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A Compilation of Rubrics to be Used in Chemistry to Emphasize Argumentative Writing in the Science Classroom

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by

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Abstract:

The new Common Core Standards for New York State and the Framework for K-12 Science Education Standards have a main focus on implementing argumentative writing into each content area. Some form of argumentative writing has always been used in the science curriculum through the creation of a lab report. However, an argumentative lab report must contain a counterclaim and specific sources of evidence to be considered a real argument.

An argument does not have to be as formal as a lab report. Arguments can be as informal as a journal article or a narrative story. As long as the main parts of the argument are present, which include the claim, warrant, evidence and counterclaim, any sample of writing can be turned into an argument.

In science, the three most important types of writing to enhance scientific literacy are lab reports, journaling and narratives. All three of these examples can be turned into argumentative writing to enhance a students' understanding of the content and the writing process.

Key words: Argument, Science Education, Warrant, Claim, Lab Report, Narrative, Journaling, Evidence

Chapter 1: Introduction

Advances in scientific knowledge and knowledge in general stem from the ability to present an argument and evidence for a given topic. In order to make advances in life, students must develop the skills of argumentation in the classroom and apply these skills to the “real world” (Wolfe, 2011). Toulmin’s (1958) model of argumentation presents a framework for formulating this type of communication successfully. Claims and data must be presented for an argument to be supported. The 2012-2013 New York State Common Core State Standards (Council of Chief State School Officers & National Governors Associations, 2010) emphasizes the importance of this skill. In science, all students are expected to be able to present a claim and support it with ample evidence. This type of argumentation can be used and applied to all areas of life. Currently, students see science as a subject which “consists of solving problems using a tool kit of assorted practices” (Kalman, 2011, p. 159-160) instead of a connected framework of evidence.

The implementation of literacy skills into elementary and secondary school science classes has been addressed by many people in the past (Toulmin, 1958). In the end, the goal of teaching science is to create scientifically literate students who can be successful in the world (McNeil et al, 2006). There are many different techniques and modes of instruction that have been implemented over the years, but one common practice is the implementation of writing into school science classes. There are many ways to implement writing into the science classroom and it has a number of benefits for science students.

“Learning science involves young people entering into a different way of thinking about and explaining the natural world.” (Driver et al, 1994, p.8).” Science education used to be viewed as route memorization and text-based information. Today, students need to use problem solving and inquiry based skills to think about science. The integration of technology has given us a whole new way to think about science and explain the world around us. Since the end goal of teaching science to young students and adults is to achieve scientific literacy, it only seems right that one goal of science education is to enhance the way students think about and explain science (Martin & Hand, 2007). Argumentative writing in science enhances a students' ability to take the appropriate steps to explain the world. Through argumentation, science students are encouraged to gather information, evaluate the text and their prior knowledge of a given subject, identify the relationship between the two and explain the new concept or idea with evidence (Kalman, 2011). It also allows students to change their minds on a given topic or support an opinion. All of these skills lead to success in the science classroom and in everyday life.

Argumentation through writing has always been a highly discussed topic and everyday practice of real-life scientists and even career centered everyday individuals. "Science is not about discovering or memorizing facts; rather it is about constructing arguments and considering and debating multiple explanations for phenomena (McNeil, 2008)." When a scientist performs and experiment and receives unexpected results, there is not an "automatic" explanation or fact for such results. Scientists must consider the data (or evidence) from the experiment, synthesize the information and provide a rationale for the outcome. This can easily be seen in scientific research papers and even everyday events such as asking for a raise or applying for a new position. The implementation of argumentative writing techniques has a real benefit on motivation, perception of science and literacy, student retention, learning and ability to support a claim.

Chapter 2: Literature Review

History of Argumentative Writing

The ideas and implementation of argumentative writing has been well researched and studied since the late 1950's (Toulmin, 1958). Not only has the implementation of this type of writing been studied in the science context, it has also had a "shorter, yet interesting history in the field of cognitive psychology (Wolfe, 2011, p 194)." In order for argumentative writing to be effective and implemented properly, ample evidence must be provided to "prove" the author's position or belief. According to Aristotle (1991), there are three main types of argumentation. These include a basic argument with logical evidence provided, an emotional appeal and an argument based off of the credibility of a given speaker (Aristotle, 1991). In science education, the utilization of all three types of argumentation can and should be used to enhance scientific literacy in the science classroom.

The first type of argumentation, presenting a basic argument with logical evidence provided, is critical to current science in society. Presented proof to "back up" a theory is used not only in science but in other real world applications. These real world applications can include anything from economic circumstances (raising the price of a product) to why a service is necessary. The second type of argumentation, an emotional appeal, is used less often than the first and third but is still important. Current socioeconomic issues that impact the environment and community are important to present to the "public" and provide evidence of their importance. The last type of argumentation, an argument based off of the credibility of a given speaker or presented, is important for peer reviewed research and even theory presented to the public. If an argument is being presented that seems wrong, a person should be able to provide a counter-argument that is supported by evidence.

The three types of argumentation presented by Aristotle (1991) was closely related the framework originally created by Toulmin (1958). Toulmin's framework (1958) suggests that argumentative writing has three main parts to a successful argument including a *claim, data and warrant.* A claim is defined as an idea that is being presented to an audience. In science writing, this can be a variety of different subjects ranging from Socioscientific issues (real-life issues) to extensive laboratory experimentation findings. Each claim must be supported by data or clear evidence to support a given idea and a clear conclusion or justification of the idea should be given. Each argumentative writing piece must include these three things (Toulmin, 1958).

An extended argument is one that is used to further support a given claim. For an extended argument to be presented properly, Toulmin (1974) presents three additional criteria that must be followed for the framework to be implemented properly. In addition to a claim, data and warrant, an extended argument should include a *qualifier, backing and rebuttal.* In elementary and secondary education, the uses of these three additional criteria are not stressed as much as the first three, main criteria. However, to build students who are scientifically literate, these three additional criteria should be considered to further their literacy skills. For example, the implementation of a counterclaim to further student problem solving and higher level thinking skills is an important idea in science writing (Wolfe, 2011).

In the elementary and secondary science classroom, argumentative writing is not always formally implemented. Writing methods such as informal journaling, reflective writing and storytelling (narrative writing) can be used to successfully implement argumentative writing techniques into the classroom. However, these methods of science writing do not formally include all six pieces of Toulmin's (1958) framework for argumentative writing. This type of writing does not have to be formal at all times to have benefits for science students.

A case study presented by Qin and Karabacak (2009) evaluated the main elements of argumentative writing presented by Toulmin (1958). These researchers examined the structure and contents of examples of argumentative writing by second language learners in an introductory English class. The main ideas that were examined included the relationship between the six main aspects of Toulmin's framework for argumentative writing and the overall quality of the students' writing. Students that used the secondary levels of an extended argument, which include a qualifier, backing and rebuttal (presented as a counterargument, rebuttal claim and rebuttal data in the research) scored higher and were able to produce an argumentative writing piece that was of higher quality than the students that solely provided a claim and evidence to back up the claim (Qin & Karabacak, 2010).

In order for students to become scientifically literate, Hand, Prain, Lawrence and Yore (1999) discussed what they should be aware of before they can enhance their current understanding of science. Hand et al (1999) said "Science literacy extends beyond the acquisition of relevant vocabulary, conceptual schemes and procedural methods. Students need to understand the nature and relationships between science as inquiry and technology as design" (p. 1022). The researchers go on to discuss the importance of student discourse and discussion of a given topic. Without said discourse, there is no real way to further scientific literacy.

In order to achieve a full grasp of science argumentation, students must understand the role that the nature of science plays with the role of reason. In order for students to consider argumentation important, they have to understand that science is ever changing (Hand et al, 1999) and it must be continuously tested, refined and debated to build an understanding of it. Without these actions, no further understanding or advancements in science will ever be made.

Testing, refining and debating are all done through argumentation: the presentation of a claim, evidence to back up the claim and a counterclaim to rebut it.

The case study presented by Qin and Karabacak (2010) shows a significant position of our current science students. According to their research, when science argumentative writing is implemented into the science classroom, only the three main elements of Toulmin's framework (1958) are seen more often than not. Unless implemented properly and continuously discussed and practices, implementing science writing that include a counterclaim and evidence to back up a rebuttal is hardly ever seen. Based on the evidence and data available, there are times when a student's beliefs or ideas of a given topic can change. If this happens, the student that did not present a counterclaim and evidence for the claim could be supporting an idea they do not even agree with. With current Socioscientific issues and real life examples of issues in science, examining both sides of the "story" can have a significant impact. This is where all 6 elements of Toulmin's (1958) framework are essential for a successful argument.

The Critical Role of Literacy in Argumentation

Link Between Argumentation and Literacy.

It seems the most successful implementation of argumentation into the science classroom is the use of compound argumentative assignments. These writing assignments combine the best qualities of all the different types of writing assignments. With the essential elements of argumentative writing and the added skill of reading literacy, combining text, discourse, thesis and discussion lead to a very fruitful piece of writing that encourages scientific literacy. "…a number of researchers have found significant links between argumentation ability and "doing science" successfully (Wolfe, 2011, p 198). Students with the ability to provide a claim, evidence and warrant for a given idea are those that are most successful in science.

A case study performed by Osborne, Erduran and Simon (2004) focused on the use of argumentation as a means to enhance science instruction using both socioscientific issues and scientific arguments. By implementing argumentation into one group only, they were able to make a judgment of its effectiveness when compared to a control. When the results of the study were analyzed, Osborne et al (2004) found that the implementation of argumentative can be successful even if there are doubts coming from teacher and student. By the end of the study, the students were able to create a scientific argument that was highly supported by evidence. These students were able to support a claim based off of scaffolding originally set forth by the teacher. With practice and fluid integration, implementing argumentation can be very fruitful.

Reading As a Method to Enhance Writing

In order to become scientifically literate and have a firm understanding of science and its' application to the real world, becoming literate in all areas is important. Reading and writing in science becomes an essential part to the process. There is a direct relationship and link between reading and writing in all subjects. It becomes an even larger issue when discussing argumentative writing.

Wolfe presents the idea that an argument, in reading, is "typically evoked by a provocative claim (Wolfe, 2010, p. 195). In order for someone to understand a given argument, the actual claim must be understood first. This is directly related the concept of reading literacy. In order for a given claim to be understood and interpreted, it must first be comprehended when read. In order for one to present a claim with evidence, research and additional information on the given claim must first be understood.

Argumentative writing is based primarily off of a student's ability to comprehend a given topic, synthesize available data and present the evidence in a way that further proves their argument (Toulmin, 1958). For this to occur, students must be first willing to gather the appropriate data necessary for a given claim or topic. This is done through reading. One must be able to read argumentatively and pick out the pieces that are most important for an argument.

A case study presented by Veerman, Andriessen, and Kanselaar (2002) describes the idea and concept of collaborative argumentation. Online discussions were used as a way to encourage student discourse and argumentation of a given subject. For these discussions to be fruitful, students had to have the ability to read what their classmates and peers wrote on a given discussion board. This not only encourages self-advocacy and motivates students, it also encourages them to read and respond to their classmates with claims and further evidence. By encouraging discussion and argumentative with peers, a direct relationship between reading and writing literacy can be identified.

Another case study that was very similar to Veerman et al (2000) was the study performed by Kalman (2010). Kalman examined reflective writing and its impact on student learning of given science concepts. Based off of the description of reflective writing used, it is a form of argumentative writing providing a main idea and evidence to back it up after research was conducted to further understanding of a given topic. Just like Veerman et al, Kalman identifies the importance of reading for this type of writing to be successful. In order to enhance student understanding of a given topic, the students had to read a given text to find evidence for a claim. If they could not comprehend the reading or they were not literate in reading, they would not achieve or perform as high as those that could.

Lauer and Hendrix (2009) also wrote a research piece on writing assignments and their relationship to reading. "The act of researching the assignment and writing a response to the questions forced students to read and to try and understand the material prior to class discussion (p. 431)." By providing the students with a writing assignment where they have to research prior to writing, it enhances student literacy and clearly identifies the relationship between reading and writing literacy.

Argumentation in context.

Argumentative writing tasks and assignments can be used in all subjects, not just science education. However, its implementation in science education can help enhance student problem solving skills and later help with content knowledge retention (Lauer and Hendrix, 2009). There is more than one kind of argumentative writing task that can be implemented into each context. Argumentation across the curriculum (Wolfe, 2011) clearly describes how argumentation can be incorporated into a variety of given context.

The traditional thesis assignment is the most commonly used argumentative writing assignment in all subjects outside of science. This assignment is centered on a central claim or theme, usually chosen by the student. After copious amounts of research and synthesizing, the student is able to gather adequate evidence for a given claim. The most common mistake or occurrence is the "my side bias (Wolfe, 2011, p 197)." According to Wolfe, the "my side bias" is usually developed when a student does not develop and use extended argumentation framework presented by Toulmin (1958) which identifies counterclaims and rebuttals.

Text centered arguments are used in all subject areas and can be directly related to reflective writing assignments. After careful analysis of a given amount of text, the author analyzes, summarizes, and synthesizes the ideas presented in the text around a given claim. Text centered arguments, according to Wolfe (2011), are closely related to the traditional lab report. "It is fruitful to think of lab reports as entailing a set of prescribed yet tacit arguments (Wolfe, 2011, p 197)". Lab reports contain all of the necessary elements of the argumentative framework. The discussion section even leaves room to present a counterclaim and rebuttal, implementing the extended argumentation elements. However, lab reports are "prescribed" in their formatting and leave little to no room for student discourse.

Current movement for argumentation

Common Core Standards.

The National Science Education Standards documents from 1996 and 2000 ((NRC, 1996, 2000) and the Framework for K-12 Science Education Standards (NRC, 2012) set a level of expectation that each science student that graduates from high school should have a developed level of scientific literacy. Part of these Standards included the expectations that students should be able to present, reason, and explain a given topic. In these standards, it stated students should also "give priority to *evidence*, this allows them to develop and evaluate explanations that address scientifically oriented questions (NRC, 1996, 2000)." The whole purpose of this part of the document was to emphasize the importance of student ability to explain a given topic and provide evidence to prove a specific rationale. The skill of arguing a given topic is one that is difficult to develop if one has never been exposed to it. The National Standards presented an outlook on science education that has been around since the late 1950's, when Toulmin developed his framework for argumentation (1958).

