An Examination of the Use of Argument Driven Inquiry Strategies to Support Argumentative Writing in the Middle School Science Classroom.

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Submitted in Partial Fulfillment of the Requirements for the

Degree of Master of Education

June 2021

Graduate Programs in Education

Goucher College

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Abstract

The purpose of this study was to explore the impact that argument driven inquiry strategies would have on the written ability of seventh grade science students. The measurement tool used was the 15-point rubric Claim Evidence Reasoning Rubric used for Grades 6-12 in the Science Curriculum. The Next Generation Science Standards have a focus on students' use of argument, particularly in writing, to communicate their knowledge and scientific findings and to develop an understanding of scientific practice. The purpose of this action research study is to evaluate the influence of inquiry-based argumentative writing exercises, based on the Argument Driven Inquiry (ADI) model, in a middle school science classroom. This study utilized a quasi-experimental pretest/-posttest using a convenience sample. Using the ADI strategies did statistically impact student written ability. The ADI strategies should continue to be implemented in various level science classes in order to assist students in their ability to validate or refute a scientific idea/phenomena/claim.

CHAPTER I

INTRODUCTION

Proficient writing is imperative for success in school and life after the classroom. The coordination of argumentation and scientific knowledge play an important role in a student's education. There are many important reasons for enhancing argumentation skills within the confines of the science classroom.

Scientists naturally engage in argumentation to develop and improve scientific understanding. "A central activity for scientists is to construct and use arguments about which of the imaginative conjectures for a puzzling phenomenon are the most convincing in light of that evidence and, of course, to obtain additional evidence when the available evidence is insufficient or lacking" (Lawson, 2003, p. 1387). In addition, scientific debate is an essential part of human existence. "Our decision-making is often based on information available through press and media accounts, which may report contested claims arising from different sources of evidence. Evaluating such reports is not straightforward, as it requires the ability to assess the validity and reliability of evidence used in scientific arguments" (Simon et al., 2003, p. 200). Through a review of the literature, Cavagnetto (2010) concludes that argument within the science classroom is essential for students to transfer an understanding of scientific practice. In practice, however, the practice of argument requires students to be able to construct an argument while utilizing appropriate evidence and science processes.

Despite this high need for proficient argument writing, the 2011 NAEP Report Card indicated that only 24% of eighth graders performed at the *proficient* level in writing (National Center for Education Statistics [NCES], 2012). The Next Generation Science Standards establish scientific argumentation as a keystone skill that is the bridge to attain scientific literacy. Students attain scientific literacy more often when teachers successfully combine inquiry and collaboration with argumentative writing. Therefore, the use of inquiry-based activities, such as the ADI model, as a framework for these argumentative writing practices enable students to be scientifically literate. There is little current research which pair argument writing and ADI science practices to increase student writing performance.

The study critically discusses, explores, and analyzes the effectiveness of inquiry-based argumentative writing exercises in the middle school science classroom. The aim of this research was to yield information on how argumentative writing strategies can impact and increase student writing ability.

Statement of the Problem

The purpose of this study was to determine the effects of Argument Driven Inquiry practices on students' written ability to validate or refute a scientific idea/phenomena/claim.

Hypothesis

The null hypothesis is that students written ability to validate or refute a scientific idea/phenomena/claim will not be significantly affected by implementing Argument Driven Inquiry practices into classroom instruction.

Limitations and Technical Terms

This study was conducted between April 26, 2021 and May 16, 2021 For the purposes of this study, the following terms will be used and defined as they were used in this paper.

- **Argument Driven Inquiry Strategies:** classroom activities which are strategies which provide classroom opportunities for students to argue from a place of their own inquiry.

- **General Education Classroom:** classroom run by a general education teacher where most students do not receive special education services.

- **Next Generation Science Standards**: the newly adopted science framework provided to align scientific teaching practices to student outcomes.

- **Scientific Literacy**: the knowledge and understanding of scientific concepts.

