation phase of the electricity and magnetism unit, the study included multiple teaching and learning activities. Although students had previously developed some understanding of the nature of science and its epistemology, these concepts and argumentation were taught explicitly through direct instruction, modeling, and examples. Explicit instruction was used because multiple researchers have found explicit instruction to yield significant results in reasoning and argument construction as well as understanding of the concepts and their use in the classroom (Hand et al., 2004; Osborne et al., 2004; Schwarz et al., 2004; Zohar & Nemet, 2001). Explicit teaching of argumentation included multimodal explanation of argument as a concept as well as the way in which scientist's debated and developed new knowledge. The individual parts of arguments were taught in accordance with Toulmin's (1958, 2003) descriptions and Kuhn's (1991) explanations of how arguments are created and used. As is done regularly with new subjects, students learned the vocabulary and the foundational principles of argumentation and how it is used. Engaging students in reading and critique of arguments that had been previously constructed was a specific part of the direct instruction and practice with argumentation.

Explicit instruction included exemplars of arguments from videos acquired via the internet which showed argumentative discourse in action. These were short clips so students were not bored. Students worked with the teacher in a discussion based format to discern the individual pieces of arguments and how they fit together to develop a convincing argument that is based in fact and theory as well as reasoning. As a class, we watched the videos and I stopped them from time to time to instigate discussions as to the pieces of argument that may be represented in the moments prior to my stopping the clip. Together we could identify the basic part of argument that was used. This effort was highly scaffolded by me in order to help students see argument in action and specifically relate to each part of the process. Questioning was a technique that I relied on heavily to help steer students towards what they were looking for as they learned the pieces of argument and how they fit together. This interactive style of viewing and deconstructing the argumentative process and the argument created lead to engagement from the students involved. As students worked with video evidence of arguments and dissected the elements of arguments and the reasoning approaches used, they created cartoons or illustrated progressions of the argument, the reasoning patterns, and the persons involved in the argument. They could draw stick figures with thought clouds or just several boxes with pictorial and written explanation of their ideas. Through this multimodal approach, students used multiple aspects of their learning styles as well as their talents to develop an understanding of what constitutes argumentation, arguments, and reasoning. Students also received direct instruction as necessary to complete their understanding of argumentative discourse and argumentation. In addition, students explored argumentation through the development of illustrated dictionaries depicting vocabulary terms in which the concepts were not only defined and exemplars of the concepts developed, but illustrations were created to represent the concepts as well.

Modeling was used to differentiate high and low quality argument. Modeling has been shown to increase argument quality and eliminate misconceptions (Cross et al., 2008; Simon et. al, 2012). In order to aid students in developing skill as argument creators, they needed to see examples of good and poor quality arguments in a scenario which allowed them to apply critiques, especially while fixing issues with the more poorly constructed arguments. This process aided them in understanding how to construct their own high quality arguments by resolving their deficits metacognitively or with their partners. Exemplars of both good and poor quality arguments were taken from videos acquired on the internet and animations created specifically by the instructor to highlight these issues. In addition, written examples of poor and high quality argument came from Kuhn (1991) and examples with analysis she used to delineate argument quality. Also, I would take ideas during class and come up with a sentence or two as part of an argument and students could rate my statements as to their quality. Then we could work on improving the statement or noting what made it powerful or of high quality.

Students examined historical arguments in science and the development of knowledge through those arguments. Clary and Wandersee (2013) note that examining controversies from the history of science in context can also help teach students to create quality arguments and identify unsound science or poor scientific arguments. Creating controversies through historically relevant scientific exploration and argument led to the development of science content that was a part of the national standards. As in the initial development of their understanding of argumentation, the use of video clips and reenactments of historical arguments was used in order for students to still use multiple dimensions of their learning styles and interests. Websites such as www.goanimate.com were employed to create animations of arguments in cases when they were not available on video.

Scaffolding worksheets (see appendix) were used to help students construct arguments based on the scheme of Zohar and Nemet (2002) in which data, warrants, and backings are collapsed into one category. This helped the students to grasp scientific reasoning, gave them multiple options to support arguments, and alleviated difficulty in distinguishing between units that make up the larger category of reasoning. The nature of the scaffolds was the construction of arguments through questions designed to elicit claims and justification needed for constructing arguments and develop oppositional thinking. Scaffolds that lead students through argument construction allow even novice students to complete well-structured arguments (Sandoval & Millwood, 2005). Chin and Osborne (2010) see that scaffolds which ask question of students develop quality arguments with appropriate claims, warrants, counterclaims, and justifications. Sandoval and Reiser (2004) suggest that it is important to link the explanations students construct with specific questions, as is done in the scientific world. Scaffolds which guided students through the process in a logical manner leading to a complete argument were specifically designed for this unit and were in many cases content specific. Students were asked for the information that goes into each portion of the argument scheme used in order to develop a complete argument. Scaffolds were similar to a recipe approach and denoted all things that must be included on the argument. Students were able to check them off as they included the important parts of the recipe and developed their finished product. Whenever students were working on the scaffolds, I was walking around the classroom observing and providing additional scaffolding through answering student questions and clarifying the scaffold worksheets.

Kuhn (1991), states that higher level arguments contain rebuttals which often develop through oppositional thinking. Clarke and Sampson (2007) see a direct correlation between opposition in argumentation and the equality of the arguments constructed, thus opposition will be a focus within the scaffolds. In addition, the constant questions of "So What?" and "Why?" were bases for prodding students to go further in examining whether their arguments were convincing and taking into account the opposition. Scaffolds also included argument maps so that students could visually examine the argument that they were creating and the connections of claims and evidence, counterclaims, rebuttals and justifications. Homer-Dixon and Karapin (1989) refer to the network theory of meaning when stating that argument maps allow for a contextualized social construction of argument in visual form which leads to more appropriate and complete understandings. Schwartz et al. (2003) reason that showing these connections benefits the construction of more complete arguments. Argument maps (see appendix) were designed and used in order to show how the argument progresses and the ways in which the counterclaims and rebuttals are pivotal to developing an argument that is suitable and powerful enough to convince and persuade. The inclusion of real world science knowledge and theory was a focus in the maps. Thus, higher level thinking and processing took place through the use of the argument maps. Showing how the argument was laid out with visuals and by tracing the development of each argument's individual pieces aided students in putting those pieces together. Theoretically, students who could see how and why the different parts of the argument were included should have been more likely to develop and articulate higher quality arguments leading to better, and more thorough, argumentative discourse.

The intervention also included group discourse to create argument and participate in argumentation. Vygotsky (1978) touts that socially shared experience aids participants in developing more ways to construct knowledge and the processes needed therein. Resnick (1991) suggests that people develop knowledge structures based not only on what they experience but on what they hear and understand from others' experiences. Group development of argument has been shown to increase the quality of reasoning produced (Sampson & Clark, 2008). Students can transfer the group discussion to their own arguments and create better individual arguments by reinforcing their own ideas through the group's discussion (Mason, 1998). The layout of the classroom, as it was populated with two person lab tables and was at the same time filled to capacity with students, lent itself to two person groupings, therefore groups were generally made up of two students. The students had opportunities to think on their own, write down some ideas, and then discuss them with a partner in the general setting. In some cases, students worked individually and as the unit progressed, partner groups developed their arguments as best they could in pairs before moving on to a larger group discussion. Groups were mixed ability and assigned by the teacher. Ability levels were determined by standardized testing and my experiences with the students were well known to me by that time in the school year. This knowledge was used to set up groups in which there are multiple levels of ability. Also, knowledge of who did and did not work well together allowed the teacher to make groups that functioned well and remained on task.

To develop interesting and engaging argumentative scenarios, students visited the www.goanimate.com website online in small oppositional groups in order to develop animations of their argumentative discourse. Through this website, they animated their argument and at the same time gave it a voice and a face. For this, groups of two opposed each other to help develop the rebuttals and counterclaims needed to identify high quality arguments. The grouping of opposing viewpoints or opposing sides of issues in practice allowed students to see the other ways of thinking and other sides of the issue that they may not have thought of before. Counterclaims, and the rebuttals necessary to negate them, became clearer to students as they practiced this in the oppositional groups. Although the multimodal instruction, modeling, and scaffolding worksheets were helpful for students in developing the skill of creating claims, providing warrants with backing to support them and developing overall lines of reasoning, the more challenging higher order thinking generally needed to develop the best arguments (using counterclaims and rebuttals) still needed to be fostered.

As students developed their skills at argumentation, after some small group argumentative discourse events, they participated in computer-based discussions in which they could remain anonymous to their classmates. Through a school system level program, students accessed discussion groups and rooms set up by the instructor in order to participate in argumentative discourse amongst multiple people and practice their argument development. Through the use of their scaffolds and experience in the classroom, students argued in a virtual situation.

Up to this point I have expressly detailed the teaching and use of argument with little attention to the role of content instruction. Although, during the examination of historical argument and preparation for other argument sessions, content learning took place, I felt it was necessary to teach the content of electricity and magnetism in my regular classroom style as well. During the unit, I spent roughly 30%-40% of the time focused on argumentation. However, the rest of the time I spent teaching in my regular fashion. This involved science lab activities, flipped classroom homework videos depicting short lecture based content instruction, weekly quizzes with immediate feedback for students, reading assignments, vocabulary instruction, and other hands on artistic activities. Overall, my classroom made great use of differentiation in teaching and learning. Argumentation was the most significant piece, but was far from the only teaching pedagogy implemented during the electricity and magnetism unit.

Data Collection in My Research

Student work collected in this study included all of the written work done on scaffolding worksheets, the essays written by students, animated arguments from www.goanimate.com, and online discussion postings students produce during the six week electricity and magnetism unit. Students were given a pretest and a posttest (see appendix A) designed to determine their skill at creating and identifying quality arguments. In addition, students were given a multiple choice exam designed to test their abilities to apply their scientific knowledge to problems (see appendix c) requiring application of that knowledge to new situations. Students needed to fully understand concepts in order to apply them to new and novel situations. They were tested both before and after the teaching unit to determine if they could apply the electricity and magnetism information to new situations with increased skill after the interventions and argumentative discussions and activities. Scaffolding worksheets (see appendix B) students complete were collected along with argument diagrams. Due to policies of the school and the district to which it belongs, there was no video and audio taping. To circumvent issues arising from not having the audio of discourse situations and argumentation, the scaffolding worksheets clearly indicated the contributions of each student and were detailed to understand reasoning patterns students were using. All of the animations created on the *GoAnimate* website were documented as to the level of argument created by specific groups. The online discussions were threaded as to indicate the specific contributions by each anonymous student and group. I identified them by their student number and thereby saw what each individual had contributed. Instead of student interviews, students answered a series of short answer questions that were similar to interview questions (see appendix C). As this was done on computer as well, it served as a transcript of student responses that I was able to analyze. I also took detailed field notes during the time students were working. I wrote reflective memos and kept a journal (see appendix D) of the experiences during the unit for examination as well. Corbin and Strauss (2008) see memo writing and journal keeping as essential to maintaining the integrity of fieldwork. These reflections are a key part of the analysis to be done when fieldwork has concluded (Wertz et al., 2011). A general idea of what data was collected is shown in table 1.

Table 1: Data Collection Procedure

Data Collection	General Argument	Content Knowledge	Argument Sessions
Pre and Post Tests	X	X	
Written Work		X	X
Presentations		X	X
Interview Questions	X		X

Data Analysis in My Research

Data analysis was both quantitative and qualitative. Quantitatively, pretests and posttests were compared to assess improvement in argumentative skill. Scores were assigned based on the number of multiple choice questions answered correctly and were based on a 100 point scale. The scores were examined to determine the change in score from pretest to posttest, the mean change in score, the standard deviation from the mean, and a standard t-test to correlate the likelihood that the changes were significant. The examination to determine skill in applying knowledge was also compared quantitatively to determine changes in ability to apply knowledge that was gained and worked with through argumentative discussion and activities. Both tests had a pre-intervention and post-intervention score for comparison.

Arguments produced on the argument maps, in the written essays, and through the online discussion were assessed for quality in multiple ways. Arguments were coded using a version of the collapsed Toulmin argument categories scheme presented by Zohar and Nemet (2002). Since this was content specifically based on the unit, data and reasoning that was used for justification was quantified for the scaffolded worksheets and the written essays as to the scientific accuracy of information. Using a content specific scheme based on the framework developed to denote the level of scientific knowledge used as reasoning and justification, the arguments were coded as to these levels:

1. no electricity and magnetism knowledge
2. incorrect electricity and magnetism knowledge,
3. non-specific electricity and magnetism knowledge or general science knowledge
4. specific and correct electricity and magnetism knowledge

These levels allowed for a score as to the scientific evidence that was used. Scores within this framework allowed me to see conceptual understandings and content knowledge students made use of in their arguments. Including content knowledge is important for the implementation of argumentation as a technique to teach not only the nature of science and its epistemology, but also the content area knowledge that is required by school systems.

Arguments created were coded to develop a sense of how oppositional discussions help to create arguments with extended thinking. A framework based on the framework developed by Erduran et al. (2004) was used for coding these arguments. The levels are as follows:

1. claim v claim or counterclaim
2. claim v claim with data
3. claim v claim with data and reasoning (warrants, or backing)
4. claim with data and reasoning and with the occasional weak rebuttal related to a counterargument
5. Extended argument with specific and accurate rebuttal (s) directly related to stated counterargument

Developing ideas as to the quality of pedagogy and intervention materials came from this data.

Qualitatively, the scaffolding sheets, the written essays, and the online discussions were examined to develop an idea of reasoning patterns most common for students. Written discourse, scaffolds, and discussion maps were coded using the iterative coding method previously described in this work. Iterative coding worked well in developing patterns specific to this group and subject matter. In examining the written work students produced, several specific words and phrases were included across multiple students' work. These words and phrases were used as the codes to develop themes and reasoning patterns in their work. These patterns and the categories that identified them developed from the data produced in class.

Common categories and the significance of their usage were discussed and analyzed with regard to field notes and student interviews.

Student interviews (see appendix B) were coded and analyzed using a grounded theory style methodology. The grounded theory approach was used here to help determine students' understandings in alignment with their conceptualizations and understanding and argumentation and how they used it to learn and solve problems. A constructivist grounded theory approach seeks to interpret and understand experiences through flexible and reflective interpretation without prescribed patterns (Wertz et.al., 2011). For all qualitative analysis, I had an outside assistant code 20% of the data to check for reliability of the researcher's coding. The outside assistant was a science colleague who taught the same material in a traditional way. I trained the teacher as to the basics of argument and what would constitute specific argument and reasoning patterns. The training involved examples and practice on the part of the assistant. I also shared the teaching materials used in class. As this person taught the same subject, there was no need for content knowledge training. All discrepancies were resolved through discussion between coders. In general, there was a very similar coding experience for both coders, though.

With the connection of theory spanning how students learn, how students communicate in discussion groups and in science classrooms, how scientists do their work, and how argumentation fits into the science classroom, the methodology presented here was developed to show how these theories fit together for teaching and learning and researching about argumentation in the science classroom. The pedagogical approach included explicit and scaffolded instruction, discussion groupings, multimodal presentation and application of information as well as argument construction, and multiple computer based activities for students to show their knowledge and processes. I expected to develop an understanding of the effects of the interventions on the research questions elucidated previously in this work through the systematically investigating the methodological tools. The overarching goal here was to gain a better understanding of the teaching and learning of argumentation in the science classroom with its effects and contributions to a better understanding for students concerning science, the nature of science, scientific work, and the critical as well as metacognitive skills of argument. The general plan for the methods of data analysis can be seen in table 2.

Table 2: Analysis Procedures

Analyses	Pre/Post Tests	Argument Quality (written Discourse)	Content Knowledge (written Discourse)	Argument and Reasoning Patterns (written Discourse)	Student Interviews
Quantitative					
Numeric Scores	X	X	X		
Comparative Statistics	X	X	X		
Qualitative					
Iterative				X	
Grounded Theory Style					X

In my approach to data analysis, I took great pains to remain objective in the collection and analysis of data. I collected and securely stored all of the data until the end of the school year. Thus, throughout the unit of instruction, I did not know who had brought back the permission slips in order to have their data analyzed and who had not, thereby I had no knowledge of who was and was not going to be a part of the study. When I looked at the data after school ended, I immediately assigned each participant a number from 1-16, as there were only 16 students who participated. I also immediately removed any identifying characteristics from the data except for the number. I then left the data alone for another month. When I analyzed the data I looked at it with the understanding of what took place in the classroom and at the same time without knowledge of the personalities behind what was in the data. This allowed me to be as objective as possible and leave any personal bias out of the analysis. In addition, another rater performed analysis on 20% of the data with little to no difference in our ratings. In cases of dispute, I erred towards the other rater's score. I felt as though I was successful in my objectivity. This design was a struggle but I believed that this analysis of the specific data with a true understanding of what took place in the classroom allowed me to develop a more detailed understanding of what effect my interventions had on the development of student understandings.

In this chapter I laid out the specific teaching methods employed in the research project and the design of the research. Specifically I outlined a plan to teach argument with explicit instruction and scaffolded worksheets. I planned to have students participate in multiple argumentative sessions individually, in pairs, and in small groups. I highlighted data collection and analysis methods that allowed me to understand what students learned as well as their argument and reasoning patterns. In the following chapter, I examine the data collected through the designed analysis methods and explain the findings from that data.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

This research study was conducted in order to ascertain overall benefits of teaching scientific argumentation in the science classroom. The use of argumentation in this particular classroom spanned the subject matter of scientific argumentation itself and its use in learning and applying electricity and magnetism knowledge. The main focus of this research centered on the teaching of scientific argumentation as a process within the scientific world and at the same time, using that process to aid in teaching and applying the content contained in the eighth grade curriculum regarding electricity and magnetism. The purpose of the research was to answer three main questions:

1. What is the overall effect on students' argument creation after being taught the concepts and processes of argumentation explicitly in an 8^{th} grade physical science classroom using multimodal, multimedia, and computer based activities?

2. What is the overall effect on students' argumentative skill, content knowledge, and overall science concept understanding after using an oppositional based approach to argumentation in paired groupings? (focusing on counterarguments and rebuttals)

3. What is the overall effect on students' abilities to use content knowledge to solve problems in which the application of science knowledge to new scenarios is necessary, after being taught using argumentative based instruction and practice?

The results of this research span both quantitative and qualitative domains. These results are detailed in the following sections: a) quantitative results, b) qualitative results: argument patterns and c) qualitative results: student perceptions.

Participation

The school resides in an area that is ethnically and socially diverse with a population consisting of 43% African-American, 30% Hispanic, 16% White, 7% Asian, and 4% either mixed or other races. For the purposes of research, the third period class was chosen due to it being a fresh start after the lunch period and the fact that students would be well fed and able to concentrate. In addition, the teacher would also be well versed in the specific lesson of the day, after teaching it twice already. In this specific class, the population contained 31% (9) boys and 69% (20) girls. The class was also ethnically diverse, with 58.7% (17) African-American, 27.5% (8) Hispanic, 6.9% White (2), and 6.9% (2) Bosnian. The Bosnian ethnicity was separated here due to the fact that they are adamant about, and proud of, their individuality as an ethnic group. In addition, it would be obtuse thinking to simply classify these students as White, as they are all immigrants to America of the first or second generation. Out of the 29 students in the class, 16 brought back permission slips signed in order to have their class work used for the purpose of the study.

The breakdown of students participating was similar to the entire class with regard to ethnicity. However, with regard to grade distribution and achievement levels, the research group was very closely representative of the entire class. The participant group contained 4 boys and 12 girls. The ethnic breakdown was 5 African-American, 8 Hispanic, 1 White, and 2 Bosnian. The discrepancies between an overall drop in African-American participation and the fact that all of the Hispanic and Bosnian students participated was glaring. It was difficult to account for this difference in participation levels, but it could be asserted that the parents of the Hispanic and Bosnian students sign whatever their students give them to sign, as many of them do not read and write English. This has been my general experience with these students. The overall grade distribution of the entire class sorted out to be A-51.7%, B-34.5%, C-10.3%, and D-3.5%. The research group was representative of the whole class, as their grade distribution was A-50%, B-25%, and C-25%. These grades are defined in the school system as A-100-90, B-89-80, C-79-73, D-72-70, and a failing grade was anything below 69.

As part of the research design, all students received the same instruction. Each student on the entire team of 116 students which made up all of my four classes for the teacher here followed the same schedule, same pacing, received the same lessons, and completed the same work. I was not aware of the specific students who had brought back permission slips, and did not assemble the student work that was to be the focus of the research until after the unit was complete. This was intentional so that I did not show any special attention to any groups or individuals. I wanted all students to be treated in the same way for as much of an unbiased look at the practices as possible. There was no opportunity for me as the teacher to alter the lessons for participating students in any way.

Quantitative Analysis

All quantitative data was analyzed using basic statistical analysis to determine the mean score, the standard deviation, and a p-test for correlation. In addition, t-tests were completed in a comparison analysis to determine the significance of the intervention effects. For the arguments that were scored based on the levels of knowledge included and for those arguments scored based on the use of the pieces of Toulmin's argument design, the scores were compared using a paired samples test. In this test, I compared the scores on students' arguments as they progressed through the unit and through the argument sessions. For example, the first argument (AC/DC) was paired with the second argument (Series and Parallel). Then, the second argument (Series and Parallel) was compared to the final argument (Power Lines). Also, the first and final arguments were compared the same way. For the paired samples test, the mean, standard deviation, and p-test were completed. Paired t-tests were also performed here. This helped to develop an idea of the ways in which performance changed from one argument session to the next and throughout the entire unit.

Argumentation/Argumentative Reasoning

All students took an identical Pretest and Posttest on their knowledge of argumentation and reasoning as well as an identical Pretest and Posttest for electricity and magnetism knowledge (see appendix C?). The tests were all multiple choice exams taken in a bubble sheet and graded with a computer program owned by the school system. The pretest scores for scientific argumentation showed a lack of knowledge on the subject. As can be seen in figure 1, the mean score was 28.25%, which was similar to the statistical likelihood of guessing at each question, as there were only four possible answers. The standard deviation of 8.046 on this showed a differential in students' initial knowledge of scientific argumentation and reasoning. This differential can also be seen in figure 2. Looking at similar data from the posttest, students showed improvement in their understandings of the concepts, as the mean score increased to 41.25%. The variation in understanding was lowered to a standard deviation of 6.578. Students showed an understanding of nearly half of the specific terminology and specific reasoning patterns associated with the scientific argumentation taught during the electricity and magnetism unit. Figure 2 shows that many students' understandings grew at a high rate, while other participants' knowledge grew at a lower rate. In two cases, a student performed equally on each test while one student had decreased performance on the posttest.