The current Common Core Standards are very detailed and explicit about what students should know how to do to become scientifically literate. These standards address writing in the content area and are broken down by grade level. It is important to note that by grade 6, students are expected to "Write arguments to support claims with clear reasons and relevant evidence (Council of Chief State School Officers & National Governor's Associations, p 42). This is the first writing standard listed in the Common Core Standards. Since this type of writing assignment clearly demonstrates argumentative writing in science, the implementation of argumentative writing is essential to meet these standards.

By grade 12, students are expected to "Write arguments to support claims in an analysis of substantive topics or texts, use valid reasoning and relevant and sufficient evidence (Common core standards, p 45)." This document goes on to discuss the importance of claims, counterclaims and supporting evidence. The data and standards presented in this Common Core document are clearly related and very similar to the expectations and framework for argumentative writing established by Toulmin in 1958. Each subsection of the standards has a direct relationship to argumentative writing and stressed the importance of these said skills.

In the past and even currently, most science education focused on conceptual change and evaluating students based on their level of content knowledge retention. The current push for the development of literacy and problem solving skills in science education leads to a different type of science education that is primarily based around evidence based learning. Teachers want students to see science content as a web of interconnectedness and currently, students see science as loosely organized content, bits and pieces of information that are weakly connected and classified by the teacher and text. By using argumentative writing, students pull from the evidence that have built up, the content knowledge that they have been able to retain.

A case study conducted by Kalman (2010) clearly examined the implications of implementing a type of evidence based argumentative writing in science. This study examined reflective writing and its connection to argumentative writing. In this study, students read the text and internalized it. They examined all parts of text and were able to identify what they understood and what they did not understand. After they were finished reading the text and gathering evidence about a common theme, the main theme, they were instructed to free write about the text. In their writing, they were told to include what the text meant, what they did not know, what they did know and what they wanted to know. In order to explain what they knew, they had to provide some sort of evidence that clearly identified their knowledge (Kalman, 2010). This type of reflective writing has a direct relationship to argumentative writing. Both types of writing include some sort of research, a given claim and supporting evidence. Reflective writing in this context was just a form of argumentative writing.

Reflective writing in science can have real benefits for student understanding. Not only does it put the text and content into student words, it also examines the evidence available to support each claim. In order for reflective writing to work, you have to know what it is you do not understand. It builds off of prior knowledge base and summarizes the information by self-dialogue and discourse to build a better understanding of the given topic (Kalman, 2010).

There is a current push for technology in the classroom that has led to the implementation of more than two types of literacy (reading and writing). This current push for technology integration relates to multimodal literacy and the importance of implementing more than one type of literacy at a time into the science classroom. Multimodal literacy incorporates more than the classic forms of literacy due to the popularity of technology integration. Multimodality is closely related to the multiple representations of science other that reading and writing. This type of literacy can be seen visually and represent science through images in many different modes, or locations (Klein and Kirkpatrick, 2010). Students can use multimodality to create images that closely relate to science concepts. They can also use multimodality as pieces of evidence to support a claim in argumentative science.

Currently, most of the multimodal images for this type of literacy are readily available on the internet and through print (Klein and Kirkpatrick, 2010). Implementing argumentative writing with multimodal elements can have a real benefit on student achievement. A case study conducted by Bell and Linn (2000) represents this by using Computer as Learning laboratory experiments. The laboratory experiments were represented through images and concept maps. They allowed students to draw from more than one source of media to incorporate their literacy skills. By incorporating these multiple modes of literacy, which also included reading and argumentative writing, students were able to provide evidence in their writing which suggested an increase in conceptual change. There was also an increase in their ability and skill to implement evidence into a given piece of writing (Bell & Linn, 2000).

Student Achievement and Motivation Through Argumentation

The concept of encouraging students to learn science in today's society is of high interest on the national, school and individual level. Development and implementation of a variety of sets of standards for teaching and learning science are continuously surfacing. Currently, our kindergarten through 12th grade students are losing interest in science education (McNeill, 2008).

As our curriculum seems to expect less depth from our students each year, our communities and government seem to expect more and more from not only teachers, but students.

Science teachers have developed many different modes to engage learners in the process of learning science. These methods are known as active learning methods and include discussions, hands-on labs, interactive and virtual labs, computer activities, argumentative writing activities and even collaborative, group activities. All of these methods are easily implemented into the classroom and engage students to learn science. However, there are no current measures to assess the value of active learning for an actual impact in place by many teachers. As teachers, assessments are given for retention and knowledge recall. In order to assess the value of active learning activities and their outcome versus traditional lecture or text-based lessons, there has to be a unique assessment tool.

Active learning can easily be assessed and encouraged by the addition of argumentative writing in the science classroom. Writing can be used as a method to engage student learning and assess student achievement and interest. As an assessment tool, argumentative writing encourages students to synthesize (put together) ideas from a given active learning lesson with their prior knowledge, hypothesis and organize these ideas, and even draw conclusions by providing evidence for a given topic.

In order for writing to be successful, Lauer and Hendrix, said "Writing should not simply be *taught* in all courses but rather; writing should be *done* in all courses (2009, p. 429)." In order for writing to be used as a successful tool to scaffold the learning process, it has to be taught and performed in the science classroom on a regular basis. Expectations MUST be clearly laid out to students before argumentative writing is implemented.

Not only does writing in science give teachers another method of assessment, it encourages students to construct explanations so they can “make sense” of the world around them. Real-life science phenomena can be difficult to understand. If students are encouraged to write about a given topic, they are also encouraged to learn about it. You cannot successfully write about a topic you do not know about. By encouraging students to research a given topic, read about it and learn about it, students are encouraged to provide evidence through writing that they understand it. Argumentative writing can also be a way to persuade students themselves about the truth of a given topic (Krajcik & Verelas, 2009).

Prior research on argumentative writing sheds a new light on its impact and importance for student learning. Lauer and Hendrix wrote a research article on the importance of repeated writing assignments and their connections with discussions (2009). They were able to study the effects of argumentative writing with first year college students in a Biology course. There were 11 assignments scaffolded into the semester that encouraged students to state a claim, provide evidence and reasoning for a given claim and draw conclusions alongside student discourse. These biology professors saw a dramatic improvement in grammar and writing styles over the semester. There was also a 12.3% increase in content knowledge from prior courses without argumentative writing. Students said writing helped them synthesize information and learn new content. If they did not understand something, they had to research it in order to provide accurate evidence for its validity (Lauer & Hendrix, 2009). This encouraged students to have all the details before they could complete an assignment.

Another important aspect of argumentation through writing is the use of a direct rationale for the importance of writing and argumentation in science. Teachers must provide students with a concrete rationale why writing is important and to explain why a given topic is important.

Without this evidence of importance, students do not see why they should be completing the tasks set in front of them. Teachers should also provide students with explicitly defined components of the argumentative writing tasks. Summarizing, synthesizing and reasoning, promotes higher order thinking skills in all students when doing these assignments. However, if they do not know WHAT they should look like or include, students cannot be successful when completing them.

Krajcik and Varelas (2009) used scaffolding of argumentative writing assignments coupled with inquiry activities to encourage student writing quality. They provided their students with investigation sheets that included claim, reasoning and evidence sections to them. As they moved through their unit, they removed bits and pieces of this scaffolding until the students were writing argumentative pieces on their own. They found that students who had argumentative writing built in to their curriculum had improved content knowledge and explanation skills compared to those that did not. Their research was interesting because it broke down the traditional classroom versus the argumentative classroom. In a traditional classroom, the teacher asks a direct question, a student responds through writing and the teacher then responds. In a classroom that uses argumentation, the teacher asks a series of questions, students respond, critique each other, reflect and conclude on their responses in their writing (Krajcik & Valeras, 2009).

The concept of motivation and perception to learn science through writing is an interesting one because of the task involved. Normally, students, especially at the middle school level, do not enjoy writing and they also do not see the purpose. Another research article breaks down scientific literacy into two parts: importance of content matter and the role of science in everyday life (Ritchie, Tomas & Tones, 2011). In order to motivate students to become scientifically literate, there must be a balance between these two parts. Writing is the perfect balance. If the writing is directly linked to content matter and science in students' lives, the motivational factor is present.

An idea to incorporate writing with the everyday lives of students and science is through story writing. Socioscientific issues (issues that are related and relevant to student lives) surround science at all time. Argumentation can be incorporated into these stories to encourage higher thinking skills and even encourage content retention (Ritchie et al, 2011). By writing stories, it makes the science topics more interesting. By incorporating argumentation into the stories, students can also synthesize prior and new knowledge to build conclusions. They can also provide evidence for their rationales.

Students that have trouble "writing science" are encouraged to use science in their writing to learn. They are also encouraged to tell their understanding of science in story form and include a real topic that directly relates to them. This encourages the student to be creative and motivated to learn science. This increased motivation will also improve their perception of writing in science. If they can do something fun, they will be more willing to complete higher quality work. The case study presented by Ritchie et al (2011) involving writing stories in science concluded that these types of writing tasks were different than anything the students' had done before, they were not seen as the typical "schoolwork" and students were more motivated to complete them (Ritchie et al, 2011).

Similarly, a study with college students and argumentative writing was done to examine the effect of writing at the college level. Students used writing assignments and discussion to help learn new information and content. They were encouraged to provide deep rationale and explanations for conclusions. A post-questionnaire administered to these students showed that students agreed the writing helped them synthesize and learn new content. A particular student said he understood the purpose of the writing tasks and was thankful they were implemented because they encouraged him to learn (Lauer & Hendrix, 2009). If argumentative writing is implemented successfully, students will see its value when they realize it helps them learn. If it is easier to learn and relate the information, student motivation increases.

Ways and methods to implement argumentative writing into the classroom

In the early 1990's, there was a sincere theoretical push for argumentative writing in science education (Wolfe, 2011) to enhance problem solving skills and higher order levels of thinking. However, there is not much research in the area of implementation of argumentative writing. According to Osbourne, Erduran, & Simon (2004), research was conducted in the area of refutable text in the late 1990's. This research led to a deeper understanding of what benefits the elements of argumentation may have when implemented properly into science education.

What major factors exist that prevent argumentative writing from being implemented properly and effectively into the science classroom? Research conducted by Martin and Hand (2004) demonstrate three main issue that are present when attempting to implement argumentative writing into the science classroom. When promoting argumentation in the classroom, the teacher has a critical role in its success (Martin & Hand, 2004). If the importance and relevance of this method of writing is not appropriately stressed to the students from the beginning, it cannot be successfully incorporated into the classroom.

Another factor that influences argumentation is the shift of questioning patterns by the science teacher (Martin & Hand, 2004). During their research, Martin and Hand found that initially, typical questions at the start were "…initiate-respond-evaluate (Martin & Hand, 2004, p

30).” Normal questions when teachers were first trying to implement argumentation would be centered on getting a response from the student on a given question, determining if it was right or wrong and explaining why. As the shift moved from traditional science education to a more student-centered, argumentative education, the types of questions and method of response to answers was one that encouraged discourse and student voice. As the student's voice is discovered and encouraged, the different elements of argumentation, including claims and evidence, are built (Martin & Hand, 2004).

In order to encourage argumentation and discourse about a given topic, there must first be a phenomenon to interpret. Osbourne et al (2004) provide details on what resources are required to initiate implementation of argumentative activities. The concept of scaffolding is discussed in detail in the case study. By putting appropriate scaffolds in place to guide student argumentation, it can be done properly and the transition can be smooth.

Another suggestion for implementation is the idea of modeling good practice. Science teachers can tell students what a good argumentative writing piece looks like but complete comprehension of the different elements involved cannot be obtained from talking about it. A model of proper argumentation should be provided for students to reference and refer back to while working (Osbourne et al, 2004). In Osbourne's case study, nine different frameworks were developed for the facilitation of argumentation in the classroom. These frameworks, or guidelines, were a scaffolded system that allowed the “training wheels” to be removed with practice. At first, students were provided with a table of statements to choose a given topic or idea to support or rebut. Then, scaffolds were removed until students were able to construct arguments and design experiments based off of a given claim (Osbourse et al, 2004). These scaffolds allowed the students to implement higher order thinking skills and problem solving skills.

Just like Osbourne et al (2004), McNeill, Krajcki, & Verala (2006) also implemented scaffolds into their argumentative practices. Instead of the term argumentation, these researchers felt the terms scientific explanations provided a better look at the overall picture of argumentation. Through the use of scaffolds, McNeill et al were able to encourage student independence by the use and later removal of prompts. These prompts allowed students to think about a given topic. The questions used led the student to a conclusion and helped them determine what evidence best supported their claim. Introducing scaffolds into the classroom allows students to slowly work at their own pace and guide their reflection. At the end of the study, the prompts were removed and students showed evidence that they were able to provide an argument without scaffolds (McNeill et all, 2006).

The implementation of argumentative writing into the science classroom should not be a one-time only assignment. Instead, it should be a fluid element of the class that leads to the construction and scaffolding of literacy skills in the science classroom. When an assignment is only used once, the benefits of the different components go unnoticed and the skills that would be learned from repeated use are not considered. A case study performed by Lauer and Hendrix (2009) showed that students who participated in argumentative writing assignments that were built into the course and used on a regular basis improved their grammar, spelling, punctuation and writing structure. Evidence was provided that showed students were able to retain scientific knowledge from their writing. "The only significant factor improving scientific writing performance was prior scientific writing experience (Lauer & Hendrix, 2009, p. 429)." Students who had argumentative writing and even scientific writing in general built into their prior science classes performed even better than those who had writing built into one class alone. This shows that scientific writing can have many advantages to building literacy skills.

Traditional Attempts at Argumentation

Argumentative writing assignments come in many different forms. For years, traditional science education has used the laboratory report. This traditional method of analysis contains a conclusion based off of evidence provided in the lab. Usually, no outside information and research is needed or used to enhance the document or claim. However, this type of argumentative writing does not include a counterclaim or evidence to support or refute a counterclaim. In today's modern educational systems, traditional methods are not giving students the opportunity to successfully use evidence to formulate and defend a given position. Traditional laboratory reports (sometimes referred to as "cookbook" lab reports) do not lead to successful argumentation.