- **Scientific Argumentation:** the ability to reason and dispute a scientific idea or phenomena.

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CHAPTER II

REVIEW OF THE LITERATURE

Since the adoption of the Next Generation Science Standards (NGSS), scientific argumentation is considered a keystone skill that is the bridge to attain scientific literacy. This literature review focuses on the specific science and engineering practice, "engage in argument from evidence," and the specific classroom strategies that can fortify that skillset. The NGSS focus on inquiry "necessitates students' use of argument, particularly in writing, to communicate their knowledge and scientific findings and to develop an understanding of scientific practice" (Mastro, 2017, p.1).

Section one of this literature review explores the concept and historical context of argumentation within the framework of NGSS. Section two addresses the importance of scientific argumentation. Section three presents barriers to scientific argumentation in the classroom, and finally, section four presents effective strategies to improve students' ability to engage in argument from evidence.

Historical Context

Historically, individual states have been the guardians of student education within their boundaries. These inconsistencies led to varying expectations for students and teachers. In 1983, Ronald Reagan's National Commission on Excellence in Education released a historical report called, *A Nation at Risk.* This document demonstrated the dire state of student achievement in the United States when compared to other countries (National Commission on Excellence, 1999). This caused a domino effect of science education reform.

One of the first attempts at national standards began in 1985 with the creation of Project 2061, a part of the American Association for the Advancement of Science (AAAS). "The goal of Project 2061 was for all Americans to be literate in science, math, and technology by the year

2061" (Morales, 2016, p. 14). This plan was later followed by the adoption of national science standards. In 1996, the National Science Education Standards (NSES) were released (NRC, 1996). While these standards were student-centered and used inquiry-based pedagogy, there was a disconnect between knowledge and practice.

Current science education indicates that students experience more success in attaining scientific literacy when students are engaged in the practice of science. The adoption of the NGSS was an answer to the gaps found within the NSES. The NGSS is heralded as one way to prepare America's students to be internationally competitive and capable of becoming active participants in a democratic society (NRC, 2012).

Introduction to NGSS and Common Core

The NGSS were specifically written to be aligned with the already accepted Common Core State Standards (CCSS). The NGSS development team worked with the CCSS literacy team to "identify key literacy connections to the specific content demands outlined in the NGSS" (NGSS Lead States, p. 159). "This deliberate alignment of NGSS with the CCSS ELA standards emphasizes that the two sets of standards are intended to work together to build students' abilities to read and write scientifically, as they engage in inquiry-based scientific practice and scientific argumentation" (Mastro, 2017, p. 6).

Since the adoption of NGSS, science education has gone through great change. Science education before NGSS, overall, consisted of "long lists of detailed and disconnected facts, leaving students with just fragments of knowledge and little sense of the creative achievements of science, its inherent logic, and consistency, and its universality": (NRC, 2012, p. 10). Due to this disconnection, "NGSS was developed in three dimensions: scientific and engineering practices, crosscutting concepts that are applicable across all scientific disciplines, and disciplinary core ideas" (Mastro, 2017, p. 2). According to NGSS, high-quality science instruction should focus on teaching "how we come to know what we know" instead of only teaching "just what we know".

NGSS and Scientific Argumentation Defined

The NGSS provide a unique approach that focuses on developing students' abilities to explain scientific phenomena and design solutions to problems. This unique approach promotes student development of these abilities to explain scientific phenomena and design solutions through their engagement with scientific practices that support students in concurrently developing knowledge using disciplinary core ideas and crosscutting concepts (Krajcik et al., 2014).