In figure 1 data show there was a significant correlation (P-value=0.000562159 <.05) with the intervention and the students' achievement on the argumentation test. Students did learn about scientific argumentation and reasoning through the unit, almost doubling their knowledge of the subject matter (25.25% to 41.25%). The growth rate was not enough to show that students had a high level of competency with their understanding of the language and specific descriptions of argumentation and reasoning patterns. The paired samples test showed significance in the two tailed T-test (.001<.05) relating again that the intervention was significant as a source of increased understanding of scientific argumentation and reasoning.

Scientific Argumentation Pre and Post Test Paired Analysis

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ArgumentPreTest	28.2500	16	8.04570	2.01143
	ArgumentPostTest	41.2500	16	6.57774	1.64444

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	ArgumentPreTest & ArgumentPostTest	16	-.564	.023

Argument
Pretest:
Number (N) = 16
Mean = 25.25
Standard Deviation = 8.046
Posttest:
Number (N) = 16
Mean = 41.25
Standard Deviation = 6.578

P-Value (<.05) = 0.000562159

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper			
Pair 1	ArgumentPreTest - ArgumentPostTest	-13.00000	12.95119	3.23780	-19.90120	-6.09880	-4.015	15	.001

Figure 1: Statistical Analyses of Argument Pretest and Posttest

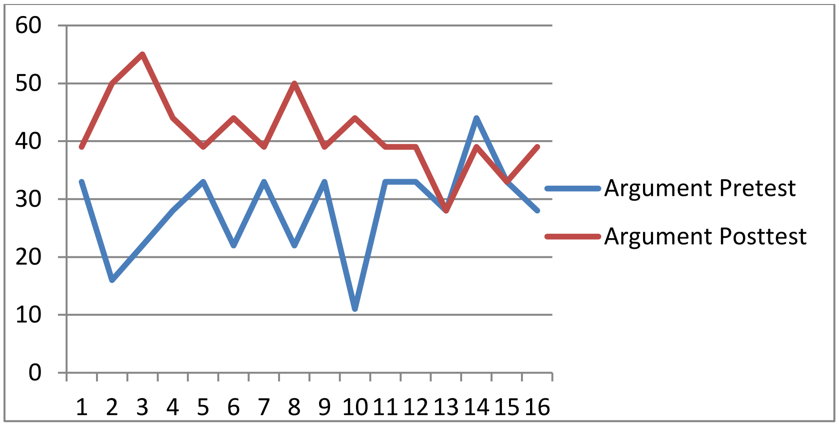

Figure 2: Graph of Argument Pretest and Posttest Scores

Argument Quality

Arguments created by students throughout the unit on electricity and magnetism were coded and rated for quality using a framework based on the works developed by Erduran et al. (2004). That system was as follows:

1. claim v claim or counterclaim
2. claim v claim with data
3. claim v claim with data and reasoning (warrants, or backing)
4. claim with data and reasoning and with the occasional weak rebuttal related to a counterargument
5. Extended argument with specific and accurate rebuttal (s) directly related to stated counterargument

This scale allowed me as the rater to ascertain the level of reasoning and argumentative skill used in the student's argument. Using this scaled score, I quantitatively assessed the effects of the argumentation intervention on the quality of argument created in class.

Throughout the unit on electricity and magnetism, students participated in the creation of four arguments. Of these four, three used the argumentation map I developed in a way that could be scored using the rating framework. These arguments were AC/DC Power (individual), Series and Parallel Wiring (limited pairs), and The Debate in Burying High Voltage Power Lines (pairs and opposing groups). Each of the arguments created by the participants, either individually or in pairs, was rated by the individual performance of the student and the work done on his or her own argument scaffold sheet.

AC/DC Power

This was the first attempt at creating an argument for these students. Students had minimal knowledge of AC/DC power at the outset of the lesson. This lesson took place on the third day of class for this unit. No instruction regarding current electricity had been given in advance. Any understanding students had would likely have come from elementary level instruction or real life experience. The argument concerning AC/DC power had the students researching the concepts of alternating and direct current with regard to the historical actions of Thomas Edison and Nikola Tesla. Students were to develop their arguments based on the arguments of either Edison or Tesla. As can be seen in Table 3, the general level of argument created was poor. Only one participant in this session included any reasoning at all. Most students simply showed a claim alone or a claim with some data related to it. Students did not connect their data and claims in any way at this point. The mean argument score was 1.81 (on a 1-5 scale) showing that the arguments created were sub-par and in general had little argumentative value. With a small window of variance, it can be seen that there was a general lack of understanding of the concept of argumentation and the pieces that fit into a quality argument.

Table 3: ACDC Argument Ratings, mean, standard deviation

Participant Number	ACDC Argument	Mean	Standard Deviation
1	2	1.81	.544
2	2		
3	1		
4	1		
5	2		
6	2		
7	2		
8	1		
9	2		
10	1		
11	2		
12	2		
13	2		
14	3		
15	2		
16	2		

Series and Parallel Circuits

The second attempt students made at developing an argument was in the lessons regarding series and parallel circuitry. This assignment started on the sixth day of the unit. In this session, students were to apply their knowledge from class lessons and labs, to the issue of whether series or parallel wiring systems were better for general use. In this case, students had the opportunity to develop an understanding of both kinds of wiring along with the usage, benefits, and drawbacks to each. In this scenario, the students were equipped with fact based scientific information and theory to fuel their arguments. Students worked for a limited time in pairs and were allowed to choose their position in order to create their claim and support it. Table 4 shows that a majority of students in this case at least supplied data to support their claims. A significant number of students supplied reasoning to connect their data to their claim in this activity. One student developed not only reasoning, but also a counterclaim and rebuttal to have an overall very strong argument. With a mean score of 2.375 in this activity, students showed an increase in their ability to find data to support their claims overall. They did not overwhelmingly reason through their arguments, but there was marked improvement. A standard deviation of 1.204, still showed significant differential in skill, yet in general the participants were at the same basic level for this argument session.

Table 4: Series/Parallel Argument Ratings, mean, standard deviation

Participant Number	Series/Parallel Argument	Mean	Standard Deviation
1	5	2.375	1.204
2	1		
3	3.5		
4	3.5		
5	2		
6	1		
7	1		
8	2		
9	2		
10	2		
11	2		
12	2		
13	2		
14	2		
15	3.5		
16	2		

High Voltage Power Lines

In the final argument session of the unit, students researched the debate surrounding high voltage power lines and where they should be placed. This argument spanned three days and began in the middle of the fourth week of the unit. The debate centered on the question of whether it is prudent and/or necessary to bury these power lines underground or if it is acceptable to have them above ground suspended along the traditional power line system. This argument combined not only specific scientific knowledge that students had acquired through class (electromagnetic radiation; electricity with regard to current, resistance, and voltage; and the operation of transformers) but also the socio-scientific knowledge they gained through research of the debate on the subject of high voltage power lines and their possible adverse effects. This argument, being the culminating session for the unit, involved everything the students had learned about argument, argumentative reasoning, and electricity and magnetism knowledge.

As can be seen in table 5, students performed well on this argument session. The vast majority of students developed arguments that included a claim, evidence to support that claim, reasoning to connect data and evidence to the support of the claim, and a counterargument with at least some sort of rebuttal, whether weak or not. Half of the students developed their argument fully with a strong rebuttal to counter the opposition. Three students were still not developed fully in their argumentation prowess. The mean score for this group was 4.313, showing that there was a high level of ability and understanding as to what makes a strong argument. The standard deviation was less than one point supporting the conclusion that most of these students had grasped the concept of argument at this point and could demonstrate the process of creating an argument with a high level of competency. These results show the inclusion of scientific evidence and theory in support of a claim and the level of reasoning necessary to connect that evidence. The fact that almost all students included counterarguments and rebuttals also portrays an understanding of the importance of those pieces of a strong argument.

Table 5: Power Lines Argument Ratings, mean, standard deviation

Participant Number	Power Lines Argument	Mean	Standard Deviation
1	5	4.313	.7932
2	5		
3	5		
4	4		
5	3		
6	5		
7	3		
8	4		
9	3		
10	5		
11			
12	5		
13	5		
14	5		
15	4		
16	4		

Comparative Progress through Argument Sessions

A comparative analysis of student achievement on all three argument sessions detailed improvement and highlighted the rate at which students developed their understandings. The progress that students made throughout the argument sessions can be seen through the paired comparisons in figure 3. Examining a paired samples test between the AC/DC session and the Series and Parallel session shows growth that was not at a significant level (p-value 0.08834555> .05). The students made no significant improvement between the first two argument sessions. The same test for the differential between the Series and Parallel Argument session and the high Voltage Power Lines session again shows improvement at the statistically significant level (p-value .0000119697< .05). Also, when the overall variance from the initial argument involving AC/DC current to the final argument concerning the Power Lines was examined, there was once again a statistically significant improvement (p-value .0000000524733< .05).

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ACDCArg	1.8125	16	.54391	.13598
	SPArg	2.3750	16	1.20416	.30104
Pair 2	SPArg	2.3750	16	1.20416	.30104
	PowerLinesArg	4.3125	16	.79320	.19830
Pair 3	ACDCArg	1.8125	16	.54391	.13598
	PowerLinesArg	4.3125	16	.79320	.19830

ACDC Argument to Series Parallel Argument	P-value - 0.08834555
Series Parallel Argument to Power Lines	P-value - .0000119697
ACDC Argument to Power Lines Argument	P-value - .0000000524733

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	ACDCArg & SPArg	16	-.293	.271
Pair 2	SPArg & PowerLinesArg	16	.148	.584
Pair 3	ACDCArg & PowerLinesArg	16	-.010	.972

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	ACDCArg - SPArg	-.56250	1.45917	.36479	-1.34003	.21503	-1.542	15	.144
Pair 2	SPArg - PowerLinesArg	-1.93750	1.34009	.33502	-2.65158	-1.22342	-5.783	15	.000
Pair 3	ACDCArg - PowerLinesArg	-2.50000	.96609	.24152	-3.01479	-1.98521	-10.351	15	.000

Figure 3: Statistical Analyses of Arguments Ratings

In figure 4, a visual representation of the progression and comparisons from argument to argument along the entire unit can be seen. In almost every case, improvement was made from the first session to the second session. In only three cases argument quality dropped off suggesting a lack of understanding in those few cases. In every case except one, there was improvement from the second session to the third session. All participants showed significant development of argumentative abilities from the beginning of the unit to its end.

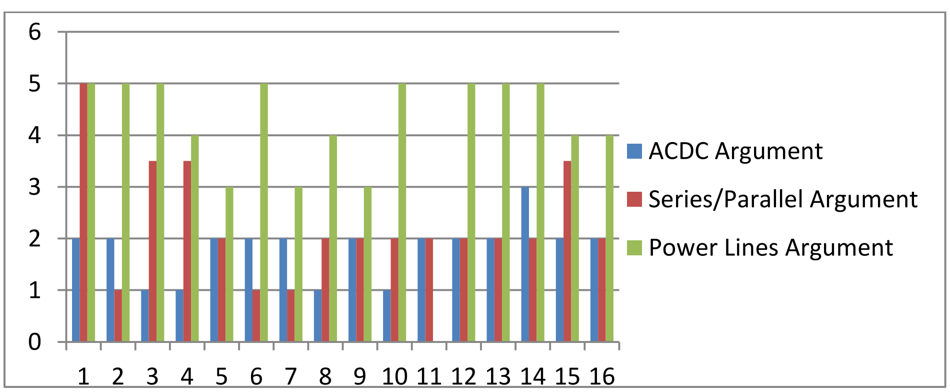

Figure 4: Graph of Argument Ratings

Electricity and Magnetism Content Knowledge

Pretest and Posttest

The pretest for electricity and magnetism knowledge showed that these students came to school with some understanding of the basic concepts of the unit. The mean score on the pretest, as seen in figure 5, was 49.19%. There was a wide range of knowledge levels, though, as portrayed in the 11.582 standard deviation. Students came to class with some knowledge, but the range of that knowledge was vast. Some students knew very little, while others seemed to have a good working knowledge of the content. The vast difference can be seen in figure6. The results on the posttest for electricity and magnetism knowledge showed that the students developed a true mastery of the subject matter during the unit. The posttest scores for all students in the study exemplified a thorough understanding of the content. The average score was 96.81% and no student in the participation group received a score of less than 90%, or an A. All students missed less than three problems on the posttest. The standard deviation of only 3.188 showed that the entire group developed a mastery of the content and there was little variation to the high level of achievement for these students.

In figure 5, data show that there was a significant correlation (P-value=.0000000000879361<.05) with the intervention and the students' achievement on the electricity and magnetism test. Students learned about the subject matter through the unit and intervention, almost again doubling their knowledge (49.19% to 96.81%). The level of understanding that students showed at the end of the unit was that of a true mastery of the content. The paired samples test showed significance in the two tailed T-test (.000<.05) relating again that the intervention was significant as a source of increased understanding of electricity and magnetism. It was clear from the data that the intervention and use of scientific argumentation led to a significant improvement for these students.

Electricity and Magnetism Pre and Post Test Paired Analysis

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ElecPre	49.1875	16	11.58285	2.89571
	ElecPost	96.8125	16	3.18787	.79697

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	ElecPre & ElecPost	16	-.199	.459

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ElecPre - ElecPost	-47.62500	12.61150	3.15288	-54.34520	-40.90480	-15.105	15	.000

Electricity and Magnetism

Pretest:
Number (N) = 16
Mean = 49.19
Standard Deviation = 11.583

Posttest:
Number (N) = 16
Mean = 96.81
Standard Deviation = 3.188

P-Value (<.05) =
.0000000000879361

Figure 5: Statistical Analyses of Content Knowledge Pretest and Posttest

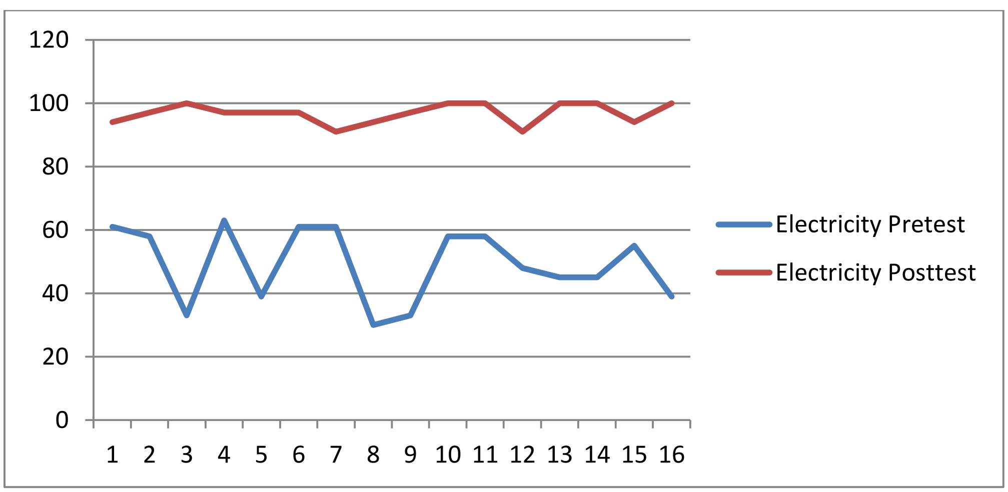

Figure 6: Graph of Content Knowledge Pretest and Posttest Scores

Content Knowledge as Applied in Argument Sessions

In order to facilitate a quantitative analysis regarding the level of content knowledge applied in a student's argument, I designed a scale specifically for this assessment. Since this was content specifically based on the unit, reasoning used for justification was quantified with regard to scientific accuracy of information. Using a content specific scheme based on the framework Zohar and Nemet (2002) developed to denote the level of scientific knowledge used as reasoning and justification, arguments were coded as to these levels:

1. no electricity and magnetism knowledge
2. incorrect electricity and magnetism knowledge,
3. non-specific electricity and magnetism knowledge,
4. specific and correct electricity and magnetism knowledge

AC/DC Argument

Once again, in the AC/DC argument session, students were researching historic arguments between Thomas Edison and Nikola Tesla with regard to the overall benefits of alternating current vs. direct current. Students completed research in a computer lab and had access to all of the information they found as they developed their argument. Students used the argument scaffold in the computer lab to help with their arguments. Levels of content knowledge used by students in the AC/DC argument can be seen in Table 6. In their initial arguments for this unit, students showed little ability to apply their content knowledge to their argument. There were some students who did include accurate content knowledge, but there were also multiple participants who included inaccurate information, showing a lack of understanding along with their inability to accurately apply scientific theory and understanding. The mean score of 2.0

indicates on average students were not using theory and understanding, not applying information appropriately, or they were using inaccurate information. For a scale with a small variation between the top score and the bottom score, the standard deviation of .817 showed great variance in understanding here.

Table 6: ACDC Content Knowledge Scores, mean, standard deviation

Participant Number	ACDC Content Knowledge	Mean	Standard Deviation
1	2	2.00	.817
2	2		
3	1		
4	1		
5	1		
6	3		
7	3		
8	2		
9	3		
10	1		
11	2		
12	3		
13	2		
14	3		
15	1		
16	2		

Series and Parallel Wiring Argument

During the second major argument session, students applied content knowledge they gained from classroom activities and labs to the topic of whether series or parallel wiring was better. In this scenario, participants used a scaffold I specifically designed to help students identify and use scientific theory and understanding as evidence and to develop reasoning in their arguments. Table 7 illustrates that, aside from two students who still struggled to apply their electricity and magnetism knowledge, participants generally used basic scientific knowledge or specific electricity and magnetism understandings in their arguments as either data/evidence or reasoning. The mean scale score of 2.875 denoted that on average, these students were applying some scientifically sound knowledge to their situations. The standard deviation was still somewhat high for this small scale, but in this case, that was due to very low scores achieved by two of the students who did not apply any science to their arguments. Another object of note here was that no student used inaccurate scientific understandings in his or her argument. Participants in this case either correctly used information or used no information at all.

High Voltage Power Lines Argument

The session regarding high voltage power lines was the culminating activity in the unit with regard to scientific argumentation. This lesson took place over three days. Students researched the topic, worked in pairs to develop their arguments, grouped themselves in fours in order to develop oppositional awareness for their arguments, and then created a summative presentation for class. Students had ample time to develop and apply their content knowledge. Table 8 displays the fruits of their labor. In all cases except one, students accurately applied scientific theory and understanding to their arguments. Nearly half of the students used specific electricity and magnetism understandings in their work. The mean score of 3.333 was representative of the high quality content knowledge students were able to apply to their situations. A lone outlier was a student that used inaccurate information in his argument. This same participant in previous arguments applied scientific understandings accurately, therefore it was interesting that he applied inaccurate information in this case. As a group, participants had a standard deviation of only .617 showing that as a whole they were accomplished here, with only one outlier.

Table 7: Series/Parallel Content Knowledge Scores, mean, standard deviation

Participant Number	Series/Parallel Content Knowledge	Mean	Standard Deviation
1	4	2.875	.806
2	3		
3	3		
4	3		
5	3		
6	3		
7	1		
8	3		
9	3		
10	4		
11	3		
12	3		
13	3		
14	3		
15	3		
16	1		

Comparative Progress Regarding Application of Content Knowledge

Developing the skill of competently applying specific scientific understandings and theory to problems was a key goal for students using scientific argumentation here. Figure 7 elucidates the development of that skill across all three main argumentative sessions from the electricity and magnetism unit. Sessions were paired to show improvements from session to session and also to show overall increases in ability from beginning to end. The paired samples test of the AC/DC and Series and Parallel sessions showed increases in application of knowledge at a significant level (p-value 0.008716135< .05). The same test to determine the differential between the Series and Parallel High Voltage Power Lines argumentation sessions once more showed statistically significant improvement (p-value 0.023957702< .05). Again, when the overall variance from the initial argument involving AC/DC current to the final argument concerning the Power Lines was examined, there was a statistically significant improvement (p-value 0.000190789< .05). Students conclusively developed their abilities to apply their scientific knowledge and understandings and continued to develop their abilities to apply specific electricity and magnetism knowledge to their reasoning.

Table 8: Power Lines Content Knowledge Scores, mean, standard deviation

Participant Number	Power Lines Content Knowledge	Mean	Standard Deviation
1	4	3.333	.617
2	3		
3	4		
4	3		
5	3		
6	3		
7	3		
8	3		
9	2		
10	4		
11			
12	4		
13	4		
14	4		
15	3		
16	3		

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ACDCCont	2.0000	16	.81650	.20412
	SPCont	2.8750	16	.80623	.20156
Pair 2	SPCont	2.8667	15	.83381	.21529
	PowerlinesCont	3.3333	15	.61721	.15936
Pair 3	ACDCCont	2.0000	15	.84515	.21822
	PowerlinesCont	3.3333	15	.61721	.15936

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	ACDCCont & SPCont	16	-.304	.253
Pair 2	SPCont & PowerlinesCont	15	.370	.174
Pair 3	ACDCCont & PowerlinesCont	15	-.137	.627

ACDC Content Knowledge to Series Parallel Content Knowledge	p-value 0.008716135
Series Parallel Content Knowledge to Power Lines Content Knowledge	p-value 0.023957702
ACDC Content Knowledge to Power Lines Content Knowledge	p-value 0.000190789

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ACDCCont - SPCont	-.87500	1.31022	.32755	-1.57316	-.17684	-2.671	15	.017
Pair 2	SPCont - PowerlinesCont	-.46667	.83381	.21529	-.92841	-.00492	-2.168	14	.048
Pair 3	ACDCCont - PowerlinesCont	-1.33333	1.11270	.28730	-1.94952	-.71714	-4.641	14	.000

Figure 7: Statistical Analyses of Content Knowledge Ratings

Figure 8 visually shows the development of these abilities to apply scientific knowledge. In almost each case, participants improved or maintained their skill levels across different sessions of the unit. In a small number of cases, students either used inaccurate information as they progressed, or applied no knowledge at all. Overall, students became better at applying their knowledge and understanding specifically regarding electricity and magnetism.