The concept of narrative writing has many implications of success in the field of argumentation. A case study conducted by Ritchie et al (2011) examined the development of students' literacy through the creation of stories from technical information (text-based information) in a narrative form. Claims and ideas were presented in each story and were used to support their stories. It was found that students' motivation to learn science and the students' sense of literacy were improved significantly from narrative writing.

Another group of researchers found similar results when implementing argumentative writing into their curriculum. Ruiz-Primo, Li, Tsai, & Schneider (2010) examined journals from science inquiry classes for explanations and evidence based learning. Their research examined journals for three specific pieces of argumentative writing: claims, evidence and reasoning.

Unlike Lauer and Hendrix, Ruiz-Primo et al (2010) concluded students' writing includes what *students* believe and think is important. Their claims and evidence was based off of what they thought was important in their argumentative writing. What the students thought was important is what they understood and retained. In order for writing assignments to be helpful for student learning, critical questions must be asked to encourage students to synthesize information and draw conclusions. This leads to the idea that argumentative writing must be built in to the science curriculum and re-enforced in order for it to be successful.

Ruiz-Primo et al (2010) was able to conclude that with an increase in the level of student explanations (arguments, evidence and reasoning), there was a definite increase in student achievement (Ruiz-Primo et al, 2010). However, in order for students to be successful with this type of writing, it has to be taught *and* used repetitively in the classroom. They also stressed the importance of teacher feedback of student writing. Without feedback, how do the students know what they can or should improve on with argumentative writing? By providing this feedback, students can improve grammatically and increase their scientific literacy with improved writing skills.

Conclusion

The current Common Core Standards (CCS) and the Framework for K-12 Science Education Standards identify a strong push towards argumentative writing. Being able to support a claim with ample evidence is not just important in science but also has real world applications. Argumentation has been "…recognized as potentially leading to the construction of knowledge… (Schwarz, Neuman, Gil & Ilya, 2003). Since argumentation leads to discourse, incorporating it into scientific writing encourages students to research a given topic to potentially change the opinions of others. Argumentation activities are rare but have real implications for increased student motivation and interest, increased retention and literacy skills.

Chapter 3: Application

In order to create a piece of argumentative writing, no matter what type, a rubric must be provided and followed. A rubric allows a student to identify the main pieces of the body of writing that must be included along with the format that must be used. To receive full credit, the different aspects of the highest rated column must be present within the sample of writing.

In science, the three most important and most used samples of writing are the scientific lab report, a scientific narrative and a scientific journal entry. Rubrics for each of these types of writing have been created to show the different pieces of each writing sample, the format for each and the contents for each. For each sample of writing, there are three examples. For the argumentative lab report, there is an exemplary, proficient and developing example that has been written by following the rubric for the argumentative lab report. These lab reports were created from a lab on water chemistry testing for dissolved oxygen concentrations in five different water samples. For the argumentative journal article, there is an exemplary, proficient and developing example that has been written by following the rubric for the argumentative journal article. These examples have been written a little differently than the lab reports. The first example, the exemplary example, has been written from a different student handout. As an introductory lesson to writing a journal article with argumentation, a simple idea has been provided to help scaffold the students learning of how to write an argumentative journal article. The other two examples, the proficient and developing examples, have been written from an example that gives data on the analysis of air quality after a firework show. The last sample of writing, the argumentative narrative samples, have an exemplary, proficient and developing example also that has been written by following the rubric for argumentative narrative. These narratives are based off of evidence provided from Rutherford's gold foil experiment.

Rubric for a Scientific Argument in a Lab Report

3- Exemplary	2-Proficient	1- Developing	0- Unacceptable
Arrangement of Lab Report Information and text are arranged in a format that is identified from the lab report information sheet. The lab report is arranged in the following manner: - Title - Introduction - Procedure - Results - Discussion - Conclusion - Resources	Information and text are arranged in a format that is identified from the lab report information sheet. Only one section is out of order or is not included.	Information and text are not arranged in a format that is identified from the lab report information sheet. Two sections are out of order or not included.	Information and text are not arranged in a format that is identified from the lab report information sheet. Three or more sections are out of order or not included.
Arrangement of Text- Text is arranged in a coherent, logical manner that is appropriate for the topic and specific audience identified in the lab report.	Text is arranged in a logical manner appropriate for the topic and audience identified in the lab report.	Text is arranged in a mostly logical manner. Paragraphs are put together well but lack a coherent "flow"	Text is not arranged in a logical manner. Paragraphs lack a coherent "flow".

Paragraphs are well put together with a coherent "flow". They are persuasive and connect to surrounding material.	Paragraphs are put together well but some lack a coherent "flow". Paragraphs are persuasive and generally connect to surrounding material.	Paragraphs make an attempt to be persuasive and generally connect to the surrounding material.	Paragraphs make not attempt to neither be persuasive nor connect to the surrounding material.
Title of Report: The title clearly identifies the **topic** and the **main point** of the document.	The title identifies the topic and gives a general idea of the main point.	The title identifies only the general topic.	The title does not identify the topic, or there is no title.
Thesis Statement: Is found in the introduction section of the lab report. Includes the following: - A testable scientific main idea. - The statement predicts an outcome of some sort about the main idea. - There is evidence given to prove the argument.	Is found in the introduction section of the lab report: Includes all of the following (minus one): - A testable scientific main idea. - The statement predicts an outcome of some sort about the main idea.	Is located outside of the introduction section and includes all of the following (minus two or three) - A testable scientific main idea. - The statement predicts an outcome of some sort about the main idea. - There is evidence given to prove the argument.	The thesis statement is left out or not included in any way.

- The thesis statement is specific and looks at a particular question or theory.	- There is evidence given to prove the argument. - The thesis statement is specific and looks at a particular question or theory.	- The thesis statement is specific and looks at a particular question or theory.	
Introduction: The introduction includes the thesis statement and gives the main idea (argument). General information about the topic is given. The reader would understand the significance of the topic.	The introduction includes the thesis statement and vaguely introduces the main idea (argument). Information about the given topic is given. The reader might understand the significance of the topic.	The introduction includes the thesis statement and but does not introduce the main idea (argument) Information about the given topic is very vague. The reader might understand the significance of the topic.	There is no thesis statement or main idea (argument) provided for the reader. The reader does not understand the significance of the topic.
Materials and Methods: The procedure for the laboratory experiment is included in this section. The procedure is written in paragraph form and can be easily repeated by another scientist.	The procedure for the laboratory experiment is included in this section. The procedure is written in paragraph form and can be repeated by another scientist.	The procedure for the laboratory experiment is included in this section. The procedure is written in paragraph form. Details are missing, making repetition of the experiment by another scientist impossible.	There is no materials and methods section provided for the reader. A scientist could not repeat the laboratory experiment from a lack of materials and methods section.

It is written in past tense to illustrate what was done during the laboratory. All materials used in the laboratory are clearly indicated in the body of each methods paragraph.	The methods section is written in past tense to illustrate what was done during the laboratory. Most materials used in the laboratory are clearly indicated in the body of each methods paragraph.	The methods section is provided but not written in past tense to illustrate what was done during the laboratory. Some materials used in the laboratory are clearly indicated in the body of each methods paragraph.	
Results: The results section describes all quantitative and qualitative observations from the laboratory. The data is tabulated and/or graphed in a way that is easy to comprehend. All tables and graphs are numbered, titles and referenced in this section. If applicable, the collected data is also graphed to further build an argument for the original claim.	The results section describes some quantitative and qualitative observations from the laboratory. The data is tabulated and/or graphed in a way that is comprehendible. All table and graphs are titled and references. Graphs are not necessarily provided where applicable.	The data presented in the table is summarized. The data is tabulated and/or graphed in a way that is not easily comprehendible. All table and graphs titled. Graphs of the given data are not provided where applicable.	The results section is not included for the reader. No description of quantitative and qualitative results and observations are provided from the laboratory. The data is not tabulated and/or graphed in any way. There are no graphs provided.

Discussion: Outside evidence (proof or information) is thoroughly discussed and introduced in the discussion section. The results are discussed here as well, in addition to the outside information. A strong connection is built between the two pieces of important information. A counterclaim is introduced to oppose the argument introduced in the thesis statement. Evidence for the claim (argument) and counterclaim are given to successfully persuade the reader towards the original claim.	Outside evidence (proof or information) is generally discussed and introduced in the discussion section. The results are mentioned here as well, in addition to the outside information. A connection is built between the two pieces of important information. A counterclaim is mentioned to oppose the argument introduced in the thesis statement. Evidence from the claim (argument) and counterclaim are given to persuade the reader towards the original claim. Detailed discussion of the evidence is provided, but still leaves the reader with doubts.	Outside evidence (proof or information) is mentioned in the discussion section but not thoroughly discussed. The results are mentioned here as well, in addition to the outside information. No connection is built between the two pieces of important information. A counterclaim is mentioned to oppose the argument introduced in the thesis statement. Evidence from the claim (argument) and counterclaim are given to persuade the reader towards the original claim. Detailed discussion of the evidence is not provided, leaving the reader with questions about the validity or point of view of the reader.	No outside evidence (proof or information) is mentioned in the discussion section. The results are not mentioned again here as well. No connection is built between the two pieces of important information. A counterclaim is not mentioned or discussed in any way. Evidence from the claim (argument) and counterclaim are not given to persuade the reader towards the original claim. No discussion of the evidence is provided, leaving the reader confused about the main idea of the lab report.

Evidence to Support the Claim: A minimum of three pieces of evidence, which clearly support the claim and oppose the counterclaim, are introduced and discussed in detail. The evidence provided to support the claim is highly reputable, taken from multiple sources and the sources are provided for the reader.	A minimum of two pieces of evidence, which clearly support the claim and oppose the counterclaim, are introduced and discussed. The evidence provided to support the claim is reputable, taken from multiple sources and the sources are provided for the reader.	A minimum of one piece of evidence, which generally supports the claim and opposes the counterclaim, is introduced and discussed. The evidence provided to support the claims is taken from a questionable source and the source is provided for the reader.	There are no pieces of evidence to support the claim and oppose the counterclaim. Evidence is provided but the sources are not given and the evidence is not discussed in detail.
Conclusion: The conclusion is strong and well summarized. It leaves the reader with a clear and thorough understanding of the writers' point of view and position. The thesis statement (claim) is effectively restated and evidence is summarized effectively.	The conclusion is well summarized. It leaves the reader with a general understanding of the writers' point of view and position. The thesis statement (claim) is restated and evidence is summarized.	The conclusion is present but not well summarized. It leaves the reader with questions about the readers' point of view and position. The thesis statement (claim) is present, but evidence is not summarized.	The conclusion is not present or summarized. The reader is left with questions about the main idea.

Grammar/ Spelling Errors: The lab report is free from most spelling and grammar errors. 0-2 errors can be identified.	The lab report is generally free from most spelling and grammar errors. 3-5 errors can be identified.	The lab report is somewhat free from most spelling and grammar errors. 4-6 errors can be identified.	The lab report has many spelling and grammar errors. At least 7 errors can be identified.

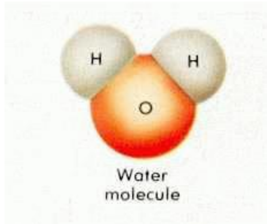
Introduction to an Argumentative Lab Report

The following lab activity is an example of a laboratory experiment that can be used to write an argumentative lab report. Students should follow the procedure, collect data and outside evidence related to the lab topic. They can then examine the data collected and the outside sources of information to create a claim that answers the main question from the lab activity. Using their claim, collected data, outside resources and background knowledge, they will write an argumentative lab report following the lab report format sheet and argumentative lab report rubric. The lab report will include all the main sections of a traditional lab report along with a claim, evidence to support the claim and a counterclaim. All of the information will then be summarized in a conclusion paragraph that leaves the reader informed and able to choose a side to answer the main question.

<u>Handout for Students (Argumentative Lab Report)</u>

Name:_______________________________________ **Date:__________________**

Lab #1 Water Chemistry



Main Question:

Is it safe to assume that the dissolved oxygen levels in each sample are safe for public consumption?

Background Knowledge:

It is possible to test water samples for many different types of dissolved solids, dissolved oxygen, nitrates, phosphates and other contaminates. Each of these water contaminates can be dangerous, in specific levels. Distilled water is pure water, composed of H_2O only, without any contaminates.

This lab focuses on dissolved oxygen, which is simply oxygen molecules (O_2), dissolved in water. Normally, in order to maintain all metabolic processes, all living creatures (except most deep ocean creatures), must have oxygen in one form or another to sustain life. Animals that live in water use dissolved oxygen for the metabolic processes.

Objective:

This laboratory is designed to improve your ability and understanding in water chemistry testing, as well as to give you an introduction to scientific data collection, graphing and analysis. You will gather water samples from various places around the school and community, and then test them for dissolved oxygen concentrations. As you gather data, you should carefully record your information in a data table so that you can organize and understand what you have found.

(* Dissolved oxygen is measured in mg/L or ppm- milligrams per liter or parts per million*)

Procedure:

For this lab, you will be using a dissolved oxygen test kit. Make sure to follow the instructions for the procedure.

Part A: Preparing materials for samples

1. Your teacher will have calibrated the dissolved oxygen probe before the laboratory starts.
2. Collect all of your materials before you start sampling.
3. Rinse 5- 250 mL bottles thoroughly with distilled water.

4. From five different locations, fill all five bottles with water samples

(Hint: You may collect from water faucets, the stream and other water supplies surrounding or in the school. You are not limited to these areas.)

5. Following the directions on the water test kit provided, determine the amount of dissolved oxygen present in each of the five water samples.
6. Record the concentration of dissolved oxygen determined and the temperature of each sample on the data table.

Data Table:

Sample Number	**Temperature (^{o}C)**	**Dissolved Oxygen Concentration (mg/L)**
1		
2		
3		
4		
5		

Conclusion/ Lab Report Format:

With the data you have collected from this lab and other reputable sources, write an argumentative lab report to answer the following question:

Is it safe to assume that the dissolved oxygen levels in each sample are safe for public consumption?