The NGSS is made up of three parts. The NGSS refer to this as three-dimensional teaching. Successful science teaching will contain all three of the following components. The first part is the Core ideas. These are also referred to as the disciplinary core ideas (DCI's). These consist of content specific scientific ideas that relate to a broader scientific idea. These are specific to scientific disciplines. There are seven crosscutting concepts (CCCs). Some of these concepts are scale, energy and matter, and patterns. These are concepts that can be identified no matter the scientific discipline. These concepts can be found in all scientific disciplines. There are also eight science and engineering practices that include but are not limited to, developing and using models, designing solutions, and engaging in argument from evidence. NGSS emphasizes scientific argumentation because it is the key to success across the board. Scientific education should involve various competencies such as science literacy, thinking, communication, problem-solving, and reasoning skills.

Argumentation in science education is different from the sense it is used in daily life. It is not a ‘heated exchange’ of opinion and emotions between two rivals, instead, it involves a logical and rational discourse aimed at finding the relationship between ideas and evidence (Fayyaz & Nisar, 2018). These competencies can be mastered by improving scientific argumentation skills (Nurinda et al., 2018). Scientists and engineers use reasoning and argumentation to explain scientific phenomena. In science, the production of knowledge is dependent on a process of reasoning that requires a scientist to make a justified claim about the world (NRC, 2012).

Scientific Argumentation Value

Scientific argumentation has four main components. These four components are the claim, evidence, reasoning, and rebuttal. The claim is a statement or conclusion that answers the problem, the evidence is scientific data, backing or warrant that supports the claim, the reasoning is a justification that connects the evidence in the claim using the principles of science, and rebuttal is the alternative answer given to refuse the claim (Nurinda et al., 2018). A student’s ability to argue from data is critical to his/her overall success in science.

Within the framework of NGSS, learning to argue scientifically offers students not only an opportunity to use their scientific knowledge in justifying an explanation and in identifying the weaknesses in others' arguments but also to build their knowledge and understanding (Lazarou et al., 2016). Evidence suggests that students who have success in scientific argumentation have success in their conceptual understanding, helping them in making informed decisions and enabling them to think and process like a scientist. (Fayyaz & Nisar, 2018).

In science education, argumentation is considered a core skill that can empower young people to attain scientific literacy, develop their critical thinking, their reasoning, communicative and metacognitive skills, and other subsidiary skills (Kelly & Takao, 2002). Scientific success is gained when scientific argumentation is a mastered skillset. True scientists engage in argumentation to develop and improve scientific knowledge: A central activity for scientists is to construct and use arguments regarding scientific phenomenon which then lead to an expansion regarding the original scientific understanding (Newton et al., 1999). Overall, students' scientific understanding can be improved through argumentation Scientific argumentation provides opportunities for students to position themselves as a "community of knowledge and evidence makers" to develop their scientific knowledge (Chen et al., 2019). Scientific argumentation skills are important for students to express their opinions, make decisions, and solve problems in daily life. There many been many studies that have focused on student's actual argumentation ability but few that propose instructional strategies that cultivate student's ability to successfully execute argumentation practices.

Scientific Argumentation Strategies

The Argument-Driven Inquiry (ADI) Model is a model that meets several important criteria for fostering argumentation in the classroom. When teaching through an inquiry lens, teachers make pedagogical decisions "to promote scientific practices such as asking testable questions, creating and carrying out investigations, analyzing and interpreting data, drawing warranted conclusions, and construction explanations that promote a deep conceptual understanding of fundamental science ideas" (Wilcox et al., 2015, p. 62). While inquiry-based activities can consist of hands-on experiences, the most important thing is that students are making meaning of whatever activity they are engaging in, through decision-making, exploring their thinking, and engaging in abstract thinking. When used in argumentative activities, the ADI model was shown to promote argumentative thinking through writing, which supports students to carefully examine their reasoning. (Songsil et al., 2019). Table 1 provides an overview of the ADI model (Sampson et al., 2010) that highlights the three different sessions recommended for engaging students in argumentative activities.