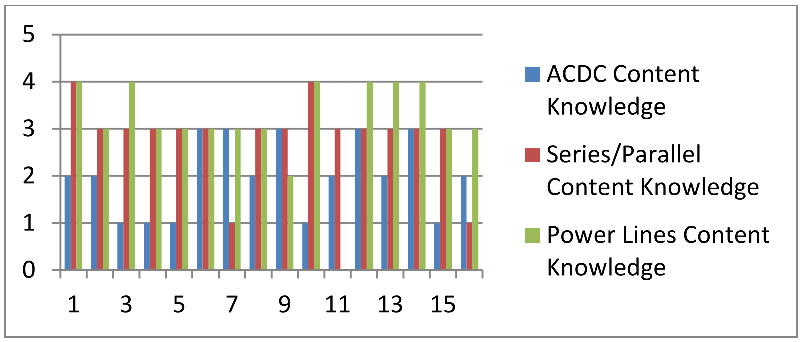

Figure 8: Graph of Content Knowledge Ratings

Summary of Quantitative Data Analysis

In summary, data regarding pretest and posttest scores on both the argumentation and the electricity and magnetism tests show statistically significant improvements. In each case the level of mastery of subject matter almost doubled. A t-test for the argument tests showed a p-value of 0.000562159, which was statistically significant at less than .05. A t-test for the electricity and magnetism tests had a p-value of .0000000000879361, which was also statistically significant.

Each argument created by students was given a numeric score based on frameworks I developed in accordance with other significant research in the field. The three argument sessions evaluated quantitatively included AC/DC Power, Series and Parallel Wiring, and High Voltage Power Lines. With regard to level of argument, which was scored with a focus on argumentative reasoning but also inclusive of the appropriate argument design, the argument quality showed statistically significant improvements throughout the course of the unit for each product in succession. From the first argument (AC/DC) to the second argument (Series and Parallel), data showed clear growth, as the mean score rose from 1.813 to 2.375 and the correlating p-value rated 0.008834555, which was significant at the .05 level. From the second argument (Series and Parallel) to the final argument (High Voltage Power Lines), there was once again statistically significant improvement, with an increase in mean score from 2.375 to 4.313 and a correlation p-value of .0000119697, which was also statistically significant at the .05 level. The overall improvement from the beginning of the unit to the end was shown in the total increase in mean score from 1.813 to 4.313 and a p-value of .0000000524733, which was statistically significant at the .05 level.

Arguments were also rated with a scale I developed regarding the level of scientific as well as specific electricity and magnetism knowledge students applied to their argument. The prowess with which participants applied their scientific knowledge showed statistically significant improvements as they progressed through argument sessions. Students in the AC/DC argument had a mean content knowledge score of 2.000 followed by a mean content knowledge score of 2.875 on the Series and Parallel argument. Improvement was statistically significant at the .05 level with a p-value of 0.008716135. Following the 2.875 mean score for content on the Series and Parallel argument the participants had a mean score of 3.333 concerning their level of content knowledge use in the High Voltage Power Lines argument. A p-value of 0.023957702 here showed statistically significant improvement at the .05 level as well. From the Unit's beginning to end, the mean content knowledge scores rose from 2.000 to 3.333 and had a p-value of 0.000190789, showing a statistically significant improvement at the .05 level.

Qualitative Analysis: Argument/Reasoning Patterns

In order to develop a better understanding of reasoning patterns that students used in their arguments and the development of their critical thinking and reasoning skills, a qualitative analysis was completed. An attempt to see into the minds of students and their processes was an overall goal in these analyses. All of the students' argument products were analyzed using an iterative analysis in which themes and patterns were developed out of the data specific to each argument and this group of participants. All written work and digital presentations were studied to develop reasoning patterns and critical themes in their work. In table 9, the general contents of each argument session can be seen with regard to the length of the activity, the preparation, and the topic.

Also in an attempt to gauge what students were thinking during the intervention and argument sessions, a written interview was given with ten questions and students typed their responses. These interviews were analyzed using a grounded theory style approach. Common themes from students were then scrutinized with a goal of determining how and why they developed their skills at argumentation and to see if critical thinking and reasoning skills could be seen emerging in their thought processes.

Table 9: Specific Argument Preparation

Topic of argument	Class time spend on topic	Science preparation to support activity	Argumentation preparation to support activity
AC/DC Current	2 days	Short Lecture Video and Notes	Basic explanations of Argument through PowerPoint and lecture notes.
Series and Parallel Circuits	3 days	Short Lecture Video and Notes, class lab activity	Reexamination and discussion of AC/DC argument products, teacher example animations of good and bad basic arguments
Gas Station Explosions	3 days	Short Lecture Video and Notes, class lab activity, reading article and watching Mythbusters video segment	Reexamination and discussion of series and parallel argument products, peer argument evaluations, class discussion on reasoning patterns
High Voltage Power Lines	4 days	Short Lecture Video and Notes, class lab activity, class discussion and practice problems with ohms law, creation of illustrated dictionary with all vocabulary from the unit, online research	Reexamination and discussion of gas station argument products, another look at argument lecture video, teacher examples of quality arguments

Argument Themes

Each argument session had distinct topics and general scientific information that could be applied. All argumentative experiences also had common information with regard to overall electricity and magnetism knowledge that could be applied to the scenario. For each argument, students needed to determine which information was accurate and could be applied to the situation, and then reason through connections between data/evidence and their claim. Here the themes were presented with regard to their reasoning patterns and application of knowledge to arguments. After the original analysis, it became apparent that certain ways in which students presented their arguments aligned with Walton's (1996) argument and reasoning schemes. As such, the themes present in the analysis were labeled accordingly when appropriate.

AC/DC Current Argument.

In the AC/DC argument session, students were not fully responsible for all reasoning in their arguments. With the research they had completed online, the historic debate between Edison and Tesla already had data and reasoning present. Therefore, in this case, students were merely responsible for critically examining these arguments and developing one to mirror or match the side they chose to support. In figure 10, major themes and specific participants who exhibited those themes can be seen. Unfortunately, the most common occurrence was an incomplete argument and assignment. In 75% of the participants' arguments multiple parts were missing. In many cases, students did not get past the claim or they developed a claim and put down only a few facts with no connection or reasoning at all. Some students (participants 2 and 11) merely restated what was in the scaffold part of the argument sheet, essentially just repeating questions that were asked of them to help elicit an appropriate piece of the argument. Attempts at reasoning were made, though, and two students cultivated a clearly reasoned connection between their data and their claim. Reasoning patterns were as follows:

The claimant or an unknown source says the claim is true, therefore it is- This fallacy of reasoning and logic is known as the "appeal to an unknown authority," and multiple arguments contained this reasoning. There are multiple instances of this reasoning

Participant 2 -"Because my evidence supports my claim because my evidence is correct, "and "The scientific theory supports my claim because it's the truth."

Participant 6 – "It support(sic) my claim because it is better"

Participant 7 – "I say that DC is better"

Each of these statements would have the opposition believe the claimant merely because they state they are correct or they say there is science to support them. In these arguments there were no clear data to suggest that fact.

My evidence proves to be good/my evidence is correct/ because it's the truth- Here the reasoning pattern seems to merely present evidence, but there was no logical or effective reasoning to connect that evidence to a claim other than the fact that evidence was present.

Participant 2-"Everything that uses batteries runs on DC power."

The participant has given a key piece of evidence that could be reasoned and connected to his or her claim by simply using the reasoning pattern known as "common practice," which states that a claim is already a common practice by many and is therefore a correct choice/option. That connection was not made, though.

Participant 3 – "AC is too powerful."

This could have been a key piece of an argument, as it was a potent piece of evidence. However here, the student had no specific data and there was no warrant or backing to develop reasoning.

Participant 9 – “That AC transformers allow the power companies to step-up the voltage of the power produced.”

Here the participant had a clear piece of scientific and content based evidence related to an advantage of AC power that could have easily been connected to the overall claim. However, when the student filled in the reasoning piece of the scaffold, only an incomplete sentence was produced, “It supports my claim because…,” which was an unfinished response to that scaffold question.

Giving reasons (less expensive, better quality) with no data. No complete thought or direction – Many students seemed to understand why their reasons would support one type of current electricity over another. They used the reasoning pattern of a more positive outcome in order to convince. However, their reasoning came without any data or evidence to support it, leaving the reasoning lacking any likelihood of being effective. Without evidence, this kind of reasoning was similar to, but better than merely stating that your opposition should trust you.

Participant 11 – “I think that DC is better than AC because it’s safer.”

This could be a good reason, but the participant gave no correct or clear evidence to connect this thought to the claim.

Participant 13 – “…that AC power is a much more efficient power than DC power.”

This student also had a solid reason for the use of AC power; however, none of the evidentiary support given actually supported this reason.

Participant 16 – “AC is power the world’s electricity and it controls all large scale power…”

This student used a “common practice” reasoning pattern, but has supplied absolutely no evidence or data to support it. Data given by the student was inaccurate and not connected to this reason in any way.

Clear reasoning pattern of Better Outcome with associated data with the purpose of supporting that reasoning. - These students showed a clear reasoning pattern with a claim, data/evidence, and reasons that specific data and evidence supported the claim. These were quality examples of the beginnings of a complete argument.

Participant 1 – “DC saves more power than AC. Greater energy efficiency.”

Here the student used the reasoning pattern of “better outcomes” clearly connected with specific evidence that came from a reputable source, “ABB estimates the savings from using DC instead of AC in buildings could be in the order of 10 to 20 percent.” The idea of greater efficiency was supported by data estimates of actual savings involved. Participant 1 showed an understanding of the basic tenets of argument and produced a quality example.

Participant 12 – “AC was a better type of electricity for homes and businesses around the country.”

This student clearly showed his or her claim that AC Power is better and results in a better outcome for homes and businesses. That reasoning was supported by specific electricity and magnetism knowledge that, “DC could only work one or two miles away (from the source); AC was proven to travel longer than DC.” The fact that AC current can travel longer distances proves the reasoning that it is a better choice for homes and businesses. The scientific theory that AC voltage can be stepped up for travel was the basis for this designation.

Participant 14 – “DC has a greater energy efficiency, which helps control costs more than AC would.”

The reasoning of a “better outcome” through greater efficiency and lower costs was supported by data that DC power has, “Higher power quality, smaller equipment, and less complexity.” The efficiency of DC power came from data pieces that the student provided. This could have been made stronger by being more specific, but the reasoning pattern and support were there.

Table 10: Themes in ACDC Argument

Theme	Participant Number
stating that you are trying to prove AC or DC is better	1, 2, 4, 5,9,10,16
I am saying/ some people say…is better - reasoning that because you say it is better or because an unknown source says it is better, then it is	2,6,7
my evidence proves to be good/my evidence is correct/ because it's the truth- - assuming that the other party understands your reasoning without stating any reasoning at all	2,3, 4,5,6,7,9
others may think…if they disagree…I can say - restating scaffolding instructions for counterargument/rebuttal	2,11
Better Outcome - Clear reasoning with associated data with the purpose of supporting that reasoning.	1,12, 14
Giving reasons (less expensive, better quality) with no data. No complete thought or direction	4,6,7,8,9,11,13,16
Incomplete	3,5,6,7,8,9,10,11,12,13,14,16
Placing reasons (less expensive, better quality) where data go in the chart	1,6,7,13,14,16

Series and Parallel Wiring Argument Essays

In the Series and Parallel argument, students worked to complete the Creating an Argument scaffold in pairs for a small amount of time, and then developed their ideas in essay form individually. Students had experienced activities, lecture notes, a laboratory day, and other practice in class to develop their knowledge and understanding of series and parallel wiring, including the benefits and drawbacks of each. Figure 11 displays reasoning patterns and attempts to reason and support claims that students used in their individual essays. One of the first things noticeable was a lack of incomplete assignments. These students at a minimum had claims and data or claims and reasoning. In examining data sheets that went along with the essays, the assumption can be made that in most cases, students thought they had a complete argument, but were misusing or mislabeling their data or reasoning. In this session, more reasoning patterns appear in students' arguments. One glaring issue for this session stemmed from misunderstandings of certain concepts concerning series and parallel wiring, leading to inaccurate or false reasoning for the participants. In some cases, students portrayed both quality reasoning patterns for some data and a lack of reasoning or data in other cases. A significant number of students showed quality reasoning connected to clear data and support.

Argument from Popular Opinion/Argument from Expert Opinion – In these cases, of which there were only two, both good and bad scenarios presented themselves. In one case, a student used the false reasoning of "popular opinion", and in the other, the reasoning of "expert opinion."

Participant 5 – "Over 60% of people prefer parallel circuits because they do not have to worry about their lights going out."

The student had a specific piece of data connected to the statistic, which was generally good. However, this is merely popular opinion and that is a fallacy of reasoning which generally does not support a claim fully. As this was the only piece of quality evidence and reasoning offered, participant 5 did not show a quality argument.

Participant 2 – "The scientists at Mythbusters proved that parallel circuits are better."

In the classroom, I allowed (when asked specifically) that the Mythbusters would be considered experts in this argument scenario. With that in mind, the student used an accurate and quality bit of reasoning known as expert opinion. The student supported this reasoning with data that the Mythbusters gathered making the argument complete.

Argument from common practice – this is already in use and therefore is the correct method – Multiple students appealed to the reasoning of "common practice." In these cases, the claimant was supportive of a particular wiring design that was already most commonly used by businesses and homeowners. These students also supported this line of reasoning by supplying data as to why parallel wiring was used most often.

Participant 3 – "When one branch of a parallel circuit is opened, the rest stay on. This is the reason parallel circuits are used for houses and businesses."

This student succinctly stated the reason of common usage and supported it with data from their electricity and magnetism understanding.

Participant 7 – "The wiring in our houses is always parallel wiring because if it was series the lights would be dimmer (the resistance gets higher with every additional load) and they would all go out every time one light goes out (the circuit is opened)."

This participant supplied the common practice reasoning and then supplied two pieces of scientific evidence to support that reasoning.

Participant 8 – "You want your house to have parallel circuits because in a series circuit the lights are less bright when you add more."

Here was the same "common practice" reasoning and a piece of evidence that undoubtedly supported it with electricity and magnetism specific content knowledge.

Argument from Example or Consequences- These students generally used an appeal to personal experience and gave an example of possible consequences of that experience. Setting the stage with a problem that could take place or a positive effect allowed the opposition to see the folly in their position or reasoning so they could make an informed decision to support the claimant. In these cases, the evidence was similar to previous cases of "common practice," however they were categorized separately because of an explicit appeal to the reader or opposition.

Participant 6 – After an explanation of what would happen if a light went out in a series circuit in your house and the same in a parallel circuit, the student asked "Series wouldn't be worth the time and have you thought about that?"

Although this student did make the appeal to common practice and support her reasoning with clear and concise data, she added the flair of appealing to a personal experience a reader might have had to fully reason through the issue. Participant 12 made a very similar argument with a similar appeal to the reader for an examination of a real life situation.

Participant 16 – Here the student detailed the branches of a parallel circuit and gave scientific evidentiary support as to how power stays on when a branch goes out. This student then went on to make a common appeal to anyone who has dealt with Christmas lights, which are generally wired in series circuits.

"Take Christmas lights for example, when one light goes out all of the rest of the lights go out as well and you have to find and replace the bulb that burned out. What a pain!!!"

Although many students used a comparative analysis of types of wiring in high quality arguments represented through the above scenarios, there were many cases of students who stopped just short of supplying clear reasoning to accompany their comparison. In addition, the session dealing with series and parallel wiring saw a large number of students who had a misunderstanding of concepts and therefore argued with false evidence or incorrect evidence and reasoning. Some examples of this included:

Participant 2- “When the lights go out in a series circuit after one bulb goes out, you have to replace all of the bulbs.”

Participant 13 – “A parallel circuit has many wires each with a switch but a series circuit only has one wire and one switch”

Participant 1 – “Parallel circuits run by themselves with no non-useful parts in them.”

Gas Station Explosions Argument

In the gas station argument session, students worked in groups of 3 and 4 in order to develop an argument using the full array of scaffold sheets I created. Students then participated in an online discussion in which they detailed their claim, evidence, and reasoning and followed that up by offering counterarguments to other students. A final post was made in which groups would rebut the counterarguments suggested by their classmates. Class discussions debriefed the activities and help with argument production. In preparation of this argument, students received instruction and demonstrations concerning static electricity and static discharge, watched an episode of Mythbusters on the topic and read an article detailing news items in which gas stations had exploded due to static discharge at gas pumps. In figure 12 basic reasoning patterns used by the groups can be seen. In general groups supplied at least one instance of reasoning for their claim supported by evidence.

Table 11: Themes in Series/Parallel Argument

Theme	Participant Number
Argument from popular opinion	5
Argument from Common Practice - (houses and businesses are wired in parallel)-people are already doing it (stating or showing that people are already using parallel wiring more)	2, 3, 6, 7,8, 15,
evidence with no reason attached (essentially stating facts/what is known about the subject)- Data/examples with no reasoning connecting it to anything	7, 3, 9, 8, 10, 1,
Reason with no data to support it (efficiency)	11,2, 9, 12
Misunderstood concept leading to false reasoning and data	1, 2, 6, 8, 13, 14, 15, 16
Argument from Expert opinion	2,
Appeal to personal experience (You wouldn't want all the power going out in your house, would you)/ real world example/illustration	6, 8 (Twice), 12, 16
Comparison in attributes- series if bulb goes out vs. parallel if bulb goes out	4, 5, 7, 11, 2, 3, 9, 8, 6, 16, 10, 1, 13, 12, 14

Argument from Waste - Only effects small number of people/small percentage of incidents – This reasoning pattern suggested that there was not enough of an issue to dictate a change in the way people pump their gas or laws/regulations surrounding the process. The general idea was that it would be wasteful and unnecessary, causing undo stress and trouble for people.

Group 1 – "There are over 7.2 billion people in the world, just because 150 of them have reported that they had a gas station accident doesn't mean we should change the way everybody does something."

This group had a clear connection to specific evidence as cited from the article read in class. For this session, the article was acceptable as factual data.

Group 2 – "People pump gas 12 billion times a year and over the last ten years only 150 gas fires have happened. Changing the rules would be too much trouble."

Here was another instance of clear evidence and reasoning to support the group's claim that we should not change laws or regulations regarding how gas is pumped at gas stations.

Argument from Consequences - If anyone gets hurt it is too many -

Group 4 – "We cannot ignore that these fires are happening. If anyone gets hurt and it can be prevented it is uncalled for. Something must be done to prevent people from building a static charge and starting fires. 150 fires in any amount of time are too many."

The data of 150 gas station fires reported was reasoned with the safety of individuals and the fact that any negative consequences that could be prevented should indeed be prevented if possible.

Argument from Expert Opinion – These students used the opinion of an expert portrayed on the Mythbusters episode to show that a sign should be placed at gas pumps warning of static discharge and possible consequences.

Group 5 – "Infuriated expert electrical engineer Steven Fowler said the solution is to put up stickers that read 'Touch Me' that are placed over metal. When the people touch them, their bodies discharge the static electricity safely."

Along with this expert opinion, these students went on to use their electricity and magnetism knowledge to explain static electricity, static discharge, and how this can start a fire and explosion at a gas pump. Group 4 made a similar argument in a very similar way.

Argument from Example/Cause and Effect- Relating story or real live event – Groups 1, 2, and 3 specifically related the story from the article that was provided about a person being severely burned after a gas pump burst into flames following a static discharge from that person to the metal pump. Along with this story, these groups provided electricity and magnetism understandings that provided for direct correlation of cause and effect specific to igniting a fire. These arguments followed the pattern in this example:

Group 3 – "Take for example Carol. Carol was pumping gas…the pump ignited from the static discharge...static electricity is being created when you get in and out of your car and can be discharged to the metal pump…This is really dangerous and we should have a different way of pumping gas in order to prevent a tragedy like Carol's."

Argument from Existing Rule/Practice – In addition to the argument made to determine that there was an issue that needed to be corrected, one group offered another reasoning pattern concerning an established practice in two states where only gas station attendants legally dispense gasoline.

They argued that this should be the change made and provided evidence from their research, that those states had lower occurrences of gas station fires.

Group 3 – "As is shown, Oregon and New Jersey have less gas station fires and you cannot pump your own gas there. We should follow these states and everyone should do it their way."

Table 12: Themes in Gas Station Argument

Theme	Group Number
Argument from Waste - Only effects small number of people/small percentage of incidents so we should not change anything (clear connection of data to reasoning)	1, 2, 3
Argument from Consequences - If anyone gets hurt it is too many - data connected to reasoning	4
Argument from Expert opinion	4, 5
Argument from Example/Cause and Effect- Relating story or real live event	1, 2, 3,
Argument from Existing Rule/Practice	3

High Voltage Power Lines: Bury or Not?

The argument session dealing with High Voltage Power lines was the culminating and summative argument of the electricity and Magnetism Unit. This activity spanned three class days. On the first day pairs of students researched the topic of High Voltage power lines through a variety of teacher provided websites and documents. I circulated throughout the room and was available to students as a resource as well. By this time, students were through a majority of the electricity and magnetism content and could apply associated theory and knowledge to their research and argument. On the second day, pairs used scaffolds provided in order to complete the Creating an Argument Scaffold. On the final day, students produced either an animated video or PowerPoint presentation (their choice) portraying their completed argument. Class presentations followed as a crowning activity. As can be seen from table 13, students not only developed complete and thorough arguments, but they used multiple lines of reasoning in their final presentations. In addition, in almost all cases, students supplied complete and accurate evidence to support their claims.

Argument from Consequences – As was the case with the three main argument and reasoning schemes used by students, most participants related consequences of burying or not burying power lines as reasons to support their claims. This reasoning in support of their claims connected different kinds of data depending on the situation, but data was commonly that of reputable sources that contributed to the power of the argument.

Participants 1 and 12 – The claim of not burying power lines was connected to data that, "It costs hundreds of thousands of dollars to bury a power line for just a mile. This is 5 times more expensive that leaving power lines as they are." Data were connected to the claim with reasoning that, "scientists state that burying the power lines is a burden on taxpayers, because they are spending their money on something that (is) a 'product' that has an unknown lifespan." These participants showed data/evidence about the cost of burying the power lines and reasoning that the burden falls on the taxpayers triggering an unwanted consequence. The connections were clear and the support was solid.

Participants 7 and 9 – The claim here was that burying power lines was beneficial. Data stated that, "Above ground power lines are vulnerable, particularly during tornadoes, ice storms, and severe winter weather. Statistics shows 3 out of 5 tragedies that involves (sic) taking the lives of innocent people during these storms are due to downed power lines." That data was connected to the claim through reasoning that, "Consequences of not burying the power lines outweigh the cost of burying them. A lot of lives will not be lost if the lines are buried so they do not break in storms." Here participants were examining the cost in human lives of not burying power lines. They specifically mentioned that the consequences would be unreasonable and added a bit of a rebuttal to the counterargument of the high monetary cost at the same time.