Make sure each source of information and evidence supports your claim and disproves your proposed counterclaim. Be sure to include and complete the following:
(Hint: Check off each box as you complete each item)

- ☐ Reference the lab report format for instructions on how to write a proper lab report
- ☐ Reference the rubric for writing an argumentative lab report to make sure you include all parts of an argumentative lab report. This will make sure you receive full credit for all parts of the lab report.
- ☐ Include a well written thesis statement that contains your claim (answer to the main question).
- ☐ Include a title for your lab report (reference rubric for full credit guidelines).
- ☐ Include an introduction for your lab report (reference rubric for full credit guidelines).
- ☐ Include the procedure section of your lab report (reference rubric for full credit guidelines).
- ☐ Include the results section of your lab report (reference rubric for full credit guidelines).
- ☐ Include a discussion for your lab report (reference rubric for full credit guidelines).
- ☐ Include a conclusion for your lab report (reference rubric for full credit guidelines).
- ☐ Include the resources that you used for your lab report.

Argumentative Lab Report Format:

For each of the following parts, follow the below format for each section. Make sure to reference the argumentative lab report rubric to receive full credit for each part.

Title: Create a title that describes the lab thoroughly. The title should include the main purpose of the lab.

Introduction: This section should be around two paragraphs describing background information on the laboratory topic. It should introduce the main question and the claim. The introduction should describe why the question is important. Make sure to state the purpose of the experiment.

Procedure: The procedure should be written in paragraph form, not in step by step, numbered format. The procedure should include the details of the experiment so a stranger could repeat the experiment. This procedure should also be in the past tense, demonstrating that the experiment was already conducted. All materials used during this experiment should be mentioned in the procedure. If the procedure was already given for you to follow, it should be rewritten, *in your own words*.

Results/ Data: This section should include a summary of the data. The results section should describe all quantitative and qualitative observations from the laboratory. Data is presented in a data table format and should include the following:

Title: The data table should include a descriptive title for each data table or graph.
Column: The data should be aligned in columns with a proper, descriptive label.
Unit: Each column heading should include a heading, if it were a measurement.

For this particular laboratory exercise, a graph of the data should be included along with the data organized in a data table. This graph will be used to evaluate the concentration of the dissolved oxygen to the temperature at which it was found for all five locations. Using excel to graph a given set of data is an important skill used by all scientists and it aids in comparing different sets of data. Using the data table that was created for the data collected, create a graph to visually represent the data. This graph should be referenced in the results section but should be provided at the end of the results section, along with the data table.

Discussion: This is also known as the critical analysis section. This section should include your interpretation and evaluation of all of the data from the lab. In this section, the claim should be re-introduced and discussed. Evidence from the lab should be given, along with outside sources of evidence, to support the claim. A counterclaim (opposite of your original claim), should be introduced and evidence should be discussed to disprove its validity.

Conclusion: The conclusion should be one to two paragraphs that summarize all the data from the laboratory experiment and evidence. It should leave the reader with a thorough understanding of the claim. The claim should be restated and evidence to support it should be summarized.

Exemplary Example of an Argumentative Lab Report:

Lab #1 Water Chemistry Lab
Chemistry Lab Day: Wednesday
Due Date: September 15th

Title: Identifying whether or not drinking water from different locations is safe after testing for dissolved oxygen levels

Introduction:

Water quality testing is a common practice to test the level of safety of drinking water, public water and even pool water (water that people swim in). There are tests for all types of water quality including phosphate, nitrate, dissolved solids, conductivity and even dissolved oxygen levels. This experiment focused on dissolved oxygen levels and compared these levels to given norms or safety standards set by the EPA. After examining the results of the water testing, it can be concluded that all dissolved oxygen levels for four of the five locations are normal and are not harmful to human health. However, one of the locations (location 2) has extremely low levels of dissolved oxygen, showing a definite increase in the levels of algae and bacteria levels.

Low levels of dissolved oxygen are usually caused from algae blooms, which appear in lakes, streams and oceans due to an increase in wastewater, fertilizers runoff and pollution. These factors increase the levels of nitrates and phosphates, which in turn increase the levels of algae growing in the water. Algae blooms push oxygen and other living species out of the water, causing "dead zones". Locations 1, 3, 4 and 5 are all safe for public consumption, swimming and fishing. Higher levels of oxygen show lower levels of algae and bacteria, meaning safer environments for public consumption, swimming and fishing (St. John's River Management).

Procedure:

In order to start this laboratory experiment, all materials were collected and observed carefully. A Vernier dissolved oxygen probe was used to test the levels of dissolved oxygen in the water samples. Before the lab was started, the instructor for the course calibrated and prepared the probe for proper use.

There were a total of five different water samples collected for analysis. A 250 mL bottle was first rinsed with a small amount of distilled water to make sure it was clear of all contamination. The bottle was then submerged in the water sample for each location and the cap was screwed on to the bottle while still submerged, guaranteeing the water collected was just the water sample needed. The temperature of the water was then taken with a thermometer and recorded to ensure proper temperature collection.

After the temperature was taken for the sample, the dissolved oxygen level was taken using the probe. This was done to make sure the temperature of the sample did not change. If it did, the concentration of dissolved oxygen that was measured by the probe would not be accurate. In order to use the probe, the tip of the probe was submerged approximately 4-6 cm into the water sample. Since the probe takes in oxygen from the surrounding water sample and measures its concentration, the probe was used to continuously and gently stir the water sample. This made the oxygen in the water continuously pass against the probe and it accurately measured the concentration. The live readout of the information was read and the concentration of dissolved oxygen for the given location was recorded.

Since there were a total of five different sample locations, five different water samples were collected, their temperatures taken with a thermometer and recorded and the data placed into the data chart. The data from the entire class was collected and tabulated, giving a more accurate sample population due to an increased number of samples.

Results:

The data table on the next page summarizes the data collected in this laboratory activity. A thermometer was used to measure the temperature of each water sample in degrees Celsius. A Vernier dissolved oxygen probe was used to determine the concentration of dissolved oxygen in each sample. The sample average was taken to determine the average amount of dissolved oxygen in each sample.

When each sample was taken, it was observed that the samples with a lower amount of dissolved oxygen were considered “dirtier”. There was more sediment, “scum” and cloudiness observed in the water samples which had a lower dissolved oxygen concentration. Specifically, at location 2, there was a greenish colored tint to the water. It was also observed that the locations with lower measured temperatures generally had higher concentrations of dissolved oxygen. The other samples, from locations 1, 3, 4 and 5 were clear and colorless.

For location 1, the average measured temperature was around 32.07^{o}C with an average measured dissolved oxygen concentration of 7.36 mg/L. For location 2, the average measured temperature was around 27.09^{o} C with an average dissolved oxygen concentration of 7.37 mg/L. For location 3, the average measured temperature was around 27.00^{o} C with an average measured dissolved oxygen concentration of 8.08 mg/L. For location 4, the average measured temperature was around 23.10^{o} C with an average measured dissolved oxygen concentration of 8.85 mg/L. For location 5, the average measured temperature was around 20.11^{o}C with an average measured dissolved oxygen concentration of 9.16 mg/L.

Data Table 1: Dissolved Oxygen Concentration (mg/L)										
	Location 1		**Location 2**		**Location 3**		**Location 4**		**Location 5**	
Sample # (Group #)	**Temp (^oC)**	**Conc (mg/L)**	**Temp (^oC)**	**Conc (mg/L)**	**Temp (^oC)**	**Conc.(mg/L)**	**Temp (^oC)**	**Conc (mg/L)**	**Temp (^oC)**	**Conc (mg/L)**
1	32.00	7.40	27.00	7.50	27.00	8.10	23.00	8.90	20.00	9.30
2	32.01	7.30	27.10	7.50	27.00	8.25	23.40	8.86	20.10	9.40
3	32.01	7.30	27.00	7.50	27.50	8.10	23.10	8.90	20.00	9.25
4	32.00	7.30	27.00	7.20	27.10	8.12	23.20	8.75	20.20	9.00
5	32.20	7.40	27.01	7.30	27.05	8.15	23.14	8.55	20.14	9.22
6	32.31	7.40	27.20	7.50	27.00	8.22	23.00	8.60	20.12	9.19
7	32.00	7.50	27.30	7.40	27.11	7.90	23.00	8.90	20.00	9.10
8	32.00	7.30	27.25	7.20	27.10	8.10	23.10	9.00	20.30	9.00
9	32.03	7.20	27.00	7.20	27.00	8.00	23.05	9.10	20.25	9.11
10	32.10	7.50	27.00	7.35	27.20	7.85	23.00	8.90	20.00	9.00
Average	**32.07**	**7.36**	**27.086**	**7.365**	**27.106**	**8.079**	**23.1**	**8.846**	**20.111**	**9.157**

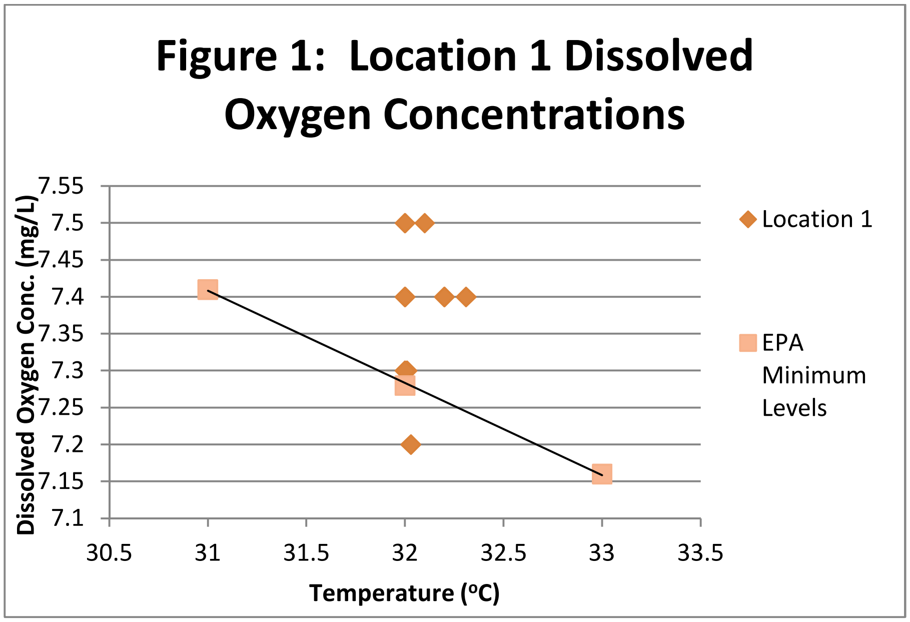


Figure 1: Location 1 Dissolved Oxygen Concentrations
Dissolved Oxygen Conc. (mg/L)
7.55
7.5
7.45
7.4
7.35
7.3
7.25
7.2
7.15
7.1
30.5
31
31.5
32
32.5
33
33.5
Temperature (°C)
Location 1
EPA Minimum Levels

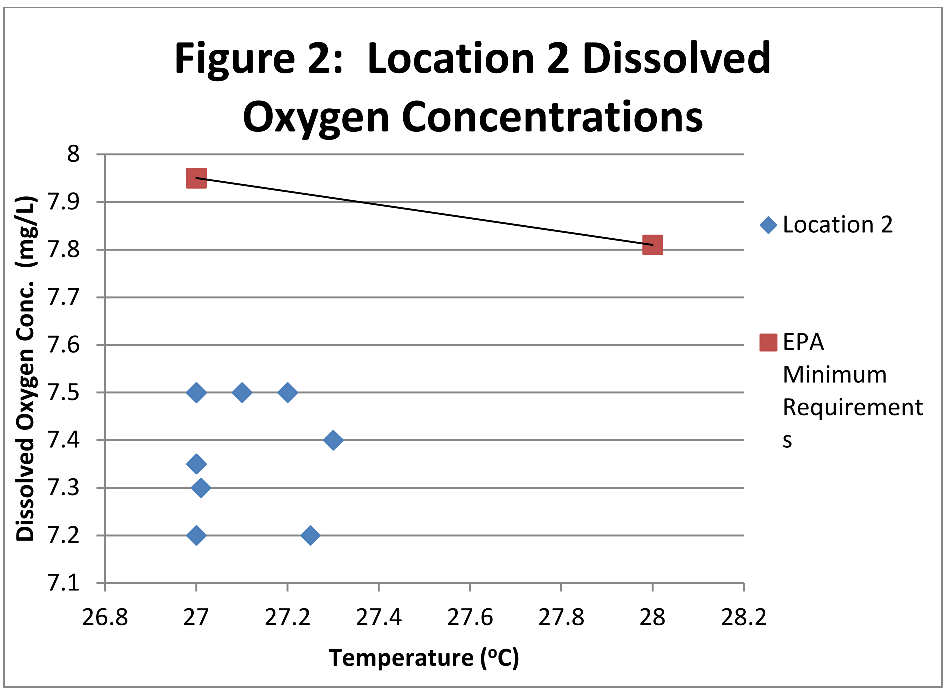


Figure 2: Location 2 Dissolved Oxygen Concentrations
Dissolved Oxygen Conc. (mg/L)
8
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
26.8
27
27.2
27.4
27.6
27.8
28
28.2
Temperature (°C)
Location 2
EPA Minimum Requirements