Table 1

Overview of ADI Instructional Model

Sessions	Overview of the ADI instructional model (Sampson et al., 2010)
Introduction Session	The teacher informally surveys and examines students' prior knowledge in scientific concepts and then guides the inquiry activity by introducing data for discussion to find answers to the questions and to produce a tentative argument.
Argumentation Session	The teacher asks each group to share their claims with the class and give their reason or evidence to justify those claims.
Conclusion Session	Individual students express their understanding of the topic under investigation and about scientific argumentation by producing formal written reports, which are evaluated in a double-blind peer-review process. The peer review sheet has specific criteria for assessing the quality of the report using comments and scores, which provide feedback to the students who wrote the report. Students have a chance to revise their report twice.

The Argument-Driven Inquiry (ADI) model, developed by Sampson et al. (2010), gives students an opportunity to both engage in scientific practices and build their scientific writing skills and content knowledge, as well as their overall scientific literacy (Mastro, 2017). The goals of ADI are for students to learn how to write scientifically by engaging in a realistic writing task and engaging in scientific practices, to provide students with opportunities to read good examples of these tasks that are written with the same goal in mind, to provide them with information about their content understanding and writing quality, and to give students opportunities to revise their work (Sampson et al., 2010).

Sampson et al. (2010) conducted a study to evaluate the effectiveness of the ADI model in science classrooms. The study was conducted in four high school classrooms and two middle school classrooms, and the researchers assisted teachers with developing a total of sixteen labs in the ADI style and measured the gains students made in their content knowledge and their argumentative writing skills. They collected data through argumentative writing assessments and science content assessments, both graded on rubrics. Researchers found that students' ability to write scientifically and to understand science content showed a significantly large improvement when implemented consistently (Mastro, 2017).

Scientific Argumentation Barriers

While argumentative writing houses many benefits to students, there are several difficult barriers in the way of successful implementation into the science curriculum. Science, by nature, is constantly changing. This rapid change is often too quick for textbooks to reflect the newfound understandings. In addition, the NGSS has established clear targets for assessment, but not a clear pathway to reach the ideals outlined in these standards (Windschitl & Stroupe, 2017). The means for supporting student learning is not spelled out as clearly as the goals. Teachers are left in the dust wondering how it is they are to successfully implement scientific argumentation practices, let alone the three dimensional of the NGSS.

Teachers state that implementing scientific argumentation strategies is difficult for various reasons. Due to the difficulty of using discussion-based argumentation in teaching, many teachers (usually but not always the less experienced) did not have the necessary pedagogical skills required to successfully implement scientific argumentation strategies within the classroom. (Aufschnaiter et al., 2007). Science teachers are charges with keeping education up to date with a discipline that is always changing and staying abreast of the changes in a specific discipline. Experienced teachers can craft their curriculum based on state standards given an ideal teaching environment (Bowman & Govett, 2015). These barriers highlight the need for educators to continue to engage in professional development that enables them to refine the skills needed to help students attain scientific literacy through the clear and intentional implementation of NGSS with a focus on scientific argumentation.

Summary

The (NGSS) establishes that scientific argumentation as a keystone skill that is the bridge to attain scientific literacy. The research bespeaks that student attain scientific literacy more often when teachers successfully combine inquiry and collaboration with argumentative writing. Therefore, the use of inquiry-based activities, such as the ADI model, as a framework for these argumentative writing practices enable students to be scientifically literate. Despite the known correlation between scientific literacy and scientific argumentation, teachers struggle to implement successful strategies. It would behoove schools and districts to implement collaboration opportunities and professional developments to support teachers in this NGSS curricular adoption.

CHAPTER III

METHODS

The purpose of this study was to determine the effects of Argument Driven Inquiry practices on students' written ability to validate or refute a scientific idea/phenomena/claim.

Design

This study consisted of a quasi-experimental pretest/posttest using a convenience sample. A pretest was administered April 2021, using a researcher designed writing assessment. The posttest was then provided May 2021, using a researcher created writing assessment. The posttest was used to evaluate students' written ability to validate or refute a scientific idea. Participants were provided Argument Driven Inquiry strategies over the course of the three weeks leading up to the posttest.