Argument from Expert Opinion – The students who argued from expert opinion generally examined scientific research connecting or showing no correlation between electromagnetic fields produced by high voltage power lines and certain instances of cancer, specifically childhood leukemia. Many scientists conducting research in the field have strong opinions and that information was made available to participants during this argument session.

Participant 4 – Here the student gave a large amount of research conclusions, "Based on studies about the incidence of childhood leukemia involving a large number of households, NIEHS found that power line magnetic fields are a possible cause of cancer, abnormal heart rhythms, miscarriages, low birth weight, birth defects, and other illnesses that might lead to premature death." This data was connected to the claim asserting power lines should be buried through the reasoning of "expert pinion" that, "Scientists say that power lines should be buried to keep us safe," and "there shouldn't be a cost to people's safety." The use of the scientists in proximity to the statement about keeping us safe and reasoning that there should not be a cost to people's safety clarified the intent of evidence provided and reasoning connecting it to the claim.

Participant 10 – This student listed a multitude of data in support of the claim that power lines are dangerous when above ground and thus should be buried. “High voltage power lines create high electromagnetic fields around them and expose anything nearby to electromagnetic radiation. The health of the people is affected because of these power lines. Over the 20 years, multiple studies have been published reviewing the affect (sic) of high – voltage lines on human health.” That data was connected to their claim through the reasoning that, “In 1998 , a working group, organized by the national institution of environmental health sciences found out that the exposure of power lines can be the cause of cancer and the burying of high voltage power lines reduces that cause.” Here an entire group of scientists stated that the lines should be buried in order to eliminate the risk of exposure to EMF radiation. This was another case of specific use of an “expert opinion” reasoning pattern.

Argument from Cause/Effect – This line of reasoning is similar to what has already been discussed here. The specific use of cause and effect terminology emanating from a discussion of EMF radiation and then continuing into the specific effects that it causes in humans led me to qualify this as a separate theme and line of reasoning.

Participants 8 and 16 – These participants focused more on the cause and effect reasoning line and data so they exemplified what others also did on a smaller scale. These students provided data such as, “The hum of the EMF radiation can be heard near the lines…some people feel a shock (static discharge) when they are close to the lines…EMF is bad and we show that people feel it near the lines.” They continue to detail that as a cause of, “possible dangers and or injuries to a child’s heath…and… building an underground power line is safer than power lines above ground." The effect of burying high voltage power lines was shown to be that children would be safer and it was assumed there would be fewer instances of some types of cancers.

Participant 14 – This student took a somewhat different cause and effect approach by negating a causal relationship as a reason not to bury power lines. They articulated that, "Scientists have shown no verifiable link between cancer and high voltage power lines." The student further associated the cause of burying power lines to the effects of, "If something goes wrong, we would have to dig them out and fix them." Connecting that cause and effect relationship with reasoning was close in the student's presentation, as they stated, "It will be more trouble digging the power lines out , would be more expensive to dig them out and bury them again." The cause of burying power lines was linked specifically to the effect of having issues with repairing the lines and reasoned that it would be a heavy burden for the economy. The student further posited that, "Our country can't afford to buy expensive equipment to bury, dig up, and then bury again" the power lines. Here the participant used the cause and effect line of argument to support and reason through their product.

Argument from Existing Practice – Only one student included the reasoning of "existing practice" as part of their argument, but as it was a scheme that was used previously in other arguments during the unit, it was included here as well. The student linked the fact that there is already a practice of burying power lines and used that to reason others should follow suit.

Participant 4 – Using their previously stated data concerning possible dangerous effects of exposure to EMF radiation and the likelihood that it emanates from high voltage power lines, this student used evidence that there are already states that place specific limits on these power lines such as, “seven states set standards for the width of right-of-ways under high-voltage transmission lines because of potential for electric shock.” This additional piece of evidence was connected to the claim that power lines should be buried through reasoning that, “If states are taking precaution (sic) against the power lines, this is a serious matter, and something should be done. So bury the power lines.” The argument from existing practice was complete and thorough.

Reasoning with no data – Unfortunately, one participant still struggled with the concept of providing data to support a claim and connecting them with reasoning. This student provided reasoning but did not have real data or evidence to support it. He detailed a claim against burying power lines. The provided text has examples of items that he may have considered data, but were not scientific or based in any fact. His list included, “is too expensive, it ruins the property.” Another was that, “Underground transmission lines do not completely eliminate the need for overhead structures.” There was no real data, these all appear as reasons to not bury the lines, yet there was no support or proof to solidify that claim.

Table 13: Themes in Power Lines Argument

Theme	Participant Number
Argument From Consequences	1,2,3,4,6,7,8, 9,10,12, 13, 14,15
Argument from Expert opinion	1,2,3,4,6,7,9,10,12, 13, 14,15
Argument from Cause/Effect	1,2,3,5,6,8, 7,9,12, 13,14,15, 16
Argument from Existing Practice	4
Reasoning with no data	5

Summary of Qualitative Analysis: Reasoning Patterns

The quantitative analysis of each argument session detailed the patterns of reasoning specific to subject matter involved and electricity and magnetism knowledge therein. The argument comprised of alternating and direct current was the first attempt by students to detail an argument using the Creating and Argument Scaffold. Students researched historic arguments between Thomas Edison and Nikola Tesla and detailed an argument for support of AC or DC power as the best way to power the world. In general, students did not demonstrate the ability to complete arguments using the scaffold. Participants did not show skills at providing evidence and reasoning together to connect to a claim they supported. The most common fallacy of reasoning present was that of an "appeal to an unknown source/opinion." Students stated that "people" supported their claim. The only strong reasoning was in the form of an "appeal to better outcomes.' These students showed data to support the fact that their chosen form of electricity was better for powering the world and connected it with reasons as to why.

In the second argument session, students applied their understandings of electricity and magnetism knowledge in the form of an argument concerning whether series or parallel wiring was, in general, better. Students had been studying series and parallel circuits for several days at the time of the argument session. They showed only a slightly improved grasp of the concept of argumentation and reasoning patterns in the arguments they created. The most common of these patterns expressed in student essays were: Argument from popular opinion, Argument from Common Practice - (houses and businesses are wired in parallel), Argument from Existing Practice (stating or showing that people are already using parallel wiring more) Argument from Expert opinion, and Appeal to personal experience (You wouldn't want all the power going out in your house, would you)/ real world example/illustration). Students had a greater variety of reasoning patterns present. Unfortunately, students also showed some serious errors when creating arguments. Issues were: having evidence with no reason attached (essentially stating facts/what is known about the subject), giving reasons with no data to support them, and a misunderstanding of the electricity and magnetism concepts involved leading to improper arguments unsupportable through data and reasoning.

The third opportunity for creating arguments was a scenario involving fires at gas stations caused by static electricity discharge. Students studied static electricity for several days before the assignment began. Students read an article from a reputable news magazine and watched an episode of Mythbusters to develop background in the specific problem. Participants worked in groups to cultivate an argument and post it to an online forum. In their arguments, they used the background of the problem along with their electricity and magnetism knowledge in order to argue a claim either for or against changing rules and regulations regarding pumping gas at service stations. In this analysis, a smaller array of reasoning patterns emerged and no groups were found to have underdeveloped basic arguments. Argument and reasoning patterns found during the analysis were: Argument from Waste – (Only affects small number of people/small percentage of incidents so we should not change anything), Argument from Consequences (If anyone gets hurt it is too many), Argument from Expert Opinion, Argument from Example/Cause and Effect (relating story or real live event), and Argument from Existing Rule/Practice.

The fourth and final opportunity for argumentation during the electricity and magnetism unit was the summative assessment. Students spent three days in class working their way through research, using scaffolds, writing out their arguments, and making presentations involving the topic of high voltage power lines. The variety of reasoning patterns used was limited here, but almost every group made use of multiple argument and reasoning patterns to support their claim, leading to high quality arguments. Argument and reasoning patterns used by the participants during this session were: Argument from Consequences, Argument from Expert opinion, Argument from Cause/Effect, and Argument from Existing Practice. Only one student submitted an argument without a clear reasoning pattern to connect their data to a claim.

Qualitative Analysis: Student Perceptions

Student perception and experience interview questions were designed to develop an understanding of what worked during the unit, what may not have worked, what was challenging, what came more naturally to students, how the students felt their understanding changed throughout the unit, and in which environment (individual, pairs, groups discussion) they learned best. To facilitate an understanding of student responses and attitudes, a grounded theory style analysis was performed on the data. Student responses were analyzed to determine common themes, and those themes were tested against all responses. The goal was to develop an understanding of how students learned and progressed through their understanding of argumentation as they navigated the electricity and magnetism unit. The overarching goal was to ascertain the effects of my researcher methodology and an effective way of teaching scientific argumentation in science classes. Figure 14 displays the results of the thematic analysis performed on student responses.

Table 14: Themes in Student Perception Questions

Theme	Participant Number
Overall Perceptions on argument what was learned	
Searching for data and learning the facts is helpful	1, 5, 8, 9, 10
Argumentation leads to better understandings	1, 4, 5, 6, 7, 8, 9, 12,14,
Argument helps you to see both sides, expanding understanding of whole topic	2, 6, 13,
Better understanding of argumentation now	6, 7, 8, 9, 1, 4,
Critical thinking	15, 16
Argument that relates to me is better	6, 15
Parts of the Argument	
claim is the most important part	1, 4, 5, 7, 14
counterarguments and rebuttals are important, make you see both sides	2, 3, 4, 6, 7, 9,10, 13, 14, 15, 16
Argument needs facts/Data to be effective but finding enough can be difficult	3, 5, 8, 9, 10, 11, 12, 14, 16
Work Environment/Groupings	
Paired groupings allow for more opinions and better arguments	1, 3, 4, 5, 6, 7, 8,9, 10, 11, 12, 13,
Discussions are helpful	5, 7
Alone is better	14, 16

During analysis, I progressed through all student interview answers and wrote down responses that actually answered the question asked and had anything to do with argumentation. Many students chose not to answer some of the questions and some answered with responses related to science laboratory, computer based exercises, or other teaching tools not related to argumentation in any way. The list of responses generated with a correlation to scientific argumentation was extensive. Through the first phase of analysis, I noted words and phrases that linked responses to questions with similar topics in order to narrow the list from each individual's response, to a more fluid group mindset. During this, three overarching thematic groups emerged from the data. Students seemed most able to articulate their opinions detailing their classroom groupings, specific parts of argument, and overall perceptions of the processes involved in argumentation and the learning that took place. Responses students gave in the areas of argument and learning were inextricably linked. Students connected their learning and their skills to the production of, and preparation for, arguments. It seemed as though participants understood that argument was a learning tool and process.

Once predominant themes had revealed themselves, ideas students related within those themes needed to be categorized and narrowed to discover base ideologies present in their responses. In order to identify a group consensus, if there was one, each theme needed to be tested against each student's responses to see if it fit with what they thought or it was a separate idea altogether. Wertz, et.al. (2011) speak of the "Human Science Attitude" with regard to understanding and identifying what the subject is conveying through an understanding of the individual and his or her ideas and attitudes. As the teacher of these participants for the entire school year, relationships with students and understandings developed over the course of that time and allowed me to deeply analyze students' responses and categorize them with regard to those understandings. In many cases students were clear with their responses and ideas, making this process tedious, but not arduous. Through a back and forth set of "conversations" between me and the data, the sets of subsequent themes presented in table 13 came to light and a greater understanding of what students experienced and gleaned from the involvement in the intervention began to develop.

Parts of the Argument

It seemed prudent to begin with student understandings and opinions on the subject of the parts of an argument. Through this analysis, I was able to understand what they learned about individual parts of the whole that is scientific argumentation. In the intervention, the parts of an argument was one of the very first things taught in the unit, thereby it also seems an appropriate place to start here.

Claim is the most important part. Participants developed an understanding that the claim is a central part, or heart, of an argument. It is the claim that the arguer is trying to convince someone of and it is the claim that all else is connected to. Almost half of the participants indicated that the claim was the most important part of an argument.

Participant 4 – “Without your claim you have no information, no structure, or meaning in your argument.”

Here the student distinctively looked at the idea of structure and meaning in the process of creating an argument. Without structure, there is no meaning. The argument was centered on an idea of which the participant was trying to convince others.

Participant 5 – “because it explains what position you are in.”

Similarly here, the idea was the centerpiece and explained the position that arguers stood in support of.

Participant 14 – “I think the most important part of an argument is a claim, because if you don’t have a claim you don’t know what you’re talking about, or you don’t know what kind of facts to collect.”

Along the same lines as the structure, this student saw that the claim led them to collect facts in support of that idea, pushing the students to learn more about what they were in dispute over and continued the deepening of their knowledge.

Argument needs facts/Data to be effective (but finding enough can be difficult). Data and facts with regard to argument was a strong theme specifically. More than half of students here presented data as a topic of concern in some way. Many students determined that data was important to the argument, as the best way to convince the opposition resides in the presence of factual information. Data in scientific argument is essential. Without emotional evidence and appeals, the claim in scientific argumentation is based on evidence and theory specifically.

Participant 9 – "I think the most important part of an argument is the information. It's important because without information u can't do anything."

This participant displayed an important understanding in scientific argumentation…without specific information, argument is not scientific in nature. There is nowhere for the claimant to progress without theory or fact in support of a claim. This was an important step for students, as scientific argumentation uses evidence as a basis for constructing claims.

Participant 14 - "I like to prove my point, so I would collect a lot of evidence to prove that I'm right."

Here again the student had the understanding that it is evidence used in argument that does much of the business of convincing the opposition of the accuracy of a claim. The use of the word "prove" showed again that the action of convincing necessitates data in a scientific argument.

Participant 5 - “I think collecting all the data is difficult when making an argument. I think it is challenging because you are trying to convince your reader of being on your side.”

Again the participant showed understanding of data’s pivotal role in argument, but here the student identified a struggle related to her performance in argument as she learned new material in the unit. Data collection (as previously shown in the argument rankings) was a point of weakness for many students throughout the electricity and magnetism unit. This participant in particular struggled through the entire unit and had data issues on the summative argument session as well.

Participant 8 – “the most difficult experience would have to be coming up with lots of facts and evidence”

Again a student identified with the struggle of developing and researching data to support their arguments throughout the unit. When attempting to learn new information through performance of argument, students needed a complete understanding of the topics in order to detail appropriate data and evidence in support of their claims. A little more than 20% of students mentioned this struggle with data in their written responses.

Counterarguments and rebuttals are important because they make you see both sides. A majority of the respondents mentioned the idea of counterarguments and rebuttals. A general congruence in ideas among the participants here showed that they saw the benefit of counterarguments and rebuttals with relation to examining the opposing side of an argument and then seeing the folly or holes in their own argument. This “seeing both sides” allowed for students to construct what they saw as stronger arguments. The responses asserted that act of developing counterargument to one's own argument and a rebuttal to defend against that counterargument allowed for students to develop more confidence in their product and abilities.

Participant 2 – "…arguing back and forth. Like when they disagree and I show them proof; which made me think more and change some of my support"

The students experienced a "back and forth" scenario twice in the unit. First, they completed discussions in an online forum. They supplied their arguments, waited for other groups to counter their arguments, and then developed rebuttals. They also experienced this in the summative argument session as they matched their paired grouping with an opposing paired group to see opposing viewpoints. Here, the participant showed a clear understanding that the opposition's disagreement along with proof needed to convince them of the claimant's superior ideas caused a reexamination of, and some change in, evidence supporting their original claim.

Participant 4 - "I think the most beneficial was the rebuttal because it made my argument even stronger. At the beginning I struggled with creating it because I did not know what to say after the counterargument. Then I figured out how to get more information I can come back with and make a rebuttal."

This student made a direct connection to the establishment of a rebuttal as a key motive for collecting more data. In the scientific argumentation process, when there is an issue with proof or a claim needs further substantiation after an opposing theory or view is detailed, one would acquire or develop more data. Here the participant specified that idea.

Participant 16 – “I believe (my strength) is when I am creating my rebuttal. I think I am good at finding out everything that is wrong with my argument. I like it because it helps me better understand the argument and make a better counter argument and shows that my argument is the better argument.”

This student has summed up the theme of counterarguments and rebuttals well in their statement. She saw the purpose of thinking about counterargument during individual argument construction in order to discover any issues in data or reasoning. She saw the need to increase their understanding of the subject matter and create a rebuttal, thus making her argument stronger.

Many students saw the rebuttal as forcing them to look up more information and to examine the other side of the argument. Specifically, they did not see the benefit of seeing the other side of the argument, rather they saw it as a chore in order to defend their argument or defeat the other side.

Participant 9 – “The difficult part about creating an argument was thinking about what the other person will say. It makes it difficult because u (sic) never know what the person might say or do & u always got to have information to back it up.”

Here the student stated her difficulty in considering the other side of their argument. However, this is important in scientific argumentation because scientists are convincing others of their ideas and thus must understand other points of view, if they plan to negate them. The respondent decidedly comprehended the idea of finding information to back up her ideas to defend against a counterargument.

Participant 13 – “The most difficult part of processing the argument is probably what you have to say after the other person already said something because you don’t know what they are going to say.”

This student saw the difficulty in rebuttals as stemming from not knowing what the other side was going to say. This highlighted an issue observed in the first two argument sessions as students did not want to think of the other side of the argument to develop their understanding of the opposition. For many students this got better, but for some it seemed an onerous and time consuming task.

Work Environment/Groupings

Themes present in the questions regarding how students were grouped in class were organized in the data clearly by student responses. The students were very clear about their choices as to how they worked and learned best. They related their ideas well to their experience with argumentation and how their specific choices affected their learning and performance in the argument sessions.

Paired groupings allow for more opinions and better arguments. Overwhelmingly, students preferred the experience of paired groupings for argument sessions. They stated a variety of reasons, but most related to aid that another person gave in the thought processes involved with creating arguments. The response was specific and a clear majority. Students experienced individual work, paired work, small group work and whole class discussions. In the following there is a clear pattern regarding having another person there, yet also a variety of reasoning.

Participant 3 – "…did better in pairs because it's easier to just bounce ideas off of each other"

Here the student referred to the feedback that she received in the conversation and the feedback that she was able to offer her partner. This was important enough to mention specifically for the student as they were working towards a common goal and helping each other to arrive at that goal.

Participant 4 – "I think I did better in a group because I got to see the subject from another person's stand point. For example, when I was doing an argument on burying power lines, all I was thinking about was if we buried them it would decrease the number of people who get leukemia. Other people in the class were talking about how it cost much more money to do that and I did not even think about that."

This student gave a specific example of how her partnership opened their eyes to information and reasoning that they had not thought of previously. The benefit to them of the grouping was specific and helpful in developing stronger arguments.

Participant 8 - "I think we generated more detailed ideas when we were in groups it really gives us a chance to express our own ideas but our partners helped us elaborate on our ideas."

Similarly, this participant enjoyed the experience of sharing ideas, but also the additional benefit of others' help in extending and elaborating those ideas.

Participant 10 - "I think I created better arguments when I was paired with someone else. I think I did better this way because, we both shared are knowledge for the same arguments so it helped us have more data for our claim."

This student cited the particular value of the pair through the development of more data to fuel their argument. A shared responsibility for an overall claim was evident in this response as well.

Participant 12 - "I felt as if it was better creating argument's (sic) in pairs I was able to brainstorm ideas with my partner we look (sic) at our ideas and find out which once would make more sense for our argument."

The concept of brainstorming was not new for these students and here the participant makes note that in addition to the incentive of more ideas, the partner gave assistance in reasoning the highest quality ideas to be used. Pairing aided in developing the most effective argument possible.

Discussions are helpful. A small number of students did not mention the paired grouping but did relay the fact that having the opinions and ideas of others benefitted them in their understandings. These two students mentioned improvements stemming from group discussions.

Participant 5 – "Discussing in class will help students who need help in the topic."

This student needed some extra help with understanding and found that class discussion was significant in filling her needs. Whole class discussions were designed to do just that in this unit.

Participant 7 – "Other people wrote their arguments better than mine and it helped to write with more details or to write it more thoroughly"

Here the participant used the examples and arguments of others as an extra scaffold in developing her own work. This was a benefit of hearing and seeing good quality work as students generated their own product.

Alone is better. Some students felt that working on their own was more beneficial for them. In the classroom, there were some students who operated this way throughout the course of the year. These students preferred to work on their own and were generally successful working in that way.

Participant 14 – "I think I created better arguments by myself, because I was more concentrated. I was more successful this way…"

This student cited the greater concentration he had when he worked on his own. He clearly understood his best environment, as he knew he was more successful going solo.

Participant 16 – "I think it is easier to work alone when constructing an argument, it helps you focus on your argument without other people suggesting things causing you to lose focus and memory on many important details."

This participant also mentioned more focus when working alone. She even mentioned the distractions of having others suggesting different things and causing a lapse in memory regarding the important details. The wording suggested that perhaps this student was not open to others' ideas during discussions.

Overall Perceptions on Argument and Learning

A main purpose of student written questions was to ascertain an understanding of how their perceptions and understandings regarding argument changed over the course of the unit. This would help me develop a more thorough understanding of what worked, how what worked could be used in an advantageous way in the future, what was troubling, and overall benefits students saw in the process. Several themes, as shown in Figure 13, developed from these questions and answers. Some were overwhelmingly iterated, while others came from smaller clusters of participants. Particular ways in which students talked about the smaller themes made them seem important; thus their inclusion here.

Searching for data and learning the facts helpful. These students cited enjoyment of finding data or learning new things. The repetition of words concerning research and searching for data showed that students enjoyed being actively engaged with the learning process. If a joy of learning could be instilled in even a few students through the practice of argumentation, then in the school setting a true higher purpose would have been achieved. While this theme was similar in nature to the concept of argument leading to better understandings, it was separated due to a focus on engagement in the hunt for data.

Participant 1 – “I like finding out the data of what I’m arguing about all the facts and ideas just come together”

Here the student spoke of hunting and finding data in the research process. The process of the hunt helped to bring data and concepts together in her understanding.

Participant 5 – "I think doing the research on the topic really helps me because I get visual pictures and it explains thoroughly"

Again a student insisted that the process of research aided in development of more thorough understandings. Searching for information in order to prove the claim helped with the overall learning outcome.

Participant 10 – "while you are searching data you learn new things"

Short, simple, and concise. This student stated succinctly that the search led to data and understanding. New information and concepts were developed through the research and argumentation process.