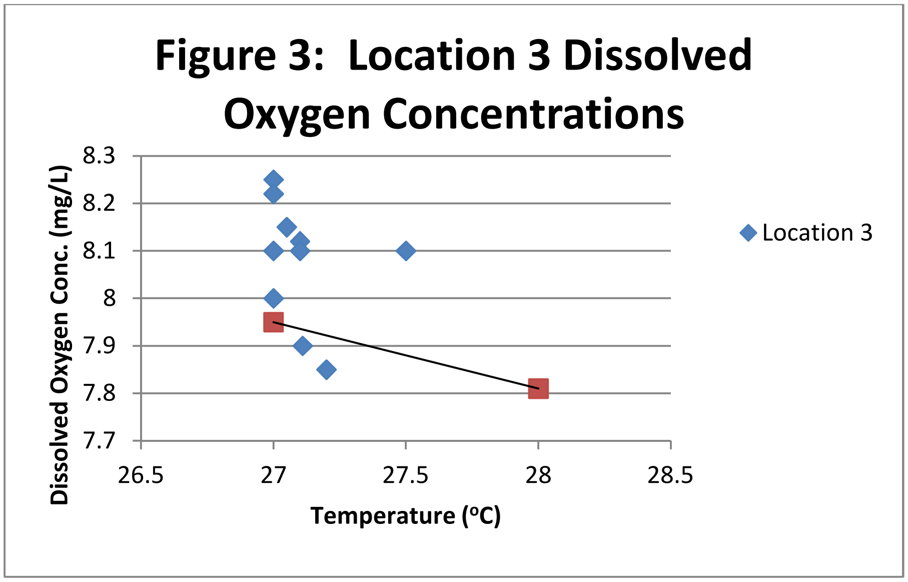


Figure 3: Location 3 Dissolved Oxygen Concentrations
Dissolved Oxygen Conc. (mg/L)
8.3
8.2
8.1
8
7.9
7.8
7.7
26.5
27
27.5
28
28.5
Temperature (°C)
Location 3

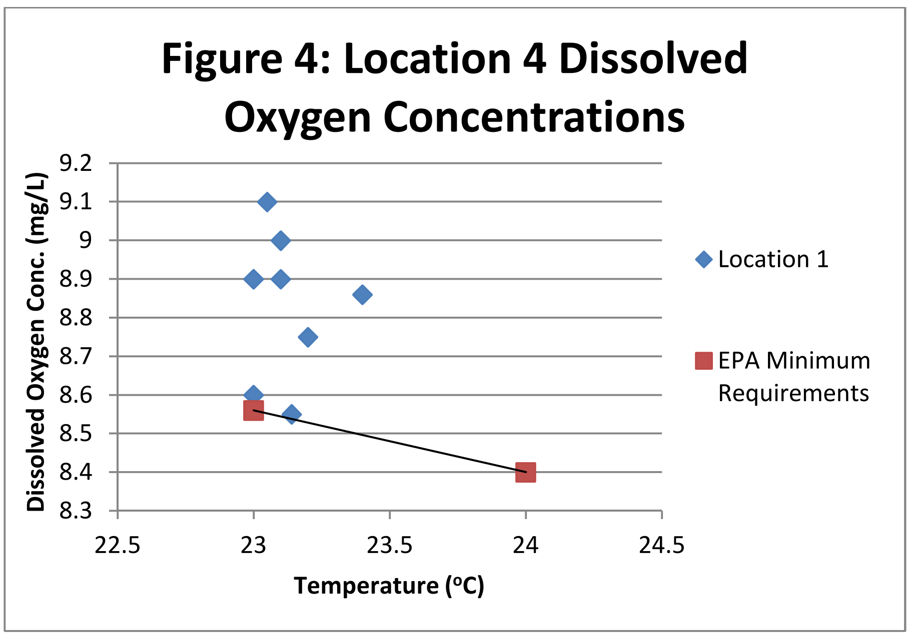


Figure 4: Location 4 Dissolved Oxygen Concentrations
Dissolved Oxygen Conc. (mg/L)
9.2
9.1
9
8.9
8.8
8.7
8.6
8.5
8.4
8.3
22.5
23
23.5
24
24.5
Temperature (°C)
Location 1
EPA Minimum Requirements

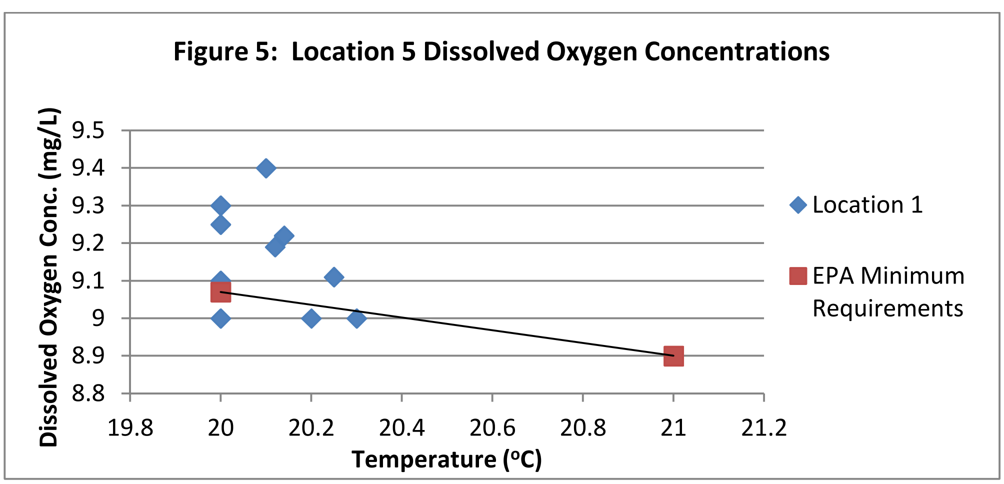


Figure 5: Location 5 Dissolved Oxygen Concentrations
Dissolved Oxygen Conc. (mg/L)
9.5
9.4
9.3
9.2
9.1
9
8.9
8.8
19.8
20
20.2
20.4
20.6
20.8
21
21.2
Temperature (°C)
Location 1
EPA Minimum Requirements

Discussion:

There are many different variables that effect the concentration of dissolved oxygen in the water. The first is temperature. The solubility of a gas is opposite that of a solid. When a gas is dissolved in water, the lower the temperature, the more gas will be dissolved in the water (Terri, 2005). This is evident when the data from the lab is examined. The samples of water that were taken at higher temperatures generally had lower concentrations of dissolved oxygen. This information can be used to help analyze the data collected from the lab.

The original question for this laboratory activity was whether or not the water samples collected from each location were safe for public consumption. After analyzing the data and outside sources of information, it can be concluded that location 2 is not safe for public consumption. However, the other locations, location 1, 3, 4 and 5 are safe.

Dissolved oxygen levels are measured to determine what lives, or could potentially be living, in a given water sample or area. In general, the higher than dissolved oxygen levels, the more oxygen is available for plants and animals to perform all their necessary life functions and metabolic reactions underwater. If the levels of oxygen fall below a certain level, it can be indicative of another organism living in the water, algae. The higher the levels of algae in the water, the higher the levels of potential toxins produced by the algae and bacteria. Algae feed off of nitrates and phosphorus, which can be found in water samples from waste, pollution and fertilizer runoff. The more of these wastes that enter the water, the higher the levels of algae, bacteria and threatening toxins and threaten plant, animal and human life ("St. johns river-water," 2011)

By analyzing water samples, it can be determined if the levels of dissolved oxygen in each water sample are in fact safe for human consumption, fishing and even swimming. If the levels are high enough, it means the water is safe. If the levels are NOT high enough, the water is not considered safe.

According to the Environmental Protection Agency (EPA), they have conducted experiments with various water temperatures to determine the minimum amount of dissolved oxygen that would be deemed “safe” for swimming, consumption and fishing. This data can be seen in Data Table 2 (“EPA,” 2012). The general trend for temperature and solubility of oxygen gas is also seen in this table. Since there is the same trend observed in the table as our data, we can conclude that our data is, in fact, accurate.

The data table presented by the EPA, data table 2, shows the minimum levels of safe oxygen dissolved in water samples. In order for water to be considered "safe", the measured level of dissolved oxygen must be equal to or greater than the given value for a measured temperature. If each graph (figures 1-5) is examined, the majority of the data points must be above the EPA minimum line in order to be considered "safe" for human consumption. The values from the laboratory experiment and the EPA can be compared for further analysis.

- For location 1, the average measured temperature was around 32.07°C with an average measured dissolved oxygen concentration of 7.36 mg/L
    - Safe levels presented by the EPA for this average temperature must be 7.28 mg/L or higher. Since the average value for Location 1 is higher, it is deemed safe.
    - Figure 1 shows a graph of all the data points collected at Location 1. There are 6 points above the EPA minimum required dissolved oxygen levels and only one point below the line. Since the majority of the points are located above the line, the water is considered "safe" for human consumption.
- For location 2, the average measured temperature was around 27.086°C with an average dissolved oxygen concentration of 7.365 mg/L.
    - Safe levels presented by the EPA for this average temperature must be 7.95 mg/L or higher. Since the measured value at Location 2 was significantly lower than the EPA value, Location 2 is not deemed safe.
    - Figure 2 shows a graph of all the data points collected at Location 2. All 8 points on the graph are located underneath the EPA minimum required dissolved oxygen levels. Since the majority of the points are located beneath the line, the water is not considered "safe" for human consumption.

- For location 3, the average measured temperature was around 27.00^{o}C with an average measured dissolved oxygen concentration of 8.079 mg/L.
    - Safe levels presented by the EPA for this average temperature must be 7.95 mg/L or higher. Since the average value for Location 3 is higher, it is deemed safe.
    - Figure 3 shows a graph of all the data points collected at Location 3. There are 8 points above the EPA minimum required dissolved oxygen levels and only two points below the line. Since the majority of the points are located above the line, the water at this location is considered "safe" for human consumption.
- For location 4, the average measured temperature was around 23.10^{o}C with an average measured dissolved oxygen concentration of 8.846 mg/L.
    - Safe levels presented by the EPA for this average temperature are 8.56 mg/L or higher. Since the average value for Location 4 is higher, it is deemed safe.
    - Figure 4 shows a graph of all the data points collected at Location 4. All of the data points are located above the EPA minimum required dissolved oxygen levels. Since the majority of the points are located above the line, the water is considered "safe" for human consumption.
- For location 5, the average measured temperature was around 20.111^{o}C with an average measured dissolved oxygen concentration of 9.157 mg/L.
    - Safe levels presented by the EPA for this average temperature are 9.07 mg/L or higher. Since the average value for Location 5 is higher, it is deemed safe.
    - Figure 5 shows a graph of all the data points collected at Location 5. There are 7 points above the EPA minimum required dissolved oxygen levels and only 3 points below the line. Since the majority of the points are located above the line, the water is considered "safe" for human consumption.

Since the levels of dissolved oxygen in Location 2 are much lower than the safe level, it can be determined that Location 2 is actually not safe for human consumption. There could be potential toxins, algae and bacteria that could threaten the health and lives of human individuals. Locations 1, 3, 4 and 5 have high enough levels of dissolved oxygen and they are, therefore, considered safe, according to the EPA.

There are some individuals that may claim the dissolved oxygen levels for location 2 are not low enough, significantly, to be considered unsafe. However, if you examine the EPA's data chart (data chart 2) for safe levels of dissolved oxygen, it can be seen that there is not a significant change in the dissolved oxygen levels for each temperature. When you move up one degree, the levels of safe dissolved oxygen only decrease by approximate 0.14 mg/L. Since there is approximately 4 times the difference from the safe level, to the measured level, it can be logically concluded the level of dissolved oxygen at location 2, is not safe at all.

Since all of the location samples were observed thoroughly when they were collect, the fact that Location 2 was the only location with a green tint should also be mentioned. According to the St. John's River Management District, a green tint is indicative of algae growth. This information, combined with the statistical factors presented in the paragraph above, leads to the conclusion that Location 2 is in fact unsafe.

Data Table 2: EPA Minimum Concentration of Dissolved Oxygen			
Temperature (°C)	**Dissolved Oxygen (mg/l)**	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.16
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.41
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Conclusion:

From the data collected during this laboratory experiment, it can be clearly seen that Locations 1, 3, 4 and 5 are safe for human consumption when compared to the EPA's data charts for safe levels of dissolved oxygen. Location 2 has a significantly and statistically lower dissolved oxygen concentration than is deemed safe by the EPA, so it would be unsafe for human consumption. Due to the differences in temperature and concentration with each location, multiple sources were collected to be effectively analyzed and summarized. From the data collected in the lab, it is recommended that no one consume water from Location 2, nor swim or fish in this location, either.

Resources:

Epa. (2012, March 06). Retrieved from http://water.epa.gov/type/rsl/monitoring/vms52.cfm

St. Johns river-water management district. (2011). Retrieved from http://www.sjrwmd.com/algae/

Terri, L. (2005, August 24). *Watershed monitoring program*. Retrieved from http://www.uwgb.edu/watershed/data/monitoring/oxygen.htm

Proficient Example of an Argumentative Lab Report

Lab #1 Water Chemistry Lab
Chemistry Lab Day: Wednesday
Due Date: September 15th

Title: Identifying safety of drinking water after testing for dissolved oxygen

Procedure:

In order to perform this laboratory experiment, five different water samples were needed for analysis. A Vernier dissolved oxygen probe was used to test the levels of dissolved oxygen in the water samples. Before the lab was started, the instructor for the course calibrated and prepared the probe for proper use.

A bottle was used to collect a water sample for each location. The temperature of the water was taken and recorded. The probe was then used by inserting it into the bottle and stirring the water sample. The probe produced a live readout of the concentration of dissolved oxygen, which can be recorded.

All of the classes' sample data was collected and tabulated.

Introduction:

Testing water quality of drinking water, pools and public water is important to identify safety and other precautionary issues. This laboratory focuses on one specific water quality test, dissolved oxygen. This experiment revealed that locations 1, 3, 4 and 5 had safe levels of dissolved oxygen. Location 2 is not considered safe for drinking, swimming or fishing due to low dissolved oxygen levels.

Results:

When each sample was collected, the temperature and dissolved oxygen concentration was recorded. This information can be found in data table 1, on the next page.

It can be noted that when each sample was collected, it was observed thoroughly. Location 2 was the only location that looked significantly different from the others. It had a green tint to it and looked very “cloudy”. The other samples were very clear and colorless.

The data from this laboratory experiment can be found in Data Table 1 on the next page. The average dissolved oxygen concentration and average temperatures are given for each location. Each sample which was taken and analyzed is also given.