Participants

The participants in the study included a convenience sample of 14 seventh-grade students at a public school in Harford County, Maryland. The sample group consisted of five (36%) males and nine (64%) females, ages 12 to 13. Five (36%) were Caucasian and nine (64%) were students of color. The selected school's population has students from diverse socio-economic backgrounds. The school has ample racial diversity with 49% of the population being Caucasian. There are 1300 students who are currently enrolled at the school. The school is a middle school in suburban Harford County. The students are of average achievement. Currently 44% of the school's population receives free and reduced lunch.

Instrumentation

The instrumentation used was a researcher developed pretest and posttest. The pretest and posttest were two separate writing prompts which asked the participants to establish and defend a scientific claim. The tests were evaluated based upon a rubric from Harford County Public Schools. The rubric measures student scientific writing on a 15-point scale. The rubric measures mastery in student ability to communicate a clear claim, evidence, reasoning, scientific ideas, and language of science. The rubric is the same tool used to evaluate eighth grade scientific argumentations writing on the Maryland Integrated Science Assessment.

Procedure

The first period students were identified as the participants in this study. The participants participated in two weeks of instruction regarding the scientific ideas of keystone species and wolves. The scientific argumentation writing pretest was then administered to students. This pretest was provided to measure student written ability to validate or refute a scientific idea/phenomena/claim. The pretest had students look at three sources of information and develop a claim about wolves as keystone species. Students were provided the prompt, sources, rubric, and writing checklist to demonstrate their writing ability. The purpose was to determine students' baseline argumentative writing ability without the addition of the ADI strategies. Students were given one 60-minute class period to complete their writing. Then, using the provided rubric, the researcher graded their writing and provided the participants with their grades.

Once the pretest was graded and feedback was provided, a two-week intensive ADI unit regarding keystone species began. The curriculum that was utilized was based off of the National Science Teacher Association book, Argument-Driven Inquiry in Life Science (Enderle ,2015). According to ADI strategies, participants need to be provided the opportunity to argue a claim based off of inquiry. This was accomplished with a town hall simulation infused with ADI strategies.

The participants were established into groups within a town. These groups were provided a situation in which the local government officials tasked them with establishing a keystone species. Participants were provided with organism cards which would represent the organisms in the area. Participants needed to create a food web with the provided information. Based off the food web and organism information, the participants needed to decide which organism was the keystone species. This simulates a situation in which the participants were motivated by inquiry. Participants were then tasked with the job of establishing their evidence to defend their claim at a simulated town hall meeting. Participants were expected to argue and defend their claim while the other groups within the town hall framework would question their scientific rationale based upon their own evidence. Once the town hall meeting day had ended, participants were provided a chance to revise and change their claim. Participants were provided with researcher created organizers to compile their data and evidence.

Once the ADI intensive simulation had completed, students were provided the posttest. This posttest was provided to measure student written ability to validate or refute a scientific idea/phenomena/claim using ADI strategies. The posttest had students look at their own data from the ADI simulation and develop a claim about their town's keystone species. Students were provided the prompt, sources, rubric, and writing checklist to demonstrate their writing ability. Again, the goal was to determine whether if students' argumentative writing ability had increased with the addition of the ADI strategies. Students were given one 60-minute class period to complete their writing. Then, using the provided rubric, the researcher graded their writing and provided the participants with their grades.

CHAPTER IV

ANAYLSYS OF THE DATA

The purpose of this study was to determine the effects of Argument Driven Inquiry practices on students' written ability to validate or refute a scientific idea/phenomena/claim.

Data were gathered using a pretest and posttest constructed by the researcher and approved by the research design advisor. Table 2 and Table 3 are labeled as such because Table 1 can be seen in Chapter II. Table 2 displays the Measures of Central Tendency for the pretest and posttest data. Table 3 contains the statistical analysis of the data using the dependent or paired samples *t* test.