Argumentation leads to better understandings. Overwhelmingly students responded that argumentation had led them to develop better understandings of what they were learning. Well over half of respondents mentioned a better comprehension of electricity and magnetism content. The activities surrounding argument and the way in which students had to apply that knowledge in a meaningful way helped them to develop conceptual mastery. Students mentioned that the processes followed in class helped them to remember information as well.

Participant 4 – "I think it was good because while I was learning about my classwork I was learning how to apply that knowledge to the argumentation."

The ability to apply what a student has learned was important to overall understandings. Here the student displays that her application was specifically to argumentation. Teaching of electricity and magnetism information at the same time as concepts of argument led the student to apply one to the other during the process.

Participant 6 – "It helped me learn way more than I knew. I never knew that something so complex could turn out to be so easy."

This student cited the processes of argumentation as aiding in the overall understanding of what they were learning. Essentially, interventions turned something that seemed overly difficult into a learning process that progressed smoothly and simply towards comprehension.

Participant 14 – "I think I understood this lesson more. When I was collecting evidence or facts to prove my point, those facts stayed in my head; we would understand the concept a little more if we included arguments in our class."

Pointedly this participant directly linked her learning to argument. The ways in which interventions made them use knowledge that they were acquiring led to retention of that information. This student went as far as suggesting that argument be used more in class.

Better understanding of argumentation now. One of the goals of this research was to cultivate an understanding of scientific argumentation in these students. Almost half of the participants cited a better understanding of argumentation in their responses. These examples were exemplary of those associations:

Participant 4 – "My understanding of arguments has changed a lot because I felt I have improved on one certain part. The part I contributed on the most was the claim and rebuttal."

This participant believed that an understanding of argument was improved greatly through the interventions. The specific mention of the claim and rebuttal pieces signified that improved understanding was likely to be the case.

Participant 7 – “The argumentation unit helped me because I can now give specific details, facts, and or statistics to support my claim”

This student showed an understanding of parts of argument needed to support a claim. Development of this knowledge over the unit likely led to the conclusion of the unit helping them improve their understanding and prowess at argument.

Participant 9 – “At first I didn’t understand argumentation but as we went one through the unit I understood more.”

Here is a clear example of a student that saw his own improvement as he progressed through the intervention unit. This student stated quite matter-of-factly that he learned more about the process as the unit went on.

Critical thinking. Here I understood the value that students receive from understanding critical thinking. As a teacher, I have heard many in the realm of education say that critical thinking is important and should be taught, but rarely does one define the concept and divulge how one might teach it. Although it was only two students who specifically referred to critical thinking or the ideas represented in critical thinking, the importance of the concept led me to include the theme.

Participant 15 – “While researching you have to make sure the data is useful and not a person opinion.”

This student highlighted a difficult skill for many students to develop (in my experience). The usefulness, appropriateness, and factual basis of data are pivotal to the success of an argument. The participant identified this as an important factor, showing a grasp of critical thinking as a necessary skill to garner from argument based lessons.

Participant 16 – “The hardest part would be coming up with the reasoning because it is very easy to mistake it for data and evidence, most people don’t understand that it means coming up with a reason that your data and evidence supports your claim, they just think that it is reason why your claim is better than the opposing claim so that is the most difficult one.”

Here the student critically assessed the scenario in which one could be confused by the concepts of data and reasoning. The fact that he detailed this issue pointed to an understanding of these concepts and an ability to distinguish between them. The participant also understood that the issue could arise in others works, thereby exhibiting an expertise that he would require to critically evaluate those other works.

*Argument that relates to me is better***.** Much attention has been given to the quality of work produced by students in the areas of scientific argument and socio-scientific argument (Jimenez-Aleixandre, 2002; Sadler, 2004; Kolsto, 2006; Sadler and Donnely, 2007, Von Aufschnaiter et.al., 2007). During the course of the unit on electricity and magnetism, both scientific and socio-scientific arguments were performed. Here, each of these students spoke of the personal connection that they had to the topic of the socio-scientific argument. In their recollections, the emotional piece as a socio-scientific topic seemed to draw the participants in more intensely.

Participant 6 – “The power lines and electricity was the most interesting to me. Why? Because I can relate that to my everyday life and it’s something I actually liked working on and I could break it down.”

The way in which the student related to the topic was of great importance to their engagement with the argument during this socio-scientific session. Their description denoted that they could more effectively deconstruct the topic because they enjoyed the experience. That connection led to a better overall performance.

Participant 15 – “While working with this argument it made me want to participate to construct an argument, because I wanted to prove my point buried power lines is a safer and better way to have your power lines to protect children like me.”

The student showed a personal relationship to the topic as she described the safety concerns for “children like me.” A personal connection was evident. With that in mind, the idea that she had a greater desire to participate and prove her point must stem from that personal connection. The student saw this topic as affecting her and her life and thus any improvement she could convince the opposition of would also affect her specifically.

Summary of Qualitative Analysis: Student Perceptions

In examining student perception written responses, a grounded theory styled approach was used to develop themes representative of how students learned, expanded their knowledge and comprehension, and how scientific argumentation might be suited for teaching content in science classes. During the analysis, three primary classifications emerged from the data. These grand themes included: classroom groupings, pieces of the argument, and students' overall perceptions of argumentation and its effects on their learning. When examining the theme of how students were grouped during the argument sessions, it was clear that the student preferred working in pairs. A great majority of participants gave comprehensive descriptions of their perceived benefits in these pairings.   Within the perception questions, students were queried as to specific parts of argument, their importance, and perceived skill level that students had on those parts. From those sections, specific themes emerged. Nearly half of the respondents directly recognized the claim as a fundamental piece of the argument. They saw that the claim served as the keystone from which the argument progressed. Also, a majority of students found that counterarguments and rebuttals were important to the development of strong and successful arguments.   In addition, participants delineated that arguments needed data and evidence to be effective, but some additionally noted that finding enough facts to support a claim could prove difficult. The overall perceptions of students regarding argumentation in science class were positive and their expositions are likely to be helpful in further research and study within the field.

In this chapter I have outlined the analyses of specific data from the research process. The details show clear connections between the interventions and students' development with regard to argumentation along with electricity and magnetism content knowledge. Students showed increased understandings, critical thinking ability, and an increase in their skills at applying their recently acquired content knowledge to science related questions. In the final chapter I will relate these findings to the goals of my study while also making suggestions for immediate applications in the science classroom and also suggestions for further research.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

At the outset of this research project, I posed three main questions concerning using scientific argumentation in the science classroom. It was with great hope for a "better way" that this project was undertaken. Findings, conclusions and implications regarding these research questions are summarized in the following sections.

Research Question 1

What is the overall effect on students' argument creation after being taught the concepts and processes of argumentation explicitly in an 8th grade physical science classroom using multimodal, multimedia, and computer based activities? In the current field of research regarding scientific argumentation, I did not find an abundance of research about explicit argumentation instruction. With that in mind I wanted to know how explicit instruction would help students develop their understanding of argumentation and their ability to create arguments. Results found in the data analysis section pointed to a correlation between interventions I provided during the unit and students developing a better understanding of the concept itself along with pieces involved. The mean grade from pretest to posttest improved from 25.25 to 41.25. This was not an extreme improvement on a test of argument knowledge, yet there was clear improvement. The correlation analysis showed improvement to be statistically significant on the test of specific argument knowledge. Interventions provided during the electricity and magnetism unit did indeed affect students' understandings of terminology and general reasoning patterns in argument as a whole.

The most distinct improvements found in the analysis centered on the students' increased argumentative abilities. There was a pointed improvement in the level of arguments students developed as the unit progressed. During the sessions, continued explicit teaching of individual parts of argument was coupled with student work on their individual and paired arguments. The scaled scores of student products continued to rise throughout the unit. Arguments were quantitatively improving as students practiced argument and received the explicit instruction on how to create arguments, what made up good arguments, and the specific qualities of each piece. A paired analysis showed that the improvements between sessions and especially from the beginning of the unit to the end showed a statistically significant improvement. In the first experiences identifying and creating arguments on their own, most students accurately identified only a claim or a claim and some data. By the end of the unit, these students were consistently producing extended arguments containing counterarguments and rebuttals. The arguments that they created were elegant and complete. Their reasoning was more thorough and they were identifying both sides of situations in their counterarguments and rebuttals. Zohar and Nemet (2002), as well as Kuhn and Udell (2003) also noted significant improvements in the quality of arguments produced in their work when their students received explicit argument instruction. That assertion is supported by the evidence here as well.

The qualitative analysis of the arguments throughout the unit also showed a path of improvement as students continued to receive direct instruction on the subject of argumentation. Examination of argument and reasoning themes from their products showed fewer fallacies in reasoning and a greater adherence to general argument themes as outlined by Walton (1996) and discussed during the interventions within the classroom. In the first argument session, students showed little grasp of the pieces of argument or the reasoning patterns that arguments generally make use of. Students could not connect their data to their claims. The thematic analysis exposed little skill or understanding on the part of students. Throughout the unit, the students made strides from session to session and began to show increasing capabilities with placing the appropriate information in the scaffolds accurately. The greatest strides came in reasoning, though. As students progressed, their extraneous reasoning patterns narrowed so that by the end of the unit, almost all students were using argument and reasoning patterns appropriate to their data and claims.

Examining the student perception analysis, there was also reason to believe that students developed a sincere understanding of the pieces of argument and the reasoning patterns necessary to be successful. Multiple students identified and explained specifically the most important pieces of argument in their opinion and parts they felt they were skilled at. Metacognition with regard to learning and personal production is important for student development. Kaya, Erduran, and Cetin (2012) denoted a lack of metacognition as to what students were doing vis-à-vis argumentation and their content related science class when there was no explicit instruction in argumentation. The opposite is what was shown in this intervention. Students developed the skill and metacognition as to their role and prowess in argumentation.

With specific data presented here it can be concluded that the explicit teaching of argumentation led to a great increase in skill level of students in producing argument and identifying parts of arguments. Progress was identified both quantitatively and qualitatively. The inclusions of appropriate pieces of argument and the use of argument and reasoning patterns appropriately progressed linearly from beginning to end for almost every participant. Notwithstanding the data analysis supporting the increased skill and understanding, almost half of the students specifically responded in their perception questions that they had developed a better understanding of argumentation through the class. Students were aware of their increased understanding on a metacognitive level. With that in mind it can be asserted that they have become aware of their learning and can make adjustments to their progress, how they approach the construction of arguments, and how they assess their products.

In this study I used lecture notes, class discussions, specific examples of arguments of both good and poor quality, and specific modeling of the pieces of argument and how they fit together in order to develop an understanding of argument with these participants. The data show that students began to use the parts of argument with better accuracy and skill as the lessons progressed. The specific instruction in the beginning to introduce argument coupled with the continued discussions and precise explanations of how to fix problems with their arguments helped students to hasten the rate at which their learning progressed. The immediate feedback, and lessons that used that feedback to teach, kept the participants moving forward continuously until they showed significant skill at creating higher level arguments by the end of the unit. The scaffolds provided with the lessons also helped students understand and use the parts of argument, as they were specifically described on the scaffolds and there was a place for each part of the argument. The spaces for each part of the argument kept the students from forgetting to include things while the instructions assisted them in understanding how to include them. The pieces of the intervention all worked in unison to help students learn argumentation. I find it unlikely that students were just “doing the lesson” or just filling in the argument maps and still developing their higher level arguments. In the first session, students had the “creating an argument” scaffold which has detailed explanations as to what each part calls for, and students were not successful. All pieces of the intervention were necessary to get the good arguments produced near the end of the unit.

Research Question 2

What is the overall effect on students' argumentative skill, content knowledge, and overall science concept understanding after using an oppositional based approach to argumentation in paired groupings? (Focusing on counterarguments and rebuttals)

Argument Skill

At the outset of the unit, basic premises and concepts of argument monopolized instruction time and activities. As the unit progressed, students began working in pairs or small groups and then worked with an opposing group to help develop their arguments. The overall effect of the oppositional groupings can be seen in the sharp increases in ability and content knowledge in the student products. As previously stated, the quantitative scale scores of student arguments increased for each session as the unit progressed. From the second event to the last (in which oppositional groupings were used) the argument score almost doubled. Improvement was shown to be statistically significant at a confidence level of 99%. The most effective arguments came from oppositional groupings.

Examining the qualitative results of the individual work and the groupings, there was significant improvement in argument themes and reasoning patterns. Students showed a better understanding of connecting theory and data to their claim with reasoning. In the gas station argument groups opposed each other in an online forum. They could question reasoning and data that each group supplied in their arguments. Clark and Sampson (2007) and Albe (2007) found that in discussions with higher rates of opposition, the development of reasoning was of a higher quality. The results of the research here highlighted that these oppositional events showed well-defined themes and reasoning and all groups created high level arguments. They unmistakably used effective reasoning patterns in the correct manner. These were some of the best arguments created in the entire unit.

Kuhn (1991) has stated that counterarguments and rebuttals are significant pieces of higher level arguments and that they can be specifically developed through opposition. In the first two sessions of the unit, students lacked development of the counterarguments and rebuttals as they were essentially non-existent. No students successfully developed a counterargument and rebuttal in the AC/DC argument and only one did so in the Series and Parallel session. When the oppositional groupings took place later in the unit, counterarguments and rebuttals began to emerge. In the online forum, students developed rebuttals to the opposition at a consistent rate. Furthermore, in the final session when students were given substantial time to find oppositional groups and work with them in discussion, the level of argument containing strong reasoning along with the counterargument and rebuttal pieces increased to 90% success. Walton (1996) showed that counterarguments and rebuttals bolster the effectiveness of reasoning in argument, which is also shown here by a correlation between stronger argument ratings and the presence of counterargument and rebuttals. The oppositional groupings in the final arguments of the unit exhibited both the presence of consistent and effective argument and reasoning patterns while at the same time containing counterargument and rebuttal. The correlation between the two was consistent in both the Gas Station argument and the High Voltage Power Lines Argument. Oppositional groupings did contribute to greater skill in argumentation with these students.

Additionally, students mentioned the benefits that they saw in the groups and pairs in which they worked. In the student perception answers, a majority of the students stated that they preferred working in the pairs for a multitude of reasons. Any of these reasons involved another point of view, seeing the other side of an argument, thinking of things that they would not have thought of on their own, and creating counterarguments and rebuttals. The data showed a distinct correlation, but here the participants themselves were arguing persuasively that the pairs and opposition that came from the groupings led to their better results. Not coincidentally, students communicated the idea that counterarguments and rebuttals forced them to see both sides of an argument. This contributed to better arguments as well.

Content Knowledge and Overall Concept Understandings

Use and application of content knowledge was a specific focus in this study. The level of content knowledge included and applied in arguments created by participants in this study paralleled the pattern indicated above with argument skill. The analysis specifically related to content knowledge associated increased content knowledge in student arguments with the argument sessions involving the oppositional groups. A quantitative examination of the scaled argument scores with regard to level and accuracy of content knowledge showed a statistically significant increase with the group work. When students were given the most amount of time to discuss in pairs and oppositional groups, the amount of accurate content knowledge used in support of the claims was at its highest level. In the final session, only one student used inaccurate content knowledge in his or her argument. A majority of students used both content specific scientific knowledge as well as general scientific knowledge in their work. Additionally, students used content related data to rebut counterarguments. Correlations between increased use of content and the presence of rebuttals to counterarguments are notable.

In student perception questions, a theme relating to content knowledge and understandings developed. Many students revealed a belief in the connection between argumentation and their understandings of the content being learned. One student had a metacognitive breakthrough and said argumentation should be used in classes more often in order to help them learn. Students referred to seeing both sides and the help that it gave them in their "big picture" comprehension overall. Students referred to paired groups and the consequential "seeing of both sides of the information" as an aid to "filling in the holes" in their understandings. Participants further elaborated some motivations stemming from the opposition. With someone present to convince of their side, they were actually more willing to research and develop their understandings in order to prove that they were right. The opposition was a rich motivator for more effective and bountiful information gathering.

In addition to the results regarding improved argumentative skill previously highlighted, here it can be seen that development of specific argument skill, content knowledge, and the overall science understanding improved greatly when the oppositional approach to the argument sessions was introduced. In the first argument session, students worked individually and argument quality, content knowledge use, and science understanding ratings were low. The themes and reasoning patterns found in the qualitative analysis showed little understanding on the part of the students. In the second session, the students had a very small amount of time to consult a peer in the process. There was no statistically significant improvement in quality and the reasoning themes were still weak and without clarity. In the final two sessions, students worked increasingly with oppositional groups and the argument, content knowledge, and science understanding levels increased rapidly. As students increasingly worked in opposition to other students, they were including more content knowledge and applying it with clear understandings. Their arguments were strong and complete. Students themselves described the fact that they found and used more information in order to win, prove others wrong, and convince the other side of their claims.

As students worked in oppositional groupings, I could also join groups at will and contribute to their discussions. Without giving students information or reasoning, I could be a resource and a sounding board. Students could also get immediate feedback and some aid in working with the scaffolds. As students used the scaffolds more often and helped each other to fill them in, they continued to learn more about how the parts of argument fit together. In oppositional groups, students began to understand the meaning and purpose of counterarguments and rebuttals. By using the "get your evidence together" scaffold, they had enough evidence to rebut the counterarguments. Each piece of the intervention worked together once more to develop understandings for students. The data and the students show that oppositional groupings advanced the comprehension and argument levels.

Research Question 3

What is the overall effect on students' abilities to use content knowledge to solve problems in which the application of science knowledge to new scenarios is necessary, after being taught using argumentative based instruction and practice?

In the modern world in which one can access information with the click of some buttons on a computer, tablet, or cellular phone, the need for memorization of information declines while the need for the ability to apply that information skyrockets. With that in mind, the third and final question in this study became increasingly important. Students in this study showed that argument based instruction in the science classroom had a significant effect on their abilities to apply their content knowledge to new (to them) and unique situations that were created for research purposes and on the electricity and magnetism unit content summative assessment.

Quantitatively, both the level of improvement and mastery cannot be denied here. Students did come to class with some previous knowledge in the area of electricity and magnetism. Pretest scores showed a mean of 49.19%, identifying far more knowledge of the content than the same participants demonstrated regarding argumentation. Several outliers who sored near 60% also showed that there were some in the group with a solid foundation in the content. However, posttest scores showed that every student demonstrated a mastery of the content and the ability to apply that mastery on a common style multiple choice test. The average score on the unit test was 96.18% with a standard deviation of only 3.188 points. Multiple students received 100% scores and no student in the group earned less than a 91%, which is an A. Statistically the improvement was significant, but to me as a teacher who had worked with this group of students over a year's time, it was shocking to see such a level of mastery and success.

Qualitatively, participants expressed increasingly specific and accurate content knowledge in their arguments. As previously stated, the level of correct use of content knowledge continued to escalate throughout the unit. On the final argument of the intervention, students did indeed use their content knowledge to effectively offer solutions to a real-world problem that was new to them. Participants detailed clear and articulate argument and reasoning patterns that were appropriate to the situation and successfully implemented. Students used expert opinions, arguments from consequences, cause and effect arguments, and an appeal to existing practices to solve a problem that could affect and pertain to them personally. As a teacher and researcher, the fact that these students showed signs that they were prepared to successfully navigate the real world caused elation.

An important result mentioned specifically by some students was increased understanding and application of critical thinking skills. In stating that they had to decide which information was useful and not just opinion students exhibited an understanding of what members of society must do to critically assess information in order to make informed decisions. This is certainly a representation of skills in applying knowledge and understanding. Furthermore, a student described the process of distinguishing data from reasoning and the appropriate place to use each to support the overall claim of an argument. Data supports the ideas these students elucidated in their perception responses. As the unit progressed, the amount of extraneous and false data reached near zero, while the appropriate use of data in the argument rose to a very high level. Through scientific argumentation, these students developed the critical thinking skills necessary to interpret data and reasoning while amassing a deeper understanding of their subject matter.

Student scores on the electricity and magnetism test increased to a high level of mastery at the end of the unit. The results were statistically significant. Students continually worked to develop their abilities at applying their content knowledge throughout the unit. In the argument sessions in which the full array of scaffolds were available, there were specific questions and scaffolds that directed participants on what kind of information was appropriate to use and how they could organize it. Also, the “so what” scaffold elicited specific connections between the data and the claim, allowing students to develop their reasoning regarding the application of their information. The scaffolds helped students to ask why evidence was important to their argument, whether the evidence was appropriate and legitimate, and asked students to have multiple kinds of evidence. In order to satisfy the need to support their claim, participants had to develop their knowledge and understand it in a way that facilitated application to the problem at hand. As students had to use their newly developed knowledge throughout the argument sessions, they learned how to more effectively use it on the final test of their knowledge.

Application of this Research in the Broader Educational Community

This study was a struggle from beginning to end. I was constantly adjusting my teaching and the materials in order to best suit the students I was working with. In the beginning of the school year, I was not even sure that this study could take place with this group of students. With the understandings that I had developed from the beginning of the year with these students also came some trepidation for me as I approached my research. As a teacher with eight years of experience in the classroom, I had never experienced a group of students that were as challenging as these in terms of their cognition of the content and their response to my teaching. At the start of the year, these students struggled to follow a basic lab from beginning to end and achieve any semblance of quality results. Their scores on the first unit test were abysmal and I was perplexed as to how I would bring them up to a level that would accommodate applying scientific understandings to a well thought out argument. As the year progressed, I saw some promise, but when the electricity and magnetism unit was looming near, I still had concerns. As can be seen from the previous section, though, these students worked hard for me and came out with skills and knowledge that they can use as they progress through high school. These results are stunning and their repetition in the context of other classrooms has not yet been attempted.

The results of this research are promising and confirm some things that others in the field have previously suggested; wisdom tells us to be cautious in our desire to universally apply these methodologies to classrooms. There are some things to think about when seeking to use this study as a pedagogical guide. This study was conducted in a singular school, in one teacher's classroom, in only one class, and with a small number of respondents. The small sample size limits the generalizability of the findings. The diversity of the members helps in the generalization of the results. In some areas, I, as both the researcher and the teacher, made errors that could have affected the data and outcomes. Specifically, the argument test was made and given as a pretest at the beginning of the unit. Throughout the unit, I did not focus on or teach certain items as much as I would have liked to when I was planning this teaching at its inception. With this in mind, if I had not been conducting a research study, I would have altered the test to reflect what the students were taught. In this case, that was not possible because of the research design. The students may have developed more understandings of argument and the specific processes and vocabulary therein, but the scores on the qualitative test of this knowledge would not exemplify those gains because of a poorly designed test. This does however highlight a great benefit to the mixed methods approach, as there was still data and knowledge to be derived from the qualitative side of the study and the open ended questions students answered at the end of the unit.