Data Table 1: Dissolved Oxygen Concentration (mg/L)										
Sample # (Group #)	Location 1 Temp (°C)	Location 1 Conc. (mg/L)	Location 2 Temp (°C)	Location 2 Conc. (mg/L)	Location 3 Temp (°C)	Location 3 Conc. (mg/L)	Location 4 Temp (°C)	Location 4 Conc. (mg/L)	Location 5 Temp (°C)	Location 5 Conc. (mg/L)
1	32	7.4	27	7.5	27	8.1	23	8.9	20	9.3
2	32.01	7.3	27.1	7.5	27	8.25	23.4	8.86	20.1	9.4
3	32.01	7.3	27	7.5	27.5	8.1	23.1	8.9	20	9.25
4	32	7.3	27	7.2	27.1	8.12	23.2	8.75	20.2	9
5	32.2	7.4	27.01	7.3	27.05	8.15	23.14	8.55	20.14	9.22
6	32.31	7.4	27.2	7.5	27	8.22	23	8.6	20.12	9.19
7	32	7.5	27.3	7.4	27.11	7.9	23	8.9	20	9.1
8	32	7.3	27.25	7.2	27.1	8.1	23.1	9	20.3	9
9	32.03	7.2	27	7.2	27	8	23.05	9.1	20.25	9.11
10	32.1	7.5	27	7.35	27.2	7.85	23	8.9	20	9
Average	**32.07**	**7.36**	**27.086**	**7.365**	**27.106**	**8.079**	**23.1**	**8.846**	**20.111**	**9.157**

Discussion:

The original question for this laboratory activity was whether or not the water samples collected from each location were safe for public consumption. After analyzing the data and outside sources of information, it can be concluded that location 2 is not safe for public consumption. However, the other locations, location 1, 3, 4 and 5 are safe.

Dissolved oxygen levels are measured to determine what lives, or could potentially be living, in a given water sample or area. In general, the higher than dissolved oxygen levels, the more oxygen is available for plants and animals to perform all their necessary life functions and metabolic reactions underwater. If the levels of oxygen fall below a certain level, it can be indicative of another organism living in the water, algae. The higher the levels of algae in the water, the higher the levels of potential toxins produced by the algae, along with bacteria ("St. johns river-water," 2011). Algae feed off of nitrates and phosphorus, which can be found in water samples from waste, pollution and fertilizer runoff. The more of these wastes that enter the water, the higher the levels of algae, bacteria and threatening toxins and threaten plant, animal and human life (sjrwmd.com). If the levels of dissolved oxygen are high enough, it means the water is safe. If the levels are NOT high enough, the water is not considered safe.

According to the Environmental Protection Agency, they have conducted experiments with various water temperatures to determine the minimum amount of dissolved oxygen that would be deemed “safe” for swimming, consumption and fishing (“EPA”, 2012). This data can be seen in Data Table 2.

The data table presented by the EPA, data table 2, shows the minimum levels of safe oxygen dissolved in water samples. In order for water to be considered “safe”, the measured level of dissolved oxygen must be equal to or greater than the given value for a measured temperature. The values from the laboratory experiment and the EPA can be compared for further analysis.

If the two data tables are compared, it can be clearly concluded the levels of dissolved oxygen in Locations 1, 3, 4 and 5 are clearly high enough. The averages for dissolved oxygen for these locations are statistically higher than the EPA's safe levels. However, Location 2 has a statistically lower average dissolved oxygen level than the EPA's safe level. This leads to the conclusion that the levels are not safe.

People that do not believe the studies conducted by the EPA are accurate may say that all of the above locations are actually in fact safe. However, something can also be said about the clarity of the water. Since location 2 was the only location that did not have clear, colorless water, it can be concluded that there was, in fact, algae growing in the water. According to St. John's River Management District, water that is tinted green may not be safe. This combined with the EPA's data, it can be concluded that the water is in fact unsafe.

Data Table 2: EPA Minimum Concentration of Dissolved Oxygen

Temperature (°C)	Dissolved Oxygen (mg/l)	Temperature (°C)	Dissolved Oxygen (mg/l)
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.16
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.41
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Conclusion:

From the data collected during this laboratory experiment, it can be seen that Locations 1, 3, 4 and 5 are safe for human consumption when compared to the EPA's data charts for safe levels of dissolved oxygen. Location 2 has a significantly lower dissolved oxygen concentration than is deemed safe by the EPA, so it would be unsafe for human consumption. From the data collected in the lab, it is recommended that no one consume water from Location 2, nor swim or fish in this location, either.

Resources:

Epa. (2012, March 06). Retrieved from http://water.epa.gov/type/rsl/monitoring/vms52.cfm

St. johns river-water management district. (2011). Retrieved from http://www.sjrwmd.com/algae/

Developing Example of an Argumentative Lab Report

Lab #1 Water Chemistry Lab
Chemistry Lab Day: Wednesday
Due Date: September 15th

Title: Testing for dissolved oxygen levels

Procedure:

Water samples from five different locations are collected and used for analysis. A dissolved oxygen probe is used to measure the dissolved oxygen concentration in the water. The information is recorded in a data table. The table in the results sections shows all of the class's data.

Introduction:

Water quality testing is important to determine the quality and contents of water in drinking water, pool water and public water. This experiment focused on one specific water quality test, dissolved oxygen, and whether or not the water was safe for public consumption.

Results:

Data Table 1 shows the data collected for this laboratory experiment. The average amounts for temperature and concentration are included.

Data Table 1: Dissolved Oxygen Concentration (mg/L)										
	Location 1		Location 2		Location 3		Location 4		Location 5	
Sample # (Group #)	Temp (^oC)	Conc (mg/L)	Temp (^oC)	Conc (mg/L)	Temp (^oC)	Conc (mg/L)	Temp (^oC)	Conc (mg/L)	Temp (^oC)	Conc (mg/L)
Average	32.07	7.36	27.086	7.365	27.106	8.079	23.1	8.846	20.111	9.157

Discussion:

The EPA has done many experiments and collected a lot of data in order to obtain the minimum levels of dissolved oxygen that make water safe for consumption ("EPA", 2012). In data table 2, the different levels of dissolved oxygen given for different temperatures are the minimum levels of dissolved oxygen that are safe. If compared to the data in data table 1 collected from this experiment, it can be seen that Locations 1, 3, 4 and 5 are in fact safe. They have the minimum level of dissolved oxygen. Location 2 is not safe because it does not have the minimum level of dissolved oxygen.

Data Table 2: EPA Minimum Concentration of Dissolved Oxygen			
Temperature (°C)	**Dissolved Oxygen (mg/l)**	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.16
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.41
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Resources:

Epa. (2012, March 06). Retrieved from http://water.epa.gov/type/rsl/monitoring/vms52.cfm

Journaling is much less formal than writing a scientific lab report. In order to make a scientific argument effective through journaling, a different format can be used. This format is less formal and takes much less time than a traditional argumentative essay. For a given journal entry, a simple picture or data set can be given and the student must use direct evidence from the given piece of information to make their argument.

The parts of an informal journal entry are as follows:

- A list of evidence and observations based DIRECTLY from the piece of information, picture or data set provided for the student.
- A table that gives a list of evidence or warrants from the piece of information.
- Included in the table, there is to be a column labeled "As a rule…" This will help the student organize their thoughts to then answer the main question or claim.

The following rubric for writing a journal entry for a scientific argument includes each of the pieces of an informal journal entry listed above. In order to write a journal entry that is considered an argument, there has to be a list of evidence and observations to work from. These observations are taken directly from the data tables or picture given. Anything the author of the journal entry observes of finds interesting should be listed in this list. A table to organize the evidence should then be created and a connection between the evidence should be made. For example, one of the columns would be labeled "Evidence". A student might put evidence from a picture here such as "The sky in the picture is green." Another column would be labeled "As a rule…". In this column, the student might write, "As a rule, the sky is blue." This table of evidence and warrants will not only help them organize their thoughts but clearly shows what evidence is available for the argument. This information can then be used to help write the conclusion.

(*Picture and information was taken from the G. Hillock's book *Teaching Argument Writing*. His example is used to teach the different pieces of argumentative writing but it not arranged into a journal entry rubric or format.)

Rubric for Journaling using Scientific Argumentation

3- Exemplary	2-Proficient	1- Developing	0- Unacceptable
Arrangement of Journal Information and text are arranged in a format that follows the order below: - Main question - Evidence and observations of the given information - Warrant and Rules Table - Conclusion	Information and text are arranged in the format in the exemplary box. Only one section is out of order or is not included.	Information and text are not arranged in the format in the exemplary box. Two sections are out of order or are not included.	Information and text are not arranged in the format in the exemplary box. Three or more sections are out of order or not included.
Main Question A general idea of what evidence is provided should be included in the main question section. The main topic and question are given along with how it relates to the claim.	A general idea of what information is provided should be included in the main question section. The main topic is given in this section along with how it relates to the claim.	The main topic is given along with how it relates to the claim.	There is no main topic or main idea given. The main question is not provided at all.
Evidence Using the information given (either from a picture, essay, article, or another source), there are a minimum of seven observations and facts listed for the reader.	Using the information given (either from a picture, essay, article, or another source), there are a minimum of five observations and facts listed for the reader.	Using the information given (either from a picture, essay, article, or another source), there are a minimum of three observations and facts listed for the reader.	There are no observations or facts given in the evidence section. The reader has no understanding of what the main topic is and how

These facts give the reader a good understanding of what the main topic is and how it relates to the main question.	These facts give the reader a good understanding of what the main topic is and how it relates to the main question.	These facts give the reader a general understanding of what the main topic is and how it relates to the main question.	it relates to the main question.
Evidence/ Warrant/ Rules Table The warrants and rules are presented in a T chart or table that organizes the ideas and evidence clearly for the reader. From the chart, the reader gets a thorough understanding of the main idea and starts to build an understanding of the claim. There are a minimum of five warrants with strong support (As a rule…) to support their reliability.	The warrants and rules are presented in a T chart or table that organizes the ideas and evidence for the reader. From the chart, the reader gets a general understanding of the main idea and starts to build an understanding of the claim. There are a minimum of three warrants with strong support (As a rule…) to support their reliability.	The warrants and rules are presented in some sort of chart that organized the ideas and evidence for the reader. From the chart, the reader gets a general understanding of the main idea and starts to build an understanding of the claim. There is a minimum of one warrant with strong support (As a rule…) to support their reliability.	There are no warrants and rules listed in any chart form. The reader does not get a general understanding of the main idea or claim. There are no warrants with support.
Conclusion: The thesis statement of the conclusion includes the claim. The thesis statement is easy for the reader to understand and clearly answer the main question. A counterclaim can be identified from the information given but is disproved with the given evidence that supports the claim. A minimum of 3 pieces of evidence from the information	The thesis statement of the conclusion includes the claim. The thesis statement is easy for the reader to understand and clearly answer the main question. A minimum of 2 pieces of evidence from the information provided are summarized clearly and discussed. The reader understands the claim and it is supported by all surrounding evidence.	The thesis statement of the conclusion includes the claim. The answers the main question. A minimum of 1 piece of evidence from the information provided is summarized and discussed. The reader understands the claim and it is supported by the surrounding evidence.	. There is no conclusion section of the journal entry. There is no thesis statement in this section. There are no pieces of evidence from the information provided. The reader cannot understand the claim due to a lack of evidence and thesis statement.

provided are summarized clearly and discussed. The reader understands the claim and it is clearly supported by all surrounding evidence.			
Grammar/ Spelling Errors: The journal entry is free from most spelling and grammar errors. 0-2 errors can be identified.	The journal entry is generally free from most spelling and grammar errors. 3-5 errors can be identified.	The journal entry is somewhat free from most spelling and grammar errors. 4-6 errors can be identified.	The journal entry has many spelling and grammar errors. At least 7 errors can be identified.

Handout given to students:

Information to go with picture:

At five-feet-six and a hundred and ten pounds, Queenie Volupides was a sight to behold and to clasp. When she tore out of the house after a tiff with her husband, Arthur, she went to the country club where there was a party going on.

She left the club shortly before one in the morning and invited a few friends to follow her home and have one more drink.

They got to the Volupides house about ten minutes after Queenie, who met them at the door and said, “Something terrible happened. Arthur slipped and fell on the stairs. He was coming down for another drink—he still had the glass in his hand—and I think he’s dead. Oh, my God—what shall I do?

The autopsy conducted later concluded that Arthur had died from a wound on the head and confirmed that he’d been drunk.

(*Picture and information was taken from the G. Hillock's book *Teaching Argument Writing*. His example is used to teach the different pieces of argumentative writing but it not arranged into a journal entry rubric or format.)

Exemplary Example of an Informal Journal Article:

(The picture and information can be used as an introductory piece for any class to introduce the argument, warrant and claim parts of argumentative writing in a journal. This is an introduction to an informal journal entry. This would be done in class to demonstrate the proper instructions and format of how to write an argumentative journal entry. This also provides an exemplary example of an argumentative journal entry based off of the rubric that students can then use when writing additional journal entries.)

Journal Entry #1

Date: Tuesday, January 2nd

Main question: Based on of the picture and information provided, can we ***believe*** Queenie's statement/ claim to the police?

(*It should be emphasized that we are NOT providing evidence of whether or not Queenie is in fact telling the truth or lying. The main question, which the students will answer WITH EVIDENCE, is whether or not we can believe Queenie's statement to the police.)*

Evidence from the picture:

- Glass in the husband's hand
- Glass in the same hand as the banister
- Stovetop is on, something/someone is clearly cooking on the stove
- Candles on the walls and the mirror are still intact and attached to the wall
- Queenie's husband's feet on the stairs and head on the floor
- Queenie has a look of shock registering upon her face
- Husband is still in dressy clothes
- Queenie is still in a dress

Evidence, Warrant and Rules:

Evidence/ Warrant (FACTS!)	As a rule….
Glass in hand, same side as the banister	As a rule, when drunk coming down the stairs, one would hold onto the banister for extra support and hold the glass in the other hand.
The candles are still in their holders	As a rule, if you fall down the stairs, a person generally tries to grab onto something to stop or slow down the fall on the way down.
The husband landed on his back, with feet on the stairs	As a rule, if you fall down the stairs, you should land on your stomach.

There is food cooking on the stove	As a rule, if you are cooking on the stove, it usually does not smoke like it is in the picture. Someone was not paying attention to their cooking.
The glass is still in the husband's hand	As a rule, if you fall down the stairs, you drop what you are carrying.