Table 2

Measures of Central Tendency

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Preassessment	8.86	15	2.445	.631
	PostAssessment	13.00	15	3.625	.936

Table 3

Statistical Analysis of Pretest and Posttest Data Utilizing the Dependent or Paired Samples t *test*

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Preassessment - PostAssessment	-4.143	4.223	1.090	-6.482	-1.804	-3.799	14	.002

The *t* test is statistically significant at the p<.002 which is smaller than p<.05 and thus statistical significance is achieved, indicating that the posttest data is different than the pretest data and the treatment had a significant effect on the data. The null hypothesis that the treatment would not have a statistical impact is rejected.

CHAPTER V

DISCUSSION

The purpose of this study was to determine the effects of Argument Driven Inquiry practices on students' written ability to validate or refute a scientific idea/phenomena/claim. Data Analysis in Chapter IV determined that the null hypothesis should be rejected.

Threats to Validity

All research studies suffer from threats to validity. These threats are divided into two classifications: external and internal validity threats. In this study, external validity threats specifically involved the sample. The sampling was not totally random. All students involved were of the same grade level and started with similar baseline data regarding academic achievement. Additionally, all the students involved came from the first period class. This population does not reflect the same academic attitude as a last period class. This threatens the ability to make generalized claims about the validity of the study. In addition, this study was conducted during a pandemic with instruction being out of the ordinary. The sample was involved in both virtual and in person learning which is not the standard experience for seventh grade students. Again, this threatens the ability to make generalized claims about the validity of the study.

Another threat to validity was found in the expertise of the instructor. The NGSS have only recently been developed and guidelines for teaching according to these standards are still under development. While the instructor has received some NGSS training, she has not been a part of a significant amount of professional development. In addition, certain NGSS strategies used within the context of this research was new to the instructor. Had the researcher had the time and experience to practice these strategies for a greater amount of time before conducting the research, different results could have been observed.

Internal validity threats deal with the research methodology design of the study. In particular, this study was conducted over a short period of time. The timing of these strategies could be a potential threat to validity because the length of study was not significant. The results cannot be generalized to a lengthy timeframe. It is possible that the effectiveness of the strategies may have increased or decreased over a longer period of time. Students may also have responded differently at the beginning of the school year.

Connections to the Literature

The data suggests that implementation of argument driven inquiry practices does increase students' written ability to validate or refute a scientific idea/phenomena/claim. This is consistent with the findings in Chapter II. The literature suggests that scientific argumentation is a keystone skill that is the bridge to attain scientific literacy. Students attain scientific literacy more often when teachers successfully combine inquiry and collaboration with argumentative writing. Therefore, the use of inquiry-based activities, such as the ADI model, as a framework for these argumentative writing practices enable students to be scientifically literate. This research acknowledges investigation, data analysis, and scientific writing as an essential part of science instruction under NGSS, and the argumentative writing instructional series under investigation incorporates several of the inquiry practices outlined by Wilcox et al. (2015). The data from this research also concluded that, in order for students to be able to engage in scientific argumentative writing, the data need to carry some degree of personal meaning. This familiarity allows for more accurate interpretation and reasoning. This research utilized the description of the ADI model in the literature and changed it to be used in the middle school science classroom.

Sampson et al. (2010) and Grooms et al. (2015) both indicated a need to determine "nonnegotiable" aspects of the ADI model. This research concluded that the following aspects should be considered non-negotiable: student-collected data, comprehensive argumentation sessions, peer feedback on lab reports, and revision of writing. This research demonstrates the strong connection between student argument writing success and the implementation of ADI strategies.

Summary, Conclusions, and Suggestions for Future Research

This research attempted to determine how utilizing argumentative writing practices influences students' ability to validate or refute a scientific idea/phenomena/claim. As the NGSS continue their cross-country implementation, science educators need to determine how to support scientific literacy. The ADI model is an excellent tool to support this implementation. This study . demonstrates athe strong connection between student argument writing success and the implementation of ADI strategies. Further teaching training addressing literacy development, NGSS training, and ADI strategies could be an area of focus for schools who want to increase student scientific literacy.