McNeil (2008) suggests that teacher effect is high with argument instruction. One teacher’s successes in the field may not lead to other successes in different classrooms. Furthermore, this intervention was only one unit in an entire year of science teaching with these students. These results are limited in their scope with reference to long term effects of argument instruction. Also, these students did indeed begin the unit with some electricity and magnetism understandings. In the school system of which this classroom is a member, students theoretically learn about electricity and magnetism in at least one elementary grade, but in general science teaching is not a high priority in terms of time and resources at the elementary level in the state due to emphasis on the high stakes testing of the subjects of reading and mathematics. It may be difficult to assume that the results here could be reproduced in a subject matter of which the students had little to no previous knowledge. Ford (2008) goes as far as stating that it is not practical to teach all content through the practice of argumentation. This study was a snapshot of the experiences of these sixteen students through one unit in their scholastic career. Multiple things in their lives could have contributed to the successes that students achieved throughout this singular unit and at the same time, specific happenings in their lives may have caused the hiccups that some experienced in their progress. Over the course of a school year, multitudes of changes take place for teenagers, especially at the middle school level. Although the data show great strides by these students, such a small sample size in every way, places limitations on the results.

With these things in mind, however, it is likely that a teacher could follow the same basic processes, be enthusiastic about teaching argumentation, have a solid background and understanding in argumentation, and get similar results. There was nothing mystical about what took place in my classroom. The theory and methodology were based in previous research with some development of new and innovative methods. Research has shown argument to be an effective pedagogical tool, and my study here confirms that once more.

Contributions to the Research Literature

Overall the current study was well designed and well implemented. The mixed methods approach and the fact that the research was done by a trained veteran teacher with extensive knowledge of both the electricity and magnetism content and the concept of argumentation aided in the quality implementation of the research design. Careful attention was paid to objectivity and to melding the quantitative and qualitative epistemologies and processes in one study. The materials were designed with an understanding of the students who would be using them and their ability levels as well as their needs for differentiation. The data collection and analysis were done meticulously with an eye towards validity and reliability. With that in mind, the following details how I view this research in relation to other research in the field.

The current field of scientific argumentation in the classroom is becoming more developed as time goes on. This study fits in well with this developing body of research. There are a number of studies that attend to the use of explicit instruction and scaffolds in order to teach argumentation. While some have shown minimal increase in content knowledge and understandings with the use of argument scaffolds in a 5th grade classroom within the United Kingdom (Simon, et.al, 2011), others have had great success with the Science Writing Heuristic, a scaffold used in exploratory lab experiments in the late elementary grades with 5th and 7th graders in the Midwestern United States (Hand et al., 2004; Choi, et.al., 2008; Cavgnetto et al., 2010). Still others, in studies in Spain with 9th graders and the Midwestern U.S., also with 9th grade, have found that scaffolds allow students to complete the activity and yet have no real comprehension of what they are learning (Jimenez-Aleixandre et al., 2000; Sandoval and Millwood, 2005).

In addition to the use of scaffolds and the mixed results stemming therein, using explicit instruction to teach argumentation has been a topic of research as well, but on a limited basis. At the high school level, Zohar and Nemet, (2002) working in Israel with 7-9 grade students, have seen an increase in both argumentative ability and understanding of content knowledge when argument was explicitly taught. Kuhn and Udell (2003), working with 8th grade students in the U.K., also have seen good results through explicit teaching coupled with discussion groups.

The issue is that there is limited research in the United States, as it is mostly in the Midwest, and little research focused in middle schools. Although some research mentioned previously takes place in what are considered the middle grades in the area of the U.S. where the current research took place, much of that research was either in an Elementary or High school which contained these grade levels. Information regarding research with low income students is also limited. The research presented in this dissertation joins both scaffolded instruction and explicit teaching of argument. This is also research done in the middle grades, in a Title I school, and the United States. This data fills a gap in the current research while also adding to the understanding that scaffolded instruction and explicit teaching both increase students' ability to argue effectively. Here I have shown that together, these techniques get very good results with middle grades students. The participants here were given scaffolds and explicit instruction and showed a significant benefit in their content knowledge understandings and argumentation skill level.

Research regarding students' abilities to create arguments based on a topic that requires specific scientific knowledge is somewhat mixed, but does not paint a promising picture. Some have found that it is difficult to get students to use specific scientific knowledge in their arguments when social knowledge can be substituted instead (Jimenez-Aleixandre, 2002); Kolsto, 2006; Sadler and Donnely, 2007; Arvola and Lundergard, 2011). Others have shown that the level of scientific knowledge on a topic has a great effect on student ability to reason with that knowledge (Sadler, 2004). Von Aufschnaiter, et.al. (2007), also have asserted that when less scientific understandings are present, the ability of students to reason effectively is inhibited.   Osborne et al. (2004) showed that students need background knowledge in order to argue with scientific topics. Also, Ford (2008) has stated that scientific argumentation may not be effective in teaching content knowledge. The research reported here adds a new dimension in the field offering that students can use argumentation to develop deeper and more thorough understandings in order to argue well when scientific knowledge that they do not possess is necessary.

The use of mixed methods designs in the field is currently not common. This study adds to the body of work that seeks to quantify how students advance in their use and understanding of argument and content knowledge and associate that advancement with the participants' understandings of their progress, the evolution of their reasoning abilities, and their overall internalizations of the unit of study. Here I have shown that it is possible to connect the epistemological underpinnings of both qualitative and quantitative research design and develop understanding that speaks to both of these research traditions. Mixed methods research can indeed be objective while at the same time developing a deep understanding and connection to the participants.

Together these ideas in the field are vastly influenced by the research I have presented here. Students in this study showed not only that they could develop their content knowledge through the practice of argumentation, but that they chose to develop that knowledge in order to argue well. It is true that they did not succeed without good content understandings, but that also could be a mitigating factor in why they developed the high content knowledge levels that they did here. Students learned content and learned to reason well while using this new content knowledge. I have shown that in one particular classroom, argumentation could be used as a tool to teach content knowledge well. Students produce better arguments when they are placed in oppositional groups. There is a significant amount of research to support that idea already in the field (Mason, 1998; Fenton, 2003; Kuhn and Crowell, 2011). This study strongly supports the research that indicates superior argument construction through oppositional groupings in an 8th grade physical science class in a Title I school serving low income and immigrant students. However, what the field lacks is information regarding the use of oppositional groups in an online forum where the students could be anonymous. The students in the online argument here showed a great level of group work and they developed extensive and high level arguments. Through the back and forth posts in which counterarguments and rebuttals were developed along with some critique of overall arguments, students were open with those critiques and superior arguments were developed. This is just an introduction to what could be a new part of the research field of argumentation. Online chat rooms could help students improve their arguments quickly with greater aid from other groups and a back and forth banter between online posts.

Recommendations for Practice in the Classroom

The results presented here make a strong case for the inclusion of scientific argumentation in science classes. The likelihood that results seen here would be transferrable to any science class is strong. A way to improve students' understandings, application of knowledge, and critical thinking skills has been outlined and shown to be effective. It is the suggestion here that teachers begin to implement scientific argumentation in their science classrooms immediately. In the research presented here, students received explicit instruction in argumentation and its subsequent pieces. Science teachers, and all teachers, can teach claims, the importance of data and evidence to support your ideas, reasoning in order to show the data is sound and how it leads to the conclusion of the claim, counterarguments in order to see opposing opinions, and rebuttals which negate opposing ideas.

With the individual parts that make up an argument, classroom teachers should teach the process of argument construction and practice, practice, practice. When I had students make their first attempt at creating an argument, it was based on their understandings of the historical argument between Tesla and Edison. As can be seen from the data, they were not ready for the task. It may be necessary to front load even more explicit instruction on argumentation and to model more before asking students to create an argument on their own, even with scaffolds. A formative assessment of some sort to determine their skill level would be advisable before setting them on the task of individual argument creation. Student experiences in developing arguments coupled with instruction as to what the individual pieces are will improve their level of comprehension of what they are researching and arguing.

Teachers should be using the tools examined here to help students take a stance or develop opinions that they can support with facts. Then use argument methodology to create understandings as to the importance of verifiable data in science. Follow that with instruction in logical reasoning patterns and fallacies in logic in order to help students grow their thinking skills while they protect against errors in judgment. Use these practices to help students see a multifaceted world containing different opinions that can also have evidence in support of them. Allow children to examine a whole world and not just their small piece of it. Teach kids to think critically about what others say and be able to stand strong in their opinions with the evidence that they have to support them.

It is not necessary to do this all at once. Teachers and schools have the ability to slowly introduce the topics and practices for students. I would advise a three year implementation plan in the middle school setting. In the first year, students would begin to develop claims and understand why they think the way they do about the subject. They would think of the facts or opinions that led them to their claim. In the second year, students would focus on supporting as many ideas and assertions as possible with the facts that they are based on and developing the reasoning that connects them. In the third year, the focus would be on seeing both sides of the subject matter through counterargument and rebuttal. Through the three year plan, students would enter high school with skills regarding applying their content knowledge and critical thinking skills necessary to reason through their increasingly complex coursework.

In examining the growth achieved by students throughout the unit, the data could be interpreted to show a connection between reasoning, content knowledge, scientific understandings, and the ability to argue. Looking at the data, students' reasoning abilities and argument scores showed a direct correlation with their inclusion of accurate and specific content knowledge in their arguments. It is possible that students realized the need for more information and a greater understanding of the content in order to reason well. This would show in increased metacognitive awareness for these students. They appeared to determine on their own what understanding they did not have and actively pursued that understanding in order to complete their argument effectively. At the same time, this connection may show that an increase in reasoning ability helped students to develop the content understandings that we as teachers want for them to develop. The motivation of successfully arguing their claim could have led these students to develop metacognitive understandings, increased reasoning ability, the drive to seek out the information and understandings they need, and the ability to apply that understanding to the situation at hand. These are the skills of a 21st century student. These are the skills and attributes that teachers have been trying to impart in students for hundreds of years. All of this may be possible through scientific argumentation.

It is completely reasonable to expect teachers to realize argument is a way to teach critical thinking skills that are being called for in the curriculum documents such as the Common Core and Next Generation Science Standards. Science teachers can partner with language arts teachers and social studies teachers to construct arguments and teach students the ability to critically analyze sources of information, data, perspectives on the world, thought patterns, literature, historical teachings, and scientific theory. Focus on the analytical underpinnings of the process of creating arguments, counterarguments, and rebuttals. Allow all students to develop the skills to apply their knowledge critically in real world scenarios. Support improvement in the students' capacities to metacognitively assess their learning and how to fix it. Help prepare them for a future in which they can think for themselves. Do all of this through the use of scientific argumentation as discussed here.

Scientific argumentation has already been included in the Next Generation Science Standards and it is my belief that the common core standards will soon adopt the NGSS as their own. The fact that scientists practice their craft in this way and the nature of science predicates on this type of argumentation should push teachers and policy makers to stress its inclusion in the classroom. A complete study of science and scientific methods must include scientific argumentation. Over a decade ago, Newton, Driver, and Osborne (1999) suggested that through a constructivist approach supported by scientific argumentation, students can develop a full understanding of the nature of science and how science is done by scientists in the real world. The research here supports this assertion as do I as the researcher and a teacher.

Recommendations for Further Research

One result of this study was the beginnings of an understanding surrounding how students developed their reasoning and critical thinking skills through their use of scientific argumentation. The thought processes of the students could have been examined more closely with some specific changes to the methodology. In order to further research in the field, developing a study that focuses on both critical thinking and reasoning in scientific argumentation would make great strides in our understanding of how these students developed their reasoning and critical thinking skills through scientific argumentation. In an environment in which students' conversations and interactions were recorded, all contributions could be detailed and evaluated in order to specifically see the progress made from session to session.

With a grounded theory approach and the constant modifications to data collection and method, real headway in understandings would be likely. In designing a study to search for these connections, a researcher could construct a methodology that seeks to show a more definitive correlation between the development of argument and reasoning skill and the acquisition of content knowledge and understandings. There seems to be a direct relationship there and a well-designed methodology could show this definitively.

Additionally, an immersion study in which the researcher is in the classroom as an observer and collaborator with a highly trained teacher implementing the argumentation intervention would give greater opportunity for focus and perception of incidental cues that might go unnoticed when a teacher is engaging an entire class of students and observing at the same time. Similarly, an experienced teacher paired with a student teacher implementing an argumentation unit could provide a dynamic collaborative research setting. These kinds of ethnographic studies would be more intense and thus develop a deeper understanding of the development of reasoning and critical thinking. Conducting student interviews in a personal interaction would benefit the study as well.

In accordance with the idea of a three-year implementation plan for a school or series of schools, a long term study to document the program would be important. A longitudinal study following a group of students for the entirety of the three years would be ideal for developing a true understanding of the effects scientific argumentation has on overall performance in science class as well as across all subject areas. The idea of argumentation is in the common core language arts standards and thus the connection across the curriculum areas could be studied further and expanded to include a more broad focus on results. Simply put, the benefits seen in the current study are applicable to more facets of the students' lives and scholastic endeavors. Detailed results would be beneficial across the board in the entire educational industry.

Research in cross curricular cooperation between subject areas could also help ascertain the benefits of scientific argumentation for schools in general. The benefits outlined for this science class and for the mastery of content knowledge and the abilities to think and reason in new ways are certain to have implications for all subject areas from elementary through college. These areas should be explored using similar methodologies, as they have been shown to be beneficial here.

In summary, I set out to study the overall effects of teaching scientific argumentation in conjunction with content knowledge in an 8^{th} grade science classroom. I wanted to determine if students could learn to argue well at the same time as they learned new content knowledge and how to apply that knowledge to situations that required science understandings. I found that through the use of explicit instruction in argumentation, scaffolds that help students develop their arguments, and oppositional groups to aid students in developing higher level and more complete arguments, students can learn how to argue effectively and apply content knowledge and understandings in those arguments. Over the course of the unit, students' arguments improved as their use of a greater quantity and quality of content knowledge grew, and they thought critically about the information they included.

The importance of this research is for all teachers at all grade levels in the field of science. The research here supports ideas that have been developed in the field of scientific argumentation for the science classroom and helps to show specifically what can work in teaching argumentation parallel to content knowledge. Some in the field (Ford, 2008) are not sure that content knowledge can be taught effectively through the argumentative process, but my students and I have shown here that it can be done. The research presented here also gives a glimpse at how argumentation can develop critical thinking in students and have them work on solving real world problems (or at least have an opinion that is educated and well supported by data and evidence). Middle school students can and will do research and reason through their ideas in order to prove a claim and show that they are right in how they think. These students showed that they can be motivated to learn new things and that they can think and reason on a high level.

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Appendix A

Knowledge and Understanding Tests

Argumentation Test:

1. What tells the audience that the data supports the argument?

a. claim
b. backing
c. qualifier
d. warrants

2. What is the stance that the arguer supports called?

a. possible rebuttal
b. modal qualifier
c. claim
d. data

3. What tells us why should the audience believe the claim?

a. verifiers
b. grounds
c. warrant
d. reasoning

4. Rebuttal is the part of the argument that

a. explains why the grounds may legitimately support the claim
b. indicates how strong the claim is
c. is the evidence used to support the claim
d. gives evidence against the claim or in support of an alternate claim

5. The data are the element of the Toulmin model of argumentation that

a. is any term or phrases that indicates the strength of the claim

b. explains why the data legitimately supports the claim

c. is the evidence used to support the claim

d. justifies believing the warrant

6. Which part of the argumentation model explains why the data actually support the claim?

a. Qualifier

b. possible rebuttal

c. reasoning

d. backing

7. The "qualifier" in the model of argumentation is

a. the proposition the arguer supports

b. tells us when the claim is true

c. a statement that explains why the data support the claim

d. the basis for the argument

8. Which part of argumentation gives evidence against another person's argument?

a. rebuttal

b. qualifier

c. backing

d. counterargumen

9. The claim is the part of the model of argumentation that

a. provides justification for believing the grounds

b. is the what the arguer supports

c. explains why the data legitimately support the conclusion

d. gives evidence against an opposing argument

10. The reasoning is the part of the model of argumentation that

a. provides justification for believing the reasoning

b. explains why the data legitimately support the claim

c. gives evidence in support of the claim

d. is the evidence used to support the claim

11. One of the elements of the model of argumentation is a statement that indicates the conditions in which the claim might be false. That element is known as the

a. rebuttal

b. qualifier

c. verifier

d. data

12. "Anecdotal evidence" is a level of poor reasoning which:

a. Substitutes individual stories for data as support for a generalization.

b. argues that something is okay because it has always been done

c. argues that since something happened first it is definitely a cause of what happens next

d. makes an argument with only a small amount of evidence or data

13. A hasty conclusion:

    a. Substitutes individual stories for data as support for a generalization.

    b. argues that something is okay because it has always been done

    c. argues that since something happened first it is definitely a cause of what happens next

    d. makes an argument with only a small amount of evidence or data

14. A false cause:

    a. Substitutes individual stories for data as support for a generalization.

    b. argues that something is okay because it has always been done

    c. argues that something has caused something else without evidence of that connection

    d. makes an argument with only a small amount of evidence or data

15. When someone uses the poor or false reasoning of appealing to common practice they:

    a. arguing a claim should be accepted based only on the suggestion that anonymous authorities accept the same idea or claim that they are making

    b. arguing that a small or insignificant issue will eventually lead to a major result or consequence

    c. drawing a conclusion after purposely leaving out evidence or ignoring known evidence that might contradict a claim

    d. Arguing that something is the right thing to do based only on evidence that other people are already doing it.

16. If someone uses the questionable reasoning practice of suppressing evidence, they:

   a. arguing a claim should be accepted based only on the suggestion that anonymous authorities accept the same idea or claim that they are making

   b. arguing that a small or insignificant issue will eventually lead to a major result or consequence

   c. drawing a conclusion after purposely leaving out evidence or ignoring known evidence that might contradict a claim

   d. Arguing that something is the right thing to do based only on evidence that other people are already doing it.

17. When someone supports their claim by appealing to an unknown authority in the world they:

   a. arguing a claim should be accepted based only on the suggestion that anonymous authorities accept the same idea or claim that they are making

   b. arguing that a small or insignificant issue will eventually lead to a major result or consequence

   c. drawing a conclusion after purposely leaving out evidence or ignoring known evidence that might contradict a claim

   d. Arguing that something is the right thing to do based only on evidence that other people are already doing it.

18. When someone reasoning by using a slippery slope they:

   a. arguing a claim should be accepted based only on the suggestion that anonymous authorities accept the same idea or claim that they are making

   b. arguing that a small or insignificant issue will eventually lead to a major result or consequence

   c. drawing a conclusion after purposely leaving out evidence or ignoring known evidence that might contradict a claim

Arguing that something is the right thing to do based only on evidence that other people are already doing it

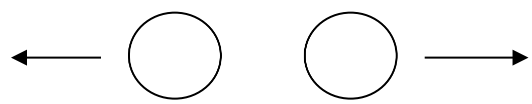
Name ______________________________________ Date ______________ Period ______

Electricity and Magnetism Test

1. All matter is composed of very small particles called (20a)
   a. photons
   b. molecules
   c. atoms
   d. elements

2. Electricity is the movement of ________________ from atom to atom. (20a)
   a. atoms
   b. electrons
   c. neutrons
   d. protons

3. If two charges repel each other, the two charges must be (20a)
   a. positive and positive
   b. positive and negative
   c. negative and negative
   d. either (a) or (c)



4. Electrons have a ______________________ charge. (20a)
   a. positive
   b. neutral
   c. negative
   d. credit card

5. The **flow** of electric charges is called?(20a)
   a. electric current
   b. static electricity
   c. electric force
   d. magnetic field

6. The **pathway** that electricity flows through is called?(20a)
   a. a sidewalk
   b. a current
   c. a charge
   d. a circuit

7. When there is an equal amount of positive and negative charges on an object, the object is _______________________ . (20a)

a. positively charged
b. negatively charged
c. neutral.
d. supercharged

8. What form of energy is associated with the movement of charges, usually electrons? (20a)

a. chemical
b. electrical
c. heat
d. sound

9. How do electrical charges move in current electricity?(20a)

a. current electricity moves in sudden and momentary movements
b. current electricity is a steady movement of electrons
c. the paths on which current electricity move are not usually conductors of electricity
d. Current electricity is a random movement of electrons on different paths

10. Which of the following BEST explains why energy stored in the battery power source diminishes over time when a circuit is complete? (20a)

a. energy is destroyed when the light bulb operates
b. the light bulb absorbs energy into light and heat
c. the light bulb converts the negative charge of electrons into light and heat
d. the power source generates energy more slowly than the light bulb consumes it.

11. An object becomes charged when the atoms in the object gain or lose (20b)

a. protons
b. neutrons
c. electrons
d. molecules

12. This girl rubbed a balloon in her hair. What type of charges do the balloon and hair have? (20c)

a. unlike charges
b. like charges
c. neutral charges
d. no charges

13. A circuit in which all parts are connected in a single loop is called a(n) (20d)
  a. open circuit
  b. open load
  c. series circuit
  d. parallel circuit

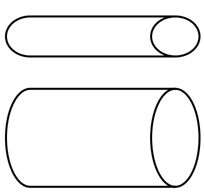
14. The ________________ is the part of a circuit that uses the electricity. (20d)
  a. switch
  b. battery
  c. conductor
  d. load

15. A circuit that has more than one pathway for electrons to follow is a(20d)
  a. closed circuit
  b. parallel circuit
  c. series circuit
  d. perpendicular circuit

16. A complete circuit is made of three things: (20d)
  a. An insulator, a source of electrons, and a path.
  b. A conductor, a source of electrons, and a path.
  c. A switch, a source of electrons, and a path.
  d. Power source, load, and a path.

17. Lightning is an example of(20d)
  a. current electricity
  b. static electricity
  c. a battery
  d. a load

18.