Conclusion:

Based on the direct, observable evidence provided in the table above, we cannot believe the statement Queenie gave to her guests and to the police. Since her husband is carrying the glass in the same hand as the banister when traveling down the stairs, this leads us to believe that he may have been, in fact, walking up the stairs. There is no direct proof to offer that Queenie is telling the truth here. A strong man who falls down the stairs would try to stop the fall by grabbing on to something around him in the stairway. The banister, candle holders on the wall and mirror are not disturbed or knocked off in any way. This leads us to believe that he did not have the opportunity to grab on to something if he fell.

Since the husband landed on his back, this is the main piece of evidence that leads us to doubt Queenie's statement. Normally, if a man was to walk down the stairs and fall, his feet would slip out from underneath him and he would land with his back on the stairs and his feet on the floor. If he tripped going down instead of slid, he would land head first with his stomach on the floor. Since both of these scenarios did not occur and the husband landed with his feet on the stairs, on his back, we are led to believe that we cannot trust Queenie's statement that he fell down the stairs coming down for another drink.

From the evidence provided in the picture and the statement Queenie gave to her friends and the police, we can conclude that we cannot trust Queenie's statement that her husband was on his way downstairs to get a drink and fell down the stairs. If Queenie was telling the truth, there would be some evidence that the husband actually did fall down the stairs in the proper way. More investigation is needed to determine the cause of his death and whether or not Queenie had any sort of involvement.

Handout for Students (Journal Entry)

The two tables below give information for specific metals that are present in most fireworks. Table 1 gives a list of 8 different metals, their potential health risks and the Environmental Protection Agency benchmarks for safe levels of these metals in the air. The second table gives a list of five metals that were detected in a series of air samples after a fireworks show in Pearl City, Hawaii. The levels of each metal sample are given on this table. Recently, the EPA has released a statement that fireworks are hazardous to people's health.

Table 1: Toxicological evaluation of EPA hazardous air pollutant metals, health risks and benchmarks

Metals	Health risks (cancer/ noncancerous)	EPA Benchmark (ng/m3)
1. Arsenic	Respiratory cancer/ developmental	0.57
2. Beryllium	Lung cancer/ respiratory	1.00
3. Cadmium	Lung cancer/ kidney	1.40
4. Chromium	Lung cancer/ respiratory	100.00
5. Lead	None/ developmental	150.00
6. Manganese	None/ neurological	52.00
7. Mercury	None/ neurological	31.00
8. Nickel	Lung cancer/ immunological	10.00

Table 2. Method comparative analysis for hazardous air pollutant metals during 2005 New Year celebrations in Pearl City, Hawaii

Metals	Analysis of Air Samples (ng/m^3)
Cadmium	1.4 - 1.6
Chromium	144.7 - 157.6
Lead	253.0 - 307.0
Manganese	87.8 - 100.3
Nickel	5.3 - 6.0

Proficient Example of an Informal Journal Article:
(* *The proficient and developing journal entry examples are based off of the fireworks journal entry.)*

Journal Entry #2

Date: Wednesday, January 3rd

Main question: Based on the two tables and information provided, can fireworks have a potential to cause cancer or other life threatening illnesses?

Evidence, Warrant and Rules:

Evidence/ Warrant (FACTS!)	As a rule….
The measured lead levels from the sample are between 253.0 and 307.0 ng/m^3.	As a rule, according to the EPA, Lead levels are only safe if they are lower than 150.0 ng/m^3.
The measured chromium levels from the sample are between 144.7 and 157.6 ng/m^3.	As a rule, according to the EPA, chromium levels are only safe if they are lower than 100.0 ng/m^3.
The measured manganese levels from the sample are between 87.8 and 100.3 ng/m^3.	As a rule, according to the EPA, manganese levels are only safe if they are lower than 52.0 ng/m^3.

Evidence from the data table:

- From the first data table, arsenic is dangerous to a person's health if it is found in levels of 0.57 ng/m^3 or greater.
- From the first data table, beryllium is dangerous to a person's health if it is found in levels of 1.00 ng/m^3 or greater.
- From the first data table, lead is dangerous to a person's health if it is found in levels of 150.00 ng/m^3 or greater.
- From the second data table, air samples showed a cadmium level of 1.4-1.6 ng/m^3.
- From the second data table, air samples showed a lead level of 253.0-307.0 ng/m^3.

Conclusion:

Based on the data from tables 1 and 2, it can be determined that fireworks can have the potential to cause cancer and other life threatening diseases. From the data tables, it can clearly be seen that the measured lead levels in the air sample that was analyzed are much higher than the safe levels recommended by the EPA. From the data, the lead levels are about two times higher than the recommended levels. Since these levels are higher than the “safe levels” identified by the EPA, there is a possibility that the lead levels could cause developmental issues in human beings.

Another piece of evidence from the data tables is the measured chromium levels in the air sample. From the data tables, it can be seen that the measured values are around 1.5 times higher than the recommended “safe levels”. Because the chromium levels measure higher, the person that is breathing in these levels has a higher risk of developing lung cancer and respiratory diseases. Since there are at least two levels of higher metals in the air than recommended by the EPA, it can be claimed that fireworks can indeed have the potential to cause cancer and other life threatening illnesses.

Developing Example of an Informal Journal Article:

(* *The proficient and developing journal entry examples are based off of the fireworks journal entry.)*

Journal Entry #3

Date: Wednesday, January 3nd

Evidence, Warrant and Rules:

Evidence/ Warrant (FACTS!)	As a rule….
The measured lead levels from the sample are between 253.0 and 307.0 ng/m^3.	As a rule, according to the EPA, Lead levels are only safe if they are lower than 150.0 ng/m^3.

Evidence from the data table:

- From the first data table, arsenic is dangerous to a person's health if it is found in levels of 0.57 ng/m^3 or greater.
- From the first data table, lead is dangerous to a person's health if it is found in levels of 150.00 ng/m^3 or greater.
- From the second data table, air samples showed a cadmium level of 1.4-1.6 ng/m$^{3.}$

Main question:

Can fireworks have a potential to cause cancer or other life threatening illnesses?

Conclusion:

Based on the data from tables 1 and 2, it can be determined that fireworks can have the potential to cause cancer and other life threatening diseases. From the data tables, it can be seen that the measured lead levels in the air sample that was analyzed are much higher than the safe levels recommended by the EPA. From the data, the lead levels are about two times higher than the recommended levels. Since these levels are higher than the "safe levels" identified by the EPA, there is a possibility that the lead levels could cause developmental issues in human beings and therefore, could cause cancer and other harmful illnesses.

Rubric for an Argumentative Narrative

3- Exemplary	2-Proficient	1- Developing	1- Unacceptable
Arrangement of Narrative Information and text are arranged in a format that includes the following: - The main story - Detective work in the story (methods and analysis of data) - The climax and claim (results) - Resolution of conflict and counterclaim (discussion)	Information and text are arranged in a format that includes the following: - The main story - Detective work in the story (methods and analysis of data) - The climax and claim (results) - Resolution of conflict and counterclaim (discussion) One of the above topics is not described effectively or is lacking details.	Information and text are arranged in a format that includes the following: - The main story - Detective work in the story (methods and analysis of data) - The climax and claim (results) - Resolution of conflict and counterclaim (discussion) Two of the above topics is not described effectively or are lacking details.	Information and text are not arranged in a format that includes the categories in the exemplary box. Three or more topics are not described effectively or are completely lacking.
Setting/ Time Period: In the narrative, an appropriate setting and time period is clearly identified for the reader. Many descriptive words and vocabulary are used to describe when and where the story took place.	In the narrative, an appropriate setting and general time period are identified for the reader.	In the narrative, a setting and time period are difficult to identify based off of the information given in the text.	In the narrative, a setting or time cannot be identified based off of the information given in the text.

Main Topics: Each main topic is addressed in detail throughout the narrative. - All four main topics are addressed and described.	Each main topic is addressed in detail throughout the narrative except one of them. - Three topics are addressed in the narrative.	Each main topic is addressed in detail throughout the narrative except one of them. - Two topics are addressed in the narrative.	There is no main topic or main idea given. The main questions are not addressed.
Methods Section Within the narrative, there is a section that thoroughly describes the methods followed to gather data and other important observations. If applicable, all the materials used to collect data are included in this section. This section builds the readers understanding of how the data was collected and its connection to the argument. The actual experiment can be thoroughly described, in detail, by the reader, if asked.	Within the narrative, there is a section that generally describes the methods followed to gather data and other important observations. If applicable, some the materials used to collect data are included in this section. This section builds the readers understanding of how the data was collected.	Within the narrative, there is a section that vaguely describes the general methods followed to gather data and other observations. If applicable, a few of the materials used to collect data are included in this section. The reader has a general understanding of how the data was collected.	There is no section within the narrative that describes the methods of gathering data or other observations, in any way. None of the materials used to collect data are included in this section. The reader does not understand how the data was collected.
Main Question and Results: The main question is addressed somewhere in the story and can be clearly found. Since the answer to the main question is the argument (claim) of	The main question is addressed somewhere in the story and can be found. Since the answer to the main question is the argument, it is	The main question is addressed somewhere in the story and can be found. Since the answer to the main question is the argument, it is	The main question is not addressed somewhere in the story. There is no evidence or support for the argument.

this argumentative piece of writing, it is supported by a minimum of 3 pieces of evidence.	supported by a minimum of 2 pieces of evidence.	supported by a minimum of 2 pieces of evidence.	
Conclusion: In a scientific narrative, the discussion section is relatable to the conflict resolution section of a story. In this section, the author clearly introduces any potential counterclaims that may be present from the given topic and how they relate to the claim. The evidence presented in previous sections is introduced and summarized again, to disprove the applicability of the counterclaims. The reader is left with proof that the counterclaims are not applicable and is able to apply the evidence to the claims.	In this section, the author introduces any counterclaims that may be present from the given topic. The evidence from the claims is summarized and gives a general understanding that the counterclaims are not correct.	The author introduces any counterclaims that may be present from the topic but does not provide any evidence or re-summarize the prior evidence to support the claim.	. There are neither counterclaims nor evidence to support or disprove them in the conclusion section.
Grammar/ Spelling Errors: The narrative is free from most spelling and grammar errors. 0-2 errors can be identified.	The narrative is generally free from most spelling and grammar errors. 3-5 errors can be identified.	The narrative is somewhat free from most spelling and grammar errors. 4-6 errors can be identified.	The narrative has many spelling and grammar errors. At least 7 errors can be identified.

Student Handout Sheet (Argumentative Narrative)

Objective: Using the pieces of evidence shown below and your background knowledge of the development of the atom, create a scientific narrative (a story), containing an argument, about the given topic. Based on the data and the results from the experiment below, create a narrative that describes an argument Rutherford would make about his experiments. From this data, what can Rutherford conclude and argue (with evidence) about the structure of the atom? Make sure you examine the evidence THOROUGHLY and prepare your argument well. The narrative should be written in a way that tells a story, shows the methods used, gives the results, and discusses them.

From the data and evidence given below, write a story about Rutherford's' experiment and results. Make sure to include any arguments Rutherford would make about his development of the atom and make sure to use the evidence provided below. Below are some examples of arguments Rutherford might pose. You are not limited to these examples:

- The atom must look different than previously discovered due to the evidence found in this experiment.
- J.J. Thomson was incorrect about his conclusion of the structure of the atom.
- A new model of the atom has successfully been discovered due to the results of Rutherford's experimentation.
-

Main Topic: Rutherford has performed a set of experiments in order to determine what the atom might look like. Using his experiment and the data given in the evidence section, create a narrative of his possible experienced. Make sure your story provides answers to the following topics:

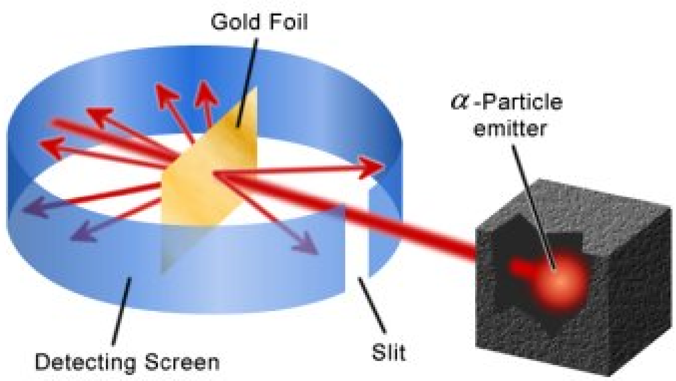
- What did he discover?
- What was the importance of his discovery?
- What would other scientists possibly say about his discovery to disprove him?
- How can he prove that he is correct?

Main question: From the results of Rutherford's experiment and what he knew about the atom, was the structure of the atom the same as what J.J. Thomson proposed, or was it different?

<u>Evidence:</u> Below are some pieces of evidence to include in your narrative. You may use as many, or as few as you like.

Results from the experiment:
1) Most of the gold particles went straight through the gold foil.
2) Some of the gold particles went through the gold foil at angles.
3) A few of the gold particles bounced back off the gold foil.

Equipment Used
1) Alpha particles from a radioactive metal source, giving the particles an overall positive charge.
2) Gold foil, pounded so thin is was approximately 400 atoms thick
3) Zinc sulfide detection screen, flashes small light when hit by a radioactive alpha particle.
4) Lead box to house and shoot alpha particles.



Exemplary Example of an Argumentative Narrative

Due Date: October 1st

Science Argument: Argumentative Narrative

Rutherford's Model of the Atom

As I was standing in my laboratory late one night, it finally dawned on me why it seemed so much colder in England than it did at home, in New Zealand. It was always raining! It seemed like every day, it rained. If only the labs in the basement were warmer, they wouldn't seem so gloomy.

For many years, I worked for J.J. Thomson. He's a hero in the world of physics. It seemed like just last year, I was working in his lab as a student when we discovered that not only do atoms exist, but they are made of positive and negative charges! The nerve of some people who questioned our work! The names they called us and how they doubted our work, saying it was all fake, that the results were fabricated. The nerve of some people!

It was another rainy, cold day in Manchester and I had to make a decision as to what I wanted my graduate students to do for me while I worked on some theoretical work for a few days. We had been doing experiments with alpha particles and observing their nature for about a week and I felt that a change in direction was needed. Since we knew that alpha particles had a nuclear nature, I decided to continue along that line of research and examine how they might act if we shot them at a solid surface, such as gold.