A

B

Which wire has the greatest resistance? (20d)

a. Wire A
b. Wire B
c. They both have the same resistance
d. It cannot be determined from the information given

19. Suppose you have four bulbs in a series circuit. If you were to add five more bulbs in series with these four, what would happen to the brightness of the bulbs? (20d)

a. the bulbs would no longer glow
b. the bulbs would grow brighter
c. the bulbs would grow dimmer
d. the brightness would not change

20. _______________ lets electricity pass easily through it. (20d)

a. an insulator
b. a conductor
c. plastic
d. air

21. When a circuit is __________________ the electrons can flow through it. (20d)

a. closed
b. open
c. unplugged
d. electrons don't flow through a circuit

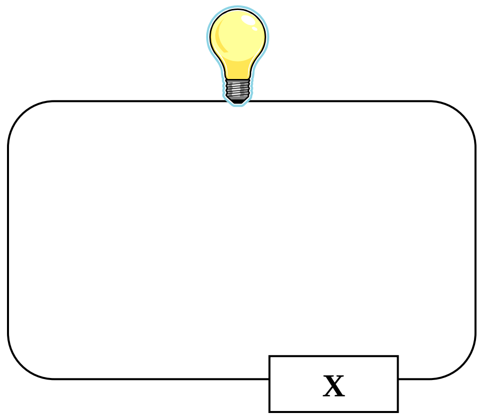
22. Which statement is usually true about the electrical properties of metals? (20d)

a. metals have high electrical resistance
b. plastics are the best conductors
c. metals and plastics are both good insulators
d. metals have low electrical resistance

23. A circuit contains four light bulbs. One light bulb goes out but the other three stay lit. This must be a(n) ______________________ circuit. (20d)

a. open
b. series
c. parallel
d. resistant

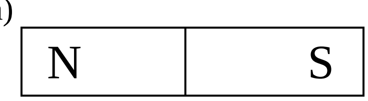
24.



In the diagram, what essential part of an electric circuit is at position **X** ? (20d)

a. load
b. on/off switch
c. wires
d. source of electric current

25. What do you end up with if you cut a magnet in half? (21a)



a. one north-pole piece and one south-pole piece
b. two unmagnetized pieces
c. two pieces, each with a north pole and a south pole
d. two north-pole pieces

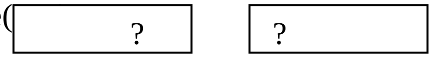
26. The magnetic effects of a bar magnet are strongest near the ______________(21a)

a. center
b. top
c. bottom
d. ends

27. All magnets(21a)

a. have two poles
b. exert forces
c. are surrounded by a magnetic field
d. all of the above

28. The magnetic force will push magnets apart if you hold the(



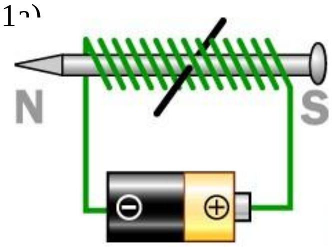
a. north poles of the magnets close together
b. south poles of the magnets close together
c. north pole of one magnet near the south pole of another magnet
d. Both (a) and (b)

29. What makes materials magnetic? (21a)
a. the atoms in these materials are magnetized by moving electrons
b. the atoms in these materials are randomly arranged
c. the atoms in all domains are arranged in the same direction
d. materials cannot be magnetic

30.

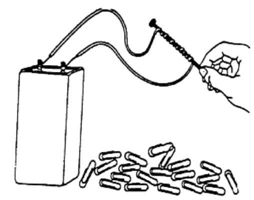
Which picture shows magnetic domains after they have been magnetized? (21a)
a. Figure A
b. Figure B
c. neither one is magnetized
d. both are magnetized

31. A magnet produced by an electric current is a(n) (21



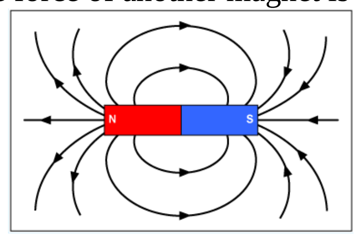
a. electromagnet
b. ferromagnet
c. horseshoe magnet
d. permanent magnet

32.What will happen when the nail touches the paper clips? (21a)



a. nothing
b. the paper clips will catch on fire
c. the paper clips will be picked up by the nail, like a magnet
d. the paper clips will be repelled by the nail

33. The area in which a magnet or piece of metal feels the force of another magnet is called (21a)



a. gravitational field
b. magnetic field
c. North and South field
d. Polar field

Appendix B
Student Perception Interview Questions

Questions about Your Learning During the Electricity and Magnetism Unit

Please answer the following questions as thoroughly as possible. You will type our answers and put only your student number on this page to identify you. Your answers on these questions will help me to make this Unit and my teaching exponentially better. Your opinions matter to me and your ideas as to the progress of our learning about Electricity and Magnetism as well as Argumentation is essential to my job and the learning of future students. Please take this seriously…as I do.

1. Which discussion during this unit did you find the most interesting? What about this discussion made you want to participate and work to construct the argument that you presented? (be sure to be through and make me understand what you are saying. Please give specific examples and statements to support what you say here)

2. What is your favorite part of the creation of arguments? Which part of the argument construction do you think you are the best at and why do you think you are good at it? EXPLAIN thoroughly please.

3. How do you feel the inclusion of argumentation affected your overall understanding of the electricity and magnetism concepts you were supposed to learn? Please be specific.

4. What is the most difficult part of the process of creating an argument? What about this makes it difficult for you?

5. What do you feel is the most important part of an argument? Why is this so important to the argument itself?

6. What do you think is the overall purpose of argumentation? Should we engage in argumentative discussions in science class? Why? Are there benefits of argumentative discussions in science class? What might be a problem with the kind of argumentation we engaged in throughout the unit?

7. Did you feel as though you created better arguments on your own or in pairs? Why do you think that you did better this way? Please give some specific reasons why you were more successful in this way?

8. How did the participation in the online discussions affect your skills at argument? Give some specific examples as to why you think this.

9. How has your understanding of argument creation and the process of argumentation changed throughout this unit? Name some specific things that you believe have contributed to your change in understanding.

10. What specific part of the process of learning about argumentation and arguments was especially beneficial to your understanding of the concepts? Why was this especially beneficial for you? Please be as detailed as possible with your explanation.

Appendix C

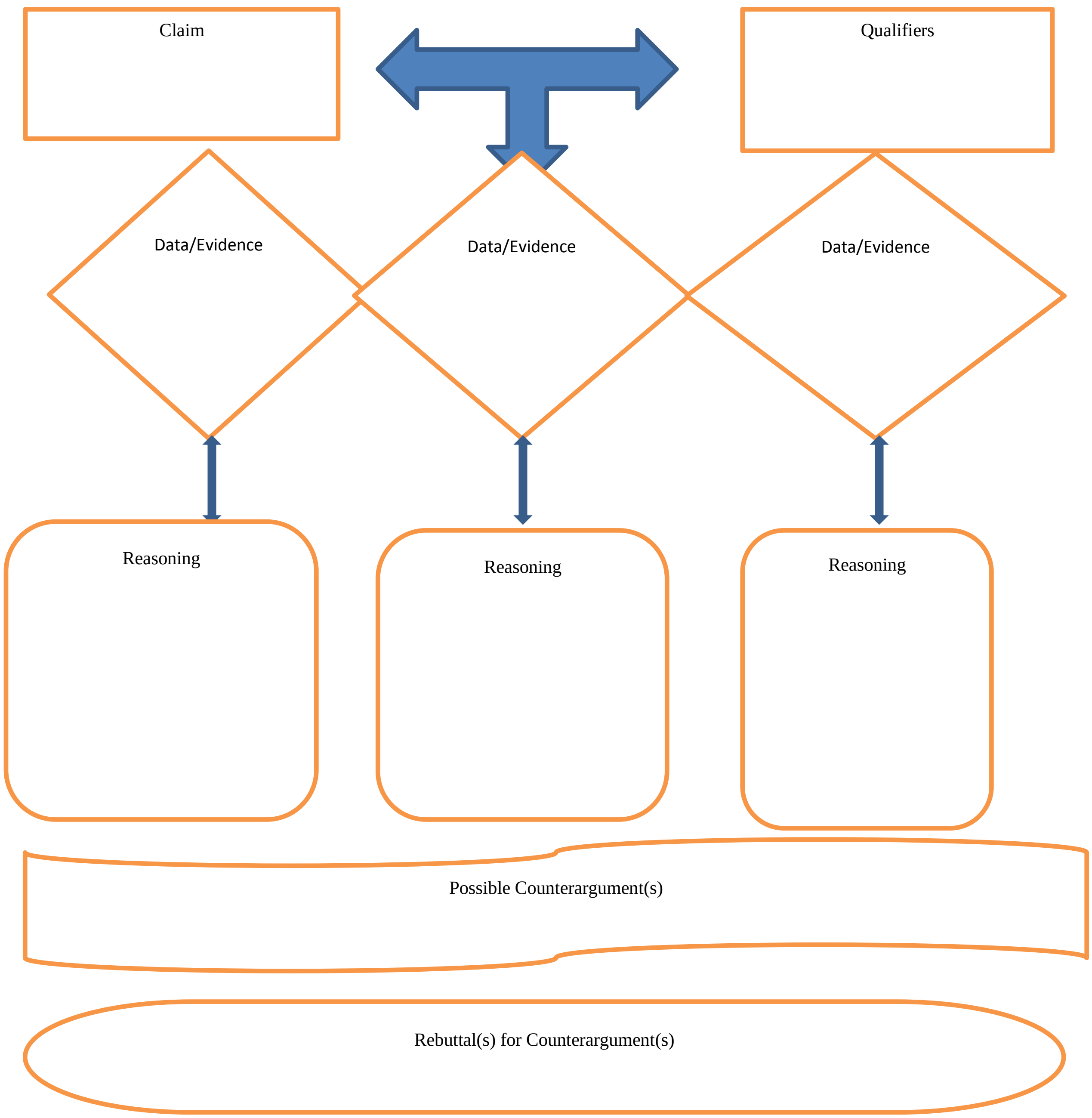
Scaffolds

Name ____________________________ Period __________ Date _________________

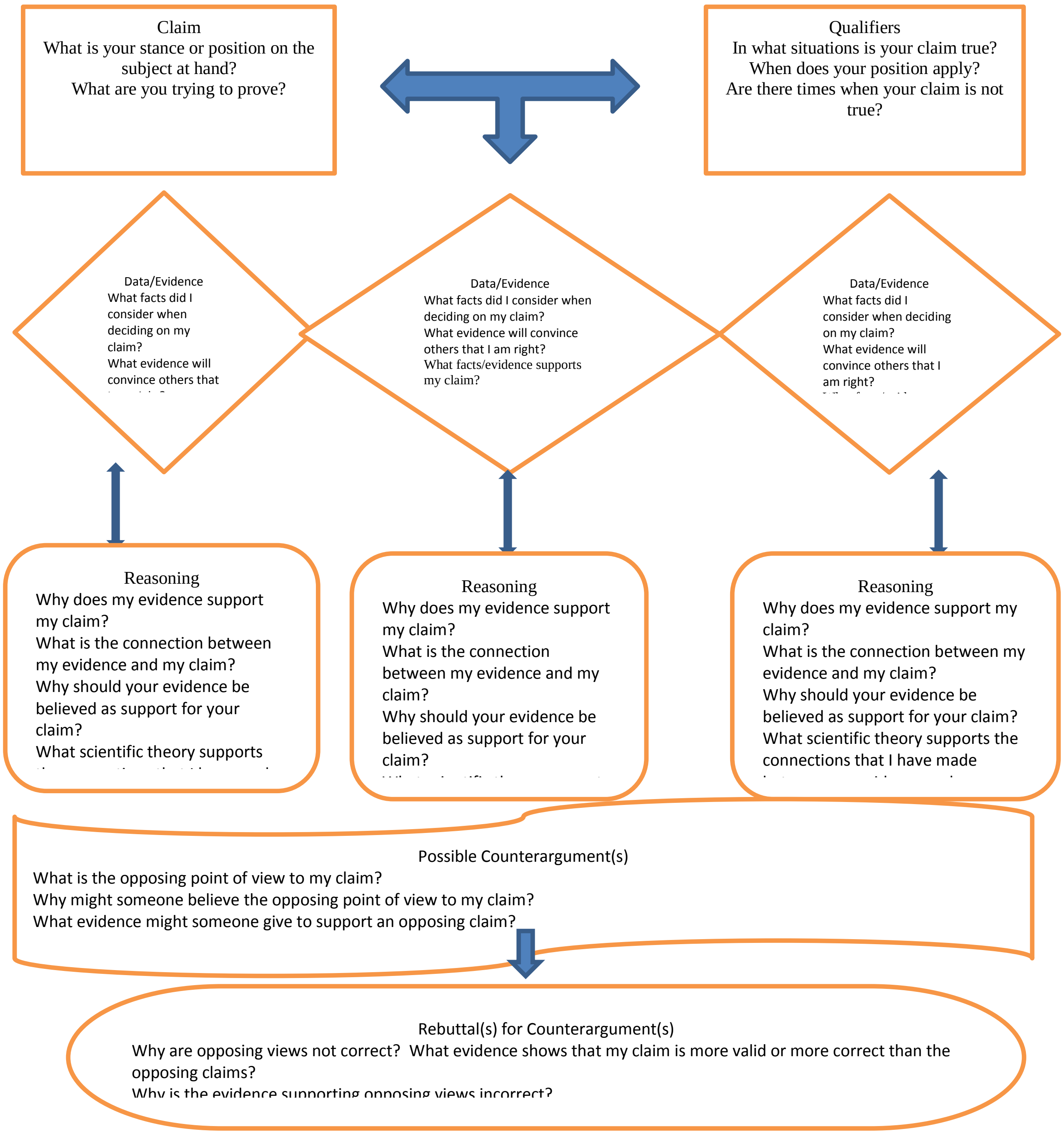
Creating an Argument

Part of Argument	Description	Questions to ask yourself	Your Argument
Claim/qualifiers	This is your argument. What are you trying to prove or convince someone of? Make this statement clear and precise. This is where you state any qualifying situations in which your claim is or is not true.	What am I trying to prove? What am I saying is the correct answer? What am I saying is the right decision to make? Is my claim true all of the time? Is my claim is true in certain situations or not true in certain situations.	
Data Evidence	This is the data that you are using to support your claim. This can also be referred to as the evidence that you have to show that your claim is correct or the right idea to consider	What facts did I consider when deciding on my claim? What evidence will convince others that I am right? What facts/evidence supports my claim?	
Reasoning	This is where you show why your data/evidence supports your claim. You are making the connections and showing why the evidence supports your thinking. AND…….You are also citing scientific theory or concepts that prove that your evidence does indeed back up your claim.	Why does my evidence support my claim? What is the connection between my evidence and my claim? Why should your evidence be believed as support for your claim? What scientific theory supports the connections that I have made between my evidence and my claim?	
Counterargument	This is where you think of positions or claims that others may have against your argument. This is where you determine what someone who doesn't agree with you might believe. This is where you determine why others might have a different opinion	What is the opposing point of view to my claim? Why might someone believe the opposing point of view to my claim? What evidence might someone give to support an opposing claim?	
Rebuttal	This is how you convince others who hold opposing view that your view is correct. This is how you show that opposing points of view are invalid or incorrect. This is where you show why opposing evidence is invalid or does not support opposing claims	Why are opposing views not correct? What evidence shows that my claim is more valid or more correct than the opposing claims? Why is the evidence supporting opposing views incorrect? Why is the science supporting opposing views not appropriate to support those claims?	

Argument Map



Argument Map



Constructing a Claim

What is your idea or position on the subject matter at hand?

What are the conditions that your claim is true in? Are there times that your claim is not true or reasonable? Write down any situational requirements of your claim here.

Can your claim be supported by evidence, data, examples and scientific fact or theory? If so list a few examples.

Are there other claims that can also be made that are similar to yours? Are there claims that are different than yours? What are they?

How can you state your claim so that it is very clear and precise? Will people reading or listening to your claim be very clear about what you are saying? Have you been specific? Write your Claim as specific and precise as possible here. Be sure to use scientific language and vocabulary.

Name ___________________ Period__________________ Date _________________________

Get Your Evidence Together Organizer

Name ___________ Period _______________ Date___________

So What? What are the reasons your Evidence and Data Prove your Claim?

Why does this data/evidence support your claim?
What is the connection between your data/evidence and your claim?

Evidence/
Data

Why is this evidence legitimate? Why should it be trusted?
What scientific Theory supports this?

Why does this data/evidence support your claim?
What is the connection between your data/evidence and your claim?

Evidence/
Data

Why is this evidence legitimate? Why should it be trusted?
What scientific Theory supports this?

Why does this data/evidence support your claim?
What is the connection between your data/evidence and your claim?

Evidence/
Data

Why is this evidence legitimate? Why should it be trusted?
What scientific Theory supports this?

Part of Argument	1 Poor Quality or not present	2 Needs improvement	3 Less than Average	4 Good Quality	5 Excellent Quality	Score
Claim	No claim present	claim has nothing to do with subject matter	Claim is not clear	Claim is clear and explains what it is support of	Claim is clear and precise as it explains what it is support of	
Qualifier	Qualifiers are needed but not present	Qualifiers are needed and partially presented	Qualifiers are needed and are present	Qualifiers are needed, they are present, and they are briefly explained	Qualifiers are needed, present, and clearly explained. Or Qualifiers not necessary	
Evidence	No evidence is provided	Evidence is provided but does not support the claim	Some evidence is provided which does support the claim.	Most evidence that supports the claim is provided.	All evidence that can be used to support the claim is provided.	
Quality of Evidence	No evidence is present	There may be data or an example but both are not present	There is at least one citation of data and one example given in support of the claim.	There is at least one citation of data and one example given in support of the claim. Some scientific theory is used as evidence	There is multiple citations od data, examples, and full scientific theory is used as evidence	
Reasoning	No reasoning is provided	Reasoning is provided but it does not connect the data to the claim	Evidence is connected to the claim	Evidence is connected to the claim and there is an explanation as to why the evidence supports the claim based on the facts presented.	Evidence is clearly and precisely connected to the claim and there is a clear explanation as to why the evidence supports the claim based on the facts presented as well as all applicable scientific theories related to the situation.	
Counterargument	There is no attention paid to a counterargument	A counterargument is noted, but it does not apply to the situation	A counterargument has been identified	Counterarguments have been identified and explained	All counterarguments have been identified and explained	
Rebuttal	There is no rebuttal for the counterargument	A rebuttal has been identified but does not apply to the counterargument	A rebuttal has been identified and applies to the counterargument described	A rebuttal which applies to a counterargument has been identified and explained	Rebuttals that apply to all counterarguments have been identified and explained	

Appendix D

Teaching Journal Outline

Teaching Journal

Monday 3-3: Electricity and Magnetism pre-test. Introduction to argument including the creation of a chart detailing both sides of a debate. 1st and 2nd – apple vs. android. 3rd – evolution vs. creationism. 4th -

Tuesday 3-4: Review the homework video. Began construction of series and parallel circuits using string and pictures.

Wednesday 3-5:

AC vs. DC Argument Assignment:

On the board –

1: Use the Ac and DC websites to increase your knowledge of both AC and DC currents.

2: Use the rest of the websites, which detail the Edison vs. Tesla arguments to fill out your argument sheet based on Either Edison's or Tesla's argument.

Thursday 3-6:

Reexamine the AC DC debate. Have students work in pairs to discern the debate main points and the benefits and drawbacks of each kind of current. Go over as a class. Watch the goanimate productions created by teacher detailing the debate's main points.

Finish series and parallel representations including directional arrows to show the direction of the power.

Friday 3-7: Quiz to discern what students have ascertained as far as basic premises of circuits and currents. Watch science court episode on electric current. Students write the basic evidence and reasoning used in the Science Court Episode.

Monday: 3-10-14: Paired argument creation with research on series an parallel circuits

Tuesday: 3-11-14 – Static electricity activity and continue per argument development

Wednesday: 3-12-14 – Using what was learned from peer argument development activity, write your argument in paragraph form. Then peer review using peer argument review sheet.

Thursday: 3-13-14 – Read article on Static electricity. Watch Mythbusters segment on static charges and gas station fires. Begin developing argument based on this information by using the full grouping of Scaffold sheets. Producing the data to support an argument

Realized today that the Mythbusters are an excellent example of scientific argumentation

Friday 3-14-14 – Quiz. Finish argument development. Introduce the full array of argument scaffolds

Monday 3-17-14: Circuits Lab – Creating different versions of series and parallel circuits

Tuesday 3-18-14: Finish Arguments on static elec. And gas stations. Online discussion.

Wednesday 3-19-14: Resistance – Practice Problems

Thursday 3-20-14: Resistance, Vocabulary review game

Friday 3-21-14: Quiz – Power Plants

Monday 3-24-14: Illustrated Dictionary

Tuesday 3-25-14: Magnets Activity

Wednesday 3-26-14: Argument Research – Burying High Voltage Power Lines

Day 1: Research based on issues on both sides of High Voltage Power Lines Issue

Thursday 3-27-14: Argument–High Voltage Power Lines

Day 2: Students decide on a claim and construct their argument using argument scaffolds.

Friday 3-28-14: Quiz, Students finish arguments and create their presentations.

Monday 3-31-14: Induction electricity video and readings/Vocabulary Game

Tuesday 4-1-14 Study Guide/Presentations of Arguments

Wednesday 4-2-14: Computer Lab/Research Questions Interview

Thursday 4-3-14: Review Game

Friday 4-4-14: Electricity and Magnetism Test/Argument Test

Appendix E

Student and Parent Permission Forms

Dear Student,

I wish to conduct a research study about middle school students' experiences with science and argumentation, titled, Argumentation in science class and its effects on argumentative skill, content knowledge, and knowledge application. Everyone on the team will participate in the same classes and do the same work. I am asking for you to allow me to use your written work and your pre-test and posttest grades for my research. You do not have to do anything extra.

You will participate in classroom activities that include:

a. Teaching and learning the concept and practice of argumentation
b. Creating arguments and participating in argumentative discussions.
c. Viewing and discussing arguments to determine their quality and at the same time emulate that quality.
d. Completing worksheets to assist them in create arguments including claims, data, evidence, and reasoning.
e. Developing arguments and argumentative scenarios and illustrating them with the www.goanimate.com website.
f. Constructing argument maps on paper with a scaffolding sheet and on a computer with the *Inspiration* computer program.
g. Computer based end of unit questions requesting information on the instructional methods encountered in the unit.

You will participate in all of the same classroom activities even if you choose NOT to participate in the research. Your choice about participating in this research will not affect your grades in the class. I will not use your name on any papers that I write about this project. All information about this project will be kept in a safe location and all information that could identify you personally will be removed from your papers. There are no known risks or discomforts associated with this study. While you will not directly benefit from participating in the research, you may learn more about science and argumentation as part of the class. I hope to learn something about science and argumentation that will help other children in the future.

Below, please check the line to tell me if you agree or do not agree to let me use your classroom for the research project, print your name and then sign the form.

If you want to stop participating in the research project, you are free to do so at any time. If you have any questions or concerns, you can always ask me or call me at the following number: (678) 478-3304. You may also contact Dr. Cory Buxton at buxton@uga.edu with any questions you may have about the research.

Sincerely, Mr. Edge

I understand the project Argumentation in science class and its effects on argumentative skill, content knowledge, and knowledge application as described. My questions have been answered and I have a copy of the information describing the project as was provided to me.

______ I **agree** to allow my work and test scores from the electricity and magnetism unit to be used for the research study.

______ I **do not agree** to allow my work and test scores from the electricity and magnetism unit to be used for the research study.

Name of the Participant **________________________________**

Signature of the Participant: ________________________________

Date: ____________

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

Dear Parents:

As part of our regular classroom routine, your child is participating in a physical science instructional program to determine ways to better serve all students. In addition to our regular classroom practices, during the spring semester we will be focusing on developing students' skills in argumentation (discussions with opposing viewpoints) and creating logical arguments (a claim or idea that has evidence which supports it and clear reasoning to connect the claim or idea and the evidence). This is part of normal classroom procedure and all students will participate in these activities during the electricity and magnetism unit. The skill of argumentation is an important goal in the Gwinnett County language arts AKS, and I will be supporting this skill in my science class. This unit will include some new and exciting teaching materials developed by me for this class in order to teach these concepts more effectively and aid your student in thinking and reasoning well as they apply their knowledge to new and unique questions and problems.

Students will participate in classroom activities that include:

a. Teaching and learning the concept and practice of argumentation
b. Creating arguments and participating in argumentative discussions.
c. Viewing and discussing arguments to determine their quality and at the same time emulate that quality.
d. Completing worksheets to assist them in create arguments including claims, data, evidence, and reasoning.
e. Developing arguments and argumentative scenarios and illustrating them with the www.goanimate.com website.
f. Constructing argument maps on paper with a scaffolding sheet and on a computer with the *Inspiration* computer program.
g. Computer based end of unit questions requesting information on the instructional methods encountered in the unit.

As part of this focus on argument, I am conducting a research study of my teaching. The study is called, <u>Argumentation in science class and its effects on argumentative skill, content knowledge, and knowledge application</u>. The study is being conducted under normal classroom conditions throughout our unit on electricity and magnetism. I am inviting your student to participate in this research study. The purpose of this study is determine if argumentative discussion helps students to understand science content, reason more effectively, and apply the knowledge that they have learned to new and unique situations.

Your student's participation in the research will involve allowing me to use the classwork that he or she is already doing in class. There will be no additional work required. Specifically, I would be using the written work done throughout the unit, the online discussion activity done throughout the unit, the scores from pre and posttests, and a typed questionnaire asking your student about the experiences he or she had with argumentation and the teaching materials I use during the electricity and magnetism unit.

Your student's involvement in the study is voluntary, and you may choose for him or her not to participate or to stop at any time without penalty or loss of benefits which he/she would otherwise be entitled. After the initial grading of the assignments for normal class purposes, I will make copies of the student work and any information that could personally identify your student will be removed from the work. If you decide to withdraw your child from the study, the information that can be identified as your child's will be kept as part of the study and may continue to be analyzed, unless you make a written request to remove, return, or destroy the information.

The results of the research study may be published, but your student's name or any identifying information will not be used. The published results will be presented in summary form only focusing on trends and changes in performance for the class as a whole and not individually for students. Researchers will not release identifiable results of the study to anyone other than individuals working on the project without your written permission unless required by law

The findings from this project may provide information on how students can learn better, learn to reason, and apply their knowledge more effectively. There are no known risks or discomforts associated with this research.

If you have any questions about this research project, please feel free to call me Jeremy Edge at 678-478-3304 or send an e-mail to jedge75@uga.edu. You may also send an email to Dr. Cory Buxton who is supervising this research at buxton@uga.edu. Questions or concerns about your child's rights as a research participant should be directed to The Chairperson, University of Georgia Institutional Review Board, 629 Boyd GSRC, Athens, Georgia 30602; telephone (706) 542-3199; email address irb@uga.edu.

After you have read this letter and had any questions answered, please see the signature lines below where you can indicate whether or not you will allow your child to participate in the research.

Your choice about your student participating in this research will not affect your child's grades in school.

Thank you for your consideration! Please keep this form for your records.

Sincerely,

Jeremy Edge

Department of Educational Theory and Practice

629 Aderhold Hall, University of Georgia, Athens, Georgia 30602

I understand the project <u>Argumentation in science class and its effects on argumentative skill, content knowledge, and knowledge application</u> as described. My questions have been answered and I have a copy of the information describing the project as was provided to me.

______ I **agree** to allow my student's work and test scores from the electricity and magnetism unit to be used for the research study.

______ I **do not agree** to allow my student's work and test scores from the electricity and magnetism unit to be used for the research study.

Name of the Student Participant: ______________________________

Name of the Parent granting permission: _________________________________

Signature of the Parent granting permission: _________________________________

Signature of Researcher: _______________________________

Date: _______________________

Please sign both copies, keep one and return one to the researcher.

Verbal Recruitment Script

Hello class. Today I am going to discuss something special that you have the opportunity to be a part of during our unit on electricity and magnetism. As you know, I am currently in graduate school at the University of Georgia pursuing a PhD degree. I will be working with a professor at th eUNiversity of Georgia whose name is Dr. Cory Buxton. I am planning on trying some interesting teaching techniques during this unit and I would like to use your work and results for my research project at the University. The title of my study is Argumentation in science class and its effects on argumentative skill, content knowledge, and knowledge application. During the research that I want to conduct, we will be learning about the concept of argumentation in science and will use this concept as a part of learning electricity and magnetism. Argumentation is a way to say informed discussion about a topic in which you develop an idea or a position on a subject and then you support that idea with data. You then connect that data to reasons why your idea or position is right. It helps you to think more intensely about what you are talking about and makes you use more information when you talk. During the unit, students will participate in classroom activities that include:

a. Teaching and learning the concept and practice of argumentation
b. Creating arguments and participating in argumentative discussions.
c. Viewing and discussing arguments to determine their quality and at the same time emulate their quality.
d. Completing Scaffolding worksheets to create arguments including claims, data, evidence, and reasoning.
e. Developing arguments and argumentative scenarios and illustrating them with the www.goanimate.com website.
f. Constructing argument maps on paper with a scaffolding sheet and on a computer with the Inspiration computer program.
g. Computer based end of unit questions requesting information on the instructional methods encountered in the unit.

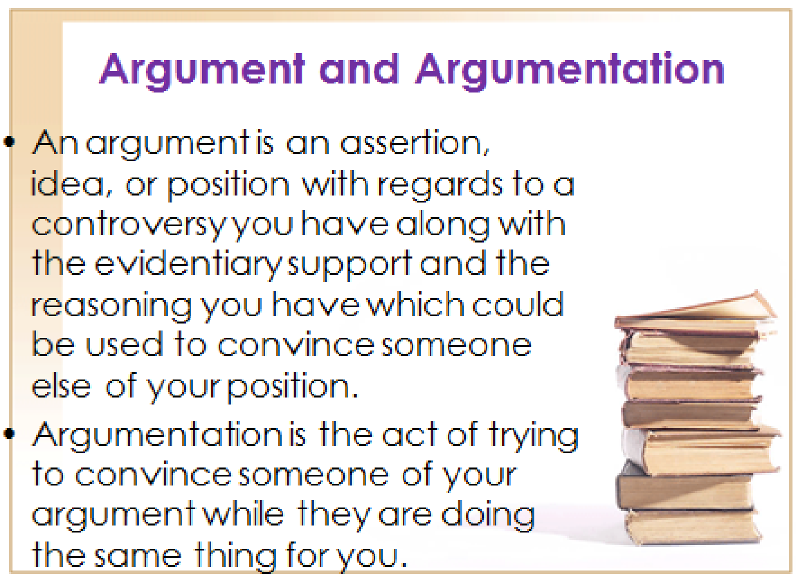
It is important for you to know that all students will participate in the classroom activities as in any unit of instruction, but data will only be gathered from this, my third period class and only data from students with parental permission will be used for the research. All identifiable characteristics will be stripped from the data before analysis. There is no practical likelihood of any adverse reactions or hardship for the students involved.

If you have any questions about the research or about clas procedures, you can contact:
Mr. Edge – 678-478-3304 – mredgescience@gmail.com
Dr. Cory Buxton – buxton@uga.edu

Appendix F

Teaching Materials

Argument PowerPoint

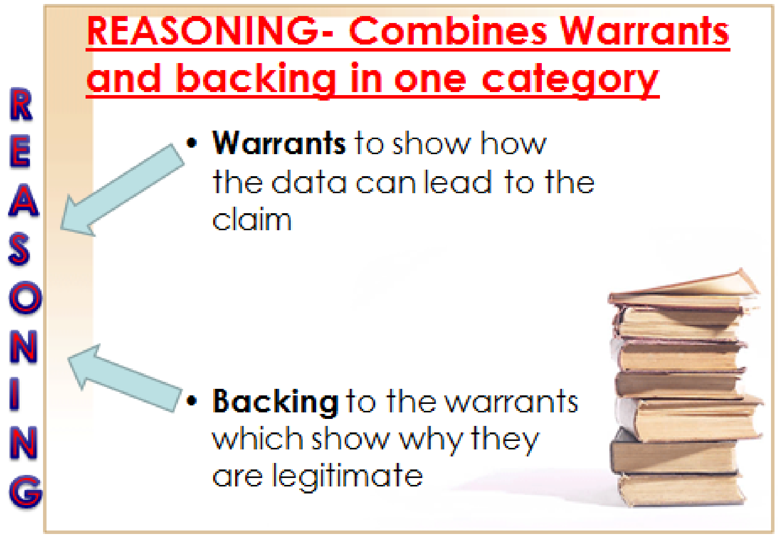


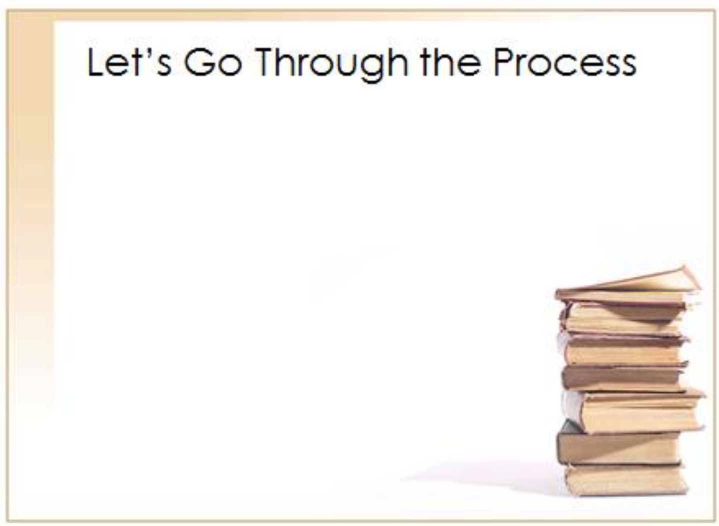
Argument in science

- Science is not a collection of facts
- What we call science is really a collection of Theories that have been developed through experimentation, observation, and argumentation over the course of human existence.
- Scientists argue to convince others that their theory is correct and fits the data and observation best.
- Theories explain how the data fit together and can be used to predict what will happen in other situations.

Toulmin's Argument Structure

- **Assertion/Claim** gives your position and essentially why you support that assertion
- **Data** to support the claim
- **Warrants** to show **how** the data can lead to the claim
- **Backing** to the warrants which show **why they are legitimate**
- **Qualifiers** that may be necessary to express what situations and conclusions the argument is valid with.


REASONING- Combines Warrants and backing in one category
R E A S O N I N G
• Warrants to show how the data can lead to the claim
• Backing to the warrants which show why they are legitimate

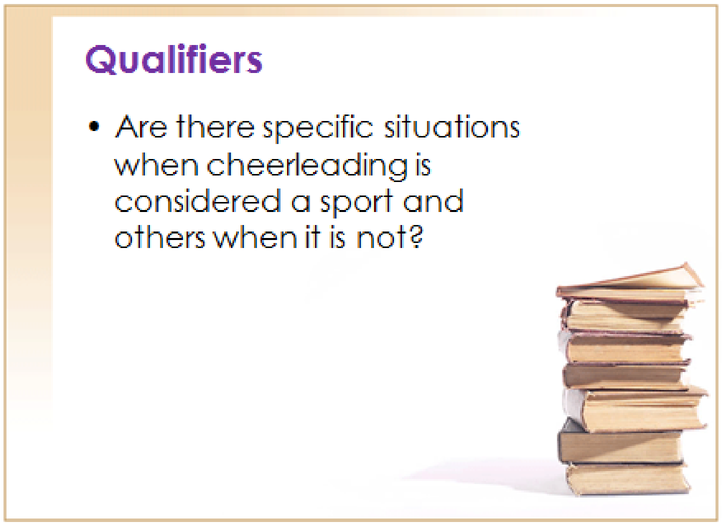

Let's Go Through the Process

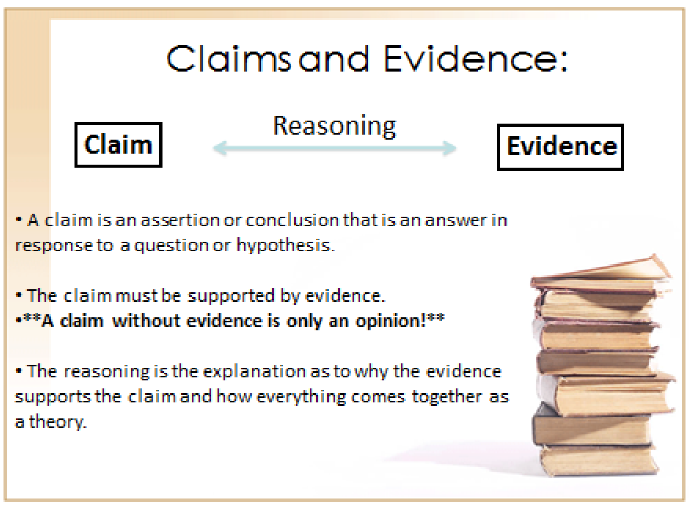
Claim - gives your position

- Make the assertion that Cheerleading is a sport
- This is what you believe (or maybe not)
- You must now create an argument to convince others that your position or idea is the best or correct one

Reasoning- show **how** the data is legitimate and **leads** to the claim

- Injuries – If Doctor's reports show cheerleaders are suffering the same kinds of injuries and in the proportion as other sports, then it is a sport.
- If there are Team competitions sponsored by major sports corporations, professional organizations, and schools which are judged, rankings are given, trophies are given, and there are winners and losers are similar to other sports, then cheerleading is a sport.
- Anyone who has witnessed cheerleading or tried it themselves sees the requirement of specific abilities related to the use of muscles in specific ways, the training that must take place in order to use the muscles in certain ways, and the specific mental focus and concentration match the requirements of other sports.


Qualifiers
• Are there specific situations when cheerleading is considered a sport and others when it is not?


Claims and Evidence:
Claim
Reasoning
Evidence
• A claim is an assertion or conclusion that is an answer in response to a question or hypothesis.
• The claim must be supported by evidence.
•**A claim without evidence is only an opinion!**
• The reasoning is the explanation as to why the evidence supports the claim and how everything comes together as a theory.

THE CLAIM

What it is…

- This is the statement of your argument.
- What are you trying to prove or convince someone of?
- Make this statement clear and precise.

Questions to ask yourself…

- What am I trying to prove?
- What am I saying is the correct answer?
- What am I saying is the right decision to make?
- Is my claim true all of the time?
- Is my claim is true in certain situations or not true in certain situations.

THE EVIDENCE

What it is…

- This is the data that you are using to support your claim.
- This can also be referred to as the evidence that you have to show that your claim is correct or the right idea to consider

Questions to ask yourself…

- What facts did I consider when deciding on my claim?
- What evidence will convince others that I am right?
- What facts/evidence supports my claim?

THE REASONING

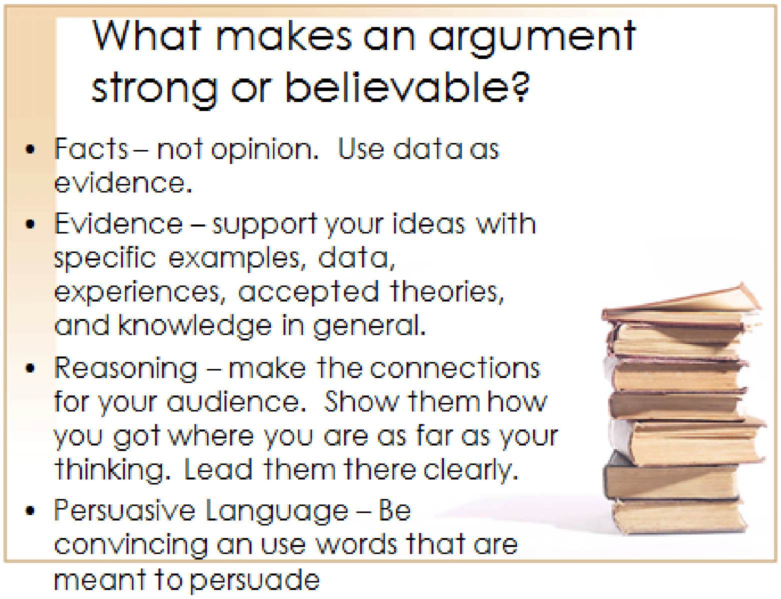
What it is…

- This is where you show why your data/evidence supports your claim.
- You are making the connections and showing why the evidence supports your thinking.
- You are also citing scientific theory or concepts that prove that your evidence does indeed back up your claim.
- You are likely using a reasoning pattern to do this.

Questions to ask yourself…

- Why does my evidence support my claim?
- What is the connection between my evidence and my claim?
- Why should your evidence be believed as support for your claim?
- What scientific theory supports the connections that I have made between my evidence and my claim?
- How can I show why someone should agree with me?

DEVELOPING ARGUMENTS


What makes an argument strong or believable?
• Facts – not opinion. Use data as evidence.
• Evidence – support your ideas with specific examples, data, experiences, accepted theories, and knowledge in general.
• Reasoning – make the connections for your audience. Show them how you got where you are as far as your thinking. Lead them there clearly.
• Persuasive Language – Be convincing an use words that are meant to persuade

Series and Parallel Website Sheet

Series and Parallel Circuits Sites

http://www.physicsclassroom.com/class/circuits/Lesson-4/Two-Types-of-Connections
http://science.howstuffworks.com/environmental/energy/circuit2.htm
http://scienceofeverydaylife.discoveryeducation.com/views/other.cfm?guidAssetId=D1507F6E-09C3-4E7B-B1E9-16708E402009
http://www.ndt-ed.org/EducationResources/HighSchool/Electricity/seriesparallelcircuits.htm
http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc

Little-known dangers at gas pumps
GAS

December 05, 2002|Elizabeth Cohen CNN

Few American motorists know that static electricity around gas pumps can ignite a deadly fire while they're filling up.

Ignacio Sierra has personal experience of that danger. He was pumping gasoline when his vehicle suddenly burst into flames with his daughter Esperanza inside.

"She started screaming," remembers Sierra. "I knew if I opened the door, the flames would start to go inside."

He did manage to get Esperanza out unharmed, but the fire ruined his car and destroyed the gas station.

Sierra set off the blaze by doing something many motorists do; he re-entered his car to retrieve money while the gas was still pumping.

His movement created friction against the car seat that built up static electricity in his body. Then when he exited the car and touched the gas pump nozzle, the electricity sparked and ignited the gas fumes coming from his car's gas tank.

About a dozen victims of static gas pump fires have talked to CNN. All said they had no idea this sort of fire was a possibility until it happened to them. And some say they will never put gas in their vehicles if their children are with them.

A woman who asked to be identified only as Carol said a static gas pump fire is blamed for burning her daughter so badly she needed skin grafts on her legs.

Carol had put the gas pump nozzle on automatic and re-entered her car to write a check. When her then-12-year-old daughter, wearing a sweater and jacket that may have created static electricity, reached for the nozzle, flames suddenly ignited her clothing.

The Petroleum Equipment Institute (PEI) has documented 129 such fires since the early 1990s.

All those fires infuriate electrical engineer Steven Fowler because he says they were all preventable.

"We have to accept the fact that refueling is dangerous. We can't hide that from the public anymore," said Fowler, a static electricity expert.

The solution, he said, is to put up stickers that read "touch me." The stickers are placed over metal and when people touch them, their bodies discharge static electricity safely.

But Fowler said no gas stations plan to put them up, except for the SPINX Oil Company chain of 80 stations in South Carolina.

The American Petroleum Institute is concerned that those stickers may detract from other warnings such as ones about smoking while pumping gas, which is far more dangerous.

High Voltage Power Lines Project

Power Line Argument Websites:
http://hps.org/hpspublications/articles/powerlines.html
http://www.epa.gov/radtown/power-lines.html#whos_protecting_you
http://healthyliving.msn.com/health-wellness/power-lines-and-your-health
http://www.mcw.edu/radiationoncology/ourdepartment/radiationbiology/Power-Lines-and-Cancer-
FAQs.htm
http://www.niehs.nih.gov/health/topics/agents/emf/
http://www.emfs.info/Sources+of+EMFs/Reducing/
http://www.outsidethebeltway.com/why-cant-we-just-bury-all-the-power-lines/

Data/Evidence Regarding High Voltage Power Lines

Likely Supports Burying Lines	Likely supports ***not*** Burying Lines

Presentation Options:

- **Making comic strips detailing your: claim, evidence, reasoning, possible counterarguments, and rebuttals to those counterarguments**

http://www.readwritethink.org/files/resources/interactives/comic/index.html

more comic strip makers:
http://chogger.com/create

http://www.stripcreator.com/make.php

- **Making animations detailing your: claim, evidence, reasoning, possible counterarguments, and rebuttals to those counterarguments**

www.goanimate.com

http://wideo.co/

http://www.powtoon.com/

- **Make a Poster that gives your: claim, evidence, reasoning, possible counterarguments, and rebuttals to those counterarguments**
- **Make a Powerpoint presentation detailing your: claim, evidence, reasoning, possible counterarguments, and rebuttals to those counterarguments**
- **Make a PREZI – WWW.PREZI.COM Detailing your: claim, evidence, reasoning, possible counterarguments, and rebuttals to those counterarguments**