I told two of my graduate students, Geiger and Marsden, what they should do. They set up an apparatus that looked very similar to a lead box gun. Inside the lead box, I instructed them to put a radioactive source. I believe one day they used Polonium and then switched to Radium. In the middle of the experiment, they placed a piece of very thin gold foil. I told them to pound it as thin as they could get it before it started to fall apart. Based off of the approximate, calculated size of an atom that Thomson determined and the thickness of the gold foil, I would have to say the gold foil was about 400 atoms thick. They did a wonderful job pounding it very thin. On the other end of the experiment, they put a zinc detection screen. With all the work we had been doing with nuclear particles, we had tried everything to detect where they were going. It just so happened that when they hit the zinc sulfide screen, a small flash would appear. We wouldn't have about this flash if we were not walking out of the laboratory one day and Geiger had forgotten to turn off the electricity to the nuclear particles in a previous experiment.

They set out on their experimental journey and I went up to my office to disappear into my work for a few days. I figured they would be fine down there by themselves; they were graduate students after all. Before I left, I had given them very strict instructions. Take shifts, turn off all the lights and shoot alpha particles from the lead box gun at the gold foil. Count the number of flashes that occur on the screen and record them. Your shifts should be every hour, giving you time for dinner and bathroom breaks. Take a 10 hour break at night for a good night's rest.

I didn't see them for two whole days. I assumed they were doing really well, considering they hadn't burst through my office door screaming about some minor problem, like my last set of graduate students. I figured 48 hours of data would give a relatively good average, so I decided to take a trip down the next morning and tell them they could stop and take a day off. Of course, this is when my brain started to work overtime.

I made my way down to the physics laboratories, where I found Geiger outside in the hallway reading a book called Dracula and Marsden, in the dark laboratory room. I told Marsden to finish up and asked both of them to join me for a cup of tea. There was a kitchen downstairs, so we headed there.

Marsden was the one that started to complain first. With emotion in his voice, he said that they couldn't continue in that dark room anymore, it was straining their eyes and they dreaded stepping back in there. I held up my hand, indicating that he needed to quiet down, and I asked how the data collection was coming. They both agreed it was coming along well and that there were a steady stream of alpha particles passing straight through the gold foil. It was then that a light went off in my brain and I had a question that I was dying to have answered.

It was a hard thing, telling them that they would have to go back in there, but it had to be done. I said to them, "Instead of just having the screen on the other side of the gold foil, we have to make it all the way around the gold foil, connecting to the lead box gun." They looked at me like I was medically insane. Geiger looked me in the eye and asked, "Why, Professor Rutherford? We know the alpha particles go right through, why put it all the way around?" I then answered him, "Well, I just had a thought. We know that two north ends of a magnet repel each other, correct? We know that two south ends of magnet also repel each other, correct? Since we know the alpha particles have a positive charge, we determined that last week, why don't the positives in the atoms do something to the positive of the alpha particle? Why don't the positives of the alpha particle attract to the negatives of the atom? We need more answers!"

Even though I could tell they thought I was crazy, they did what I asked them to. I asked for hourly reports from them. I wanted to know where they were seeing the little flashes of light. It took 3 hours before either one of them showed up in my office, but when they did, they nearly broke down the door. They came in screaming about something at first, but I could not understand them. Again, I held up my hand for them to be quiet and I asked what they found. Marsden, the one who had said that did not want to go back into the dark lab, was the one to speak up first. He said, "They bounced back! Six tiny alpha particles hit the screen all the way back near the lead box. I can't believe it! I asked, "How did you know?"

I was floored by their discovery. I had an idea something would happen, but I did not expect this. The alpha particles had completely bounced back, what could that mean? I asked them to continue observing the alpha particles for two more days. They knew something exciting was going to come out of this, so they left willingly.

I had to think about the experimental results for some time before I came up with the solution. If the alpha particles bounced back, they had to have hit something solid, something with the same charge as them. However, most of them went straight through, so there was something to that too. It was a solid substance, why did they go through? It was then that I looked out the window and saw a pine tree, with all its branches and spaces. If I was to go out and throw a ball at the tree, it would most likely go straight through, due to all the empty space between the branches. However, there would be a possibility that the ball would bounce back if it hit a branch! That was it! That was the explanation. I had to go and tell Thomson.

I had to take a carriage to Cambridge University to see Thomson and discuss my findings, but it was worth the journey. When I arrived there, I immediately asked him to have a cup of tea with me so I could discuss what I had found. He was excited at first to hear what I had to say, but as I continued to describe it to him, his face started to fall. This is what I said, “Thomson, I do not want to insult you with my new discovery, but I have found something huge. Alpha particles pass straight through gold foil when you shoot them at it, but some bounce back. Some even deflect at smaller angels. The only conclusion is that there must be a small, dense center in each atom. Since it’s so small, most of them pass right through! However, some bounce back or are even deflected, meaning they must have the same charge! There must be a small, dense center of the atom with a positive charge AND the atom must be made of mostly empty space! This does not disprove your model of the atom Thomson, it just improves it!” That seemed to be the last bit of information Thomson could handle because he looked quite angry at that point.

He looked at me quite sternly and asked, “Is it just possible that your two, *graduate boys*, pounded the foil thinner on one side and not on the other. If it was thicker in one area, it is possible for them to travel straight through in the thinner section, but bounce back from the thicker section.” I was flabbergasted. He was proposing a clear counterclaim to my evidence. I had always thought of Thomson as a father figure, one who would believe my research and not question it like the naysayers did when we discovered his model.

I left Cambridge feeling hurt and confused. I needed to prove his counterclaim was wrong. The next day, I made sure the gold foil was the same thickness all the way around. I had Geiger and Marsden collect another set of data and they found the same results. It was then that I wrote a strongly worded letter to Thomson expressing my thoughts of his doubt. I was sure to include the fact that I made sure the foil was the same thickness and it gave them same results, most passed straight through, some deflected at small angles and others bounced back at large angles. There was no other way to put it, I was correct and he was not.

I made sure to collect a lot more data and I published my paper two years after my discoveries. Without my *"graduate boys"*, I wouldn't have been able to figure it out. There had to be a small, dense positively charge nucleus in the middle of the atom. Also, most of the atom was empty space. Since Thomson already proved there were positive and negative charges, I concluded even though we cannot see the atom, the negatives must be on the outside, positives in the inside. With my proof compiled in a paper, Thomson finally accepted my work and we shook hands, becoming friends again.

Proficient Example of an Argumentative Narrative

Due Date: October 1st

Science Argument: Argumentative Narrative

Rutherford's Model of the Atom

It was an interesting day in the middle of December when I came up with the idea for a new experiment. My graduate students and I had been working with nuclear particles, observing their characteristics and activity. We had recently discovered that these particles all had a positive charge. I decided to name them alpha particles, envisioning them as little alpha symbols traveling through the air.

It is customary in the lab to assign graduate students work that will keep them occupied and interested in continuing in their science career. At Manchester University, the graduate students in the physics department usually were assigned meaningless tasks. I decided to make it my job as their advisor to set them on work that would make a name for them starting out. At the time, I had two graduate students, Geiger and Marsden. They had helped me extensively collecting data and information about nuclear alpha particles in the lab.

There came a point when I decided to change the direction we were headed with these nuclear particles. They acted like they had a lot of energy, so I decided to have my two graduate students shot them at a solid to see what happened. The main question I had for them was: Will they bounce right off the solid? We decided to start with something thin at first so the alpha particles would not go that far is they did bounce off. I helped them set up the apparatus (a lead box with radioactive source, gold foil and a detection screen) and asked them to keep me updated on the details.

It was two days before they came to see me. They had decided to take shifts and watch the detection screen in a dark room, counting the number of flashes that occurred. They said that all of the alpha particles traveled right through the gold foil. Nothing else happened. They wanted to know whether or not I wanted to try something thicker and see if the alpha particles would also travel right through. That was went a thought popped into my head: Why are they going through?

I decided to ask them that. Why are they going through? They looked at me with blank faces that had no idea. I then continued to question them saying, "If the particles are hitting the golf foil, they are hitting a solid barrier of atoms, why are they going through?" They still did not quite understand the question, so I came up with another experiment for them to try. I told them to put the detection screen all the way around the gold foil, shoot alpha particles at the foil and determine the number of flashes around the foil.

They must have thought I was strange, but they left and performed the experiment. After two more days, they came back with interesting news. Most of the alpha particles went straight through, but once in a while, around 1 in every 1000, a particle would bounce completely back! This baffled Geiger and Marsden, so I decided to collect their data and think about their observations.

After 24 hours of deep thought, I had my answer. The model of the atom was not exactly like my teacher and advisor, Thomson, had thought. It was actually more complex than a sphere with negative and positives throughout. It was then that I decided to write Thomson and tell him of our discovery. My letter was as follows:

Dear J.J.,

Hope you are well. Everything here in Manchester is going well, except of course for the constant rain. I have heard of your recent discoveries in the field of nuclear decay with Potassium and it sounds interesting. I hope you will write to me soon with details!

My graduate assistants have been working on an experiment of mine that I found to have quite interesting results. They shot alpha particles at a very thin piece of gold foil and most of them went right through! I simply cannot believe the outcome. Every once in a while, the alpha particles bounced completely back towards the source. This presented me with some serious questions about your current model of the atom.

Thomson, if the atom is a solid sphere containing both negative and positive charges, why then would particles shoot right through? Why would only 1 in 1000 bounce back? It took me some time, but I believe I understand now. Since most of them passed straight though, the atom has to be full of empty space. Since some bounced back, there has to be a small, dense positively charged nucleus. They bounce off each other because they have the same charge. This is the only explanation!

What are your thoughts?

Sincerely,

Ernest Rutherford

It took a few weeks to receive a reply from Thomson and when I received it, it was full of doubt. He made claims such as, the gold foil must have been thicker in some areas and thinner in others, allowing particles to pass through where there were less atoms. He also made the claim that alpha particles have energy. They could push the other atoms out of the way.

When I sent back my reply, I was very honest. I told him that that gold foil was thoroughly measured and was the same thickness in all areas. I also told him that if they alpha particles did push the atoms out of the way, there would be evidence of this. There was no damage or even rippling of the gold foil. The only conclusion was that the atom is mostly empty space with a positive center.

<u>Developing Example of a Narrative Argument</u>

Due Date: October 1^{st}

Science Argument: Argumentative Narrative

Rutherford's Model of the Atom

I was sitting in my office in Manchester when I came up with a question that really needed to be answered. What would happen if we shot alpha particles at a piece of solid, thin material? We knew they had energy and we knew some of their more general properties. I collected two of my graduate students and set them to work.

They came up with an apparatus to test this question quite quickly. They shot alpha particles at a piece of gold foil and were able to see what happened. After two days of continuously shooting these alpha particles, my students were ready for their big revel. They said that all of the particles shot straight through the gold foil and were detected on the other side. After thinking about their results, I had them redesign their experiment. They only were testing to see if they shot right through, they didn't even consider any other angles.

I had them retest their experiment. They came and saw me 12 hours later and said that for every 1000 alpha particles that shot straight through, one bounced back. BOUNCED BACK! I wasn't sure how to act when they told me this and I understood what the outcome meant. The particles were traveling straight through the gold foil because Thomson's model of the atom, the one I had helped develop as a student myself, was wrong. The atom was not a solid sphere of positives and negatives. It was mostly empty space! How else would all those particles travel right through?

It was harder to determine the other part, however. So, one in 1000 bounced back. That could mean many different things. I finally concluded that the only logical explanation was that there was a very small, dense (solid) mass in the center.

I published my paper on my model of the atom some time later. I received many letters claiming I was wrong. A physicist in Yorkshire said the atoms could actually be solid after all, and that was why they were bouncing back. Other scientists claimed my methods were incorrect or my sample of gold was no sufficient. After having them recreate the experiment themselves and get the same results.

Chapter 4: Conclusions and Recommendations

The incorporation of the Common Core Standards (CCS) into existing Chemistry and science curriculum seems like a monumental task to enter into. However, the main goal of the CCS is to build literate students who are ready to enter into the world ready for success. The main goal of the existing science curriculum is to build students who are scientifically literate, knowledgeable and ready to enter into the world informed to make decisions on their future. Being able to write, read and give an argument is part of the process of encouraging not only literacy, but critical thinking skills and self-advocacy. The CCS stresses the importance of not only incorporating the argument into English or Social Studies, but it also stresses the importance of incorporating it into all content areas.

Since the implementation of argumentation into the science classroom may be new for many of the current science teachers, it is important to build resources for them. Making these resources available to science teachers is the key to success in the implementation of not only the Common Core Standards but in the entire science curriculum. Future involvement and research is needed in this area to see what other resources teachers may need to not only improve their understanding of argumentative writing but also to improve their students understanding of what an argument is and why it is so important.

Since lab reports and laboratory activities are the most common type of writing in the Chemistry classroom, implementation of this type of argumentative writing may be the easiest for most classrooms. With proper distribution of the given rubric and examples provided for the students, incorporating the claim, evidence and counterclaim into the lab report may not be as difficult as some teacher may think it is. Scaffolding these types of writing assignments into everyday classes and assignments will make for a most successful transition.

Many arguments given by science teachers who do not want to implement argumentation into the science classroom focus on the fact that this is a writing assignment. In order to be successful writing in science, science teachers must teach how to write in science. This takes time from the content that must be taught for the standardized tests at the end of the year. However, it is important to realize the importance of an argument in science. If a student can write a successful argument, they can also think critically, therefore increasing their chances of doing even better on these standardized tests.

Narrative and journaling arguments are much less formal than an argumentative lab report. However, they build flexibility into the science curriculum. They allow for certain levels of creativity and encourage students to gather evidence and facts to support their stories or journal entries. This makes science more interesting.

The implementation of argumentation into the classroom does not have to be a monumental task. With the proper resources, scaffolding and encouragement, students will learn how to write an argument and begin to build their critical thinking skills much easier than direct instruction. Writing helps students think deeper thoughts, synthesize information and learn new content. Scientific literacy can be achieved with proper implementation of the Common Core Standards, the current science curriculum, controversial topics and student engagement. All these important things lead students to the collection of data and information to support their positions and synthesize their arguments.

Resources:

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