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Appendix A

Pretest: Are wolves a keystone species?
Michele Barrie

Are wolves a keystone species?

1. *Use the space below to write your argument.*
2. *Go through the provided check list to check your writing.*

Please use the space below to write.

Argument Writing Check List
What am I being asked? 1. **Restate the question.** ____
Claim: Answer the question • Answers the question. • 1 sentence in length • Concise & specific • Do not explain it yet.
Evidence: Explain why you answered the question that way. • Bring in data that you collected from your research and observations. • Use 4 pieces of evidence to support your claim.
Reasoning: Connects claim and evidence to match one of the Science Writing Purposes. • Restate your claim. • At least 2 sentences in length explaining to your reader how the detail from the evidence supports the claim. • Use a transition word (therefore or in conclusion)

Points	3	2	1	0
Claim	Claim clearly and directly addresses the topic, is accurate and complete. "1 Sentence long"	Claim addresses the topic and is accurate.	Claim includes inaccuracies, is off-topic, vague or incomplete.	The explanation does not make a claim.
Evidence	Thorough evidence is given that includes clear, accurate data from the given sources that is either/both qualitative and quantitative. 4 individual pieces of evidence	Evidence includes some data, and is appropriate, but may not be entirely sufficient from the sources that is either/both qualitative and quantitative.	Evidence is lacking, inaccurate or presented in vague terms and sources are not used.	No evidence (data) is present.
Reasoning	Reasoning clearly links evidence to the claim and provides coherent justification for it. Relevant disciplinary core ideas are used accurately to provide a solution or explanation of the claim. Discuss what a keystone species is and why your organism is a keystone species	Reasoning is used to show some link between evidence and claim and provides justification for it. Relevant disciplinary core ideas are used to provide a solution or explanation of the claim.	Reasoning provides little or no connection to evidence and/or claim. Minimal use of disciplinary core ideas to provide a solution or explanation of the claim.	Does not provide reasoning.
Ideas	Response includes clear explanation of ideas including cross-cutting concepts and application of them in a real-world situation. Relate this to a real world example	Response includes explanation of ideas including cross-cutting concepts and some application of them in a real-world situation.	Response includes little or no explanation of ideas including cross-cutting concepts and minimal application of them in a real-world situation.	Response does not provide ideas.
Language of Science	The student consistently provides scientific vocabulary and language choices for effective expression of meaning. Used words: Keystone Species Biodiversity Population Affect Ecosystem	The student fluently provides scientific vocabulary and language choices for effective expression of meaning.	The student sometimes provides scientific vocabulary and language choices for effective expression of meaning.	The student never provides scientific vocabulary and language choices for effective expression of meaning.

Total Score = __________/15

Appendix B

Posttest: What is your town's KEYSTONE species?
Michele Barrie

What is your town's KEYSTONE species?

1. *Use the space below to write your argument.*
2. *Go through the provided check list to check your writing.*

Please use the space below to write.

Argument Writing Check List
What am I being asked? 1. **Restate the question.** ____
Claim: Answer the question 1. Answers the question 2. 1 sentence in length 3. Concise & specific 4. Do not explain it yet
Evidence: Explain why you answered the question that way. 1. Bring in data that you collected from your research and observations. 2. Use 4 pieces of evidence to support your claim.
Reasoning: Connects claim and evidence to match one of the Science Writing Purposes. 5. Restate your claim. 6. At least 2 sentences in length explaining to your reader how the detail from the evidence supports the claim. 7. Use a transition word (therefore or in conclusion)

Points	3	2	1	0
Claim	Claim clearly and directly addresses the topic, is accurate and complete. "1 Sentence long"	Claim addresses the topic and is accurate.	Claim includes inaccuracies, is off-topic, vague or incomplete.	The explanation does not make a claim.
Evidence	Thorough evidence is given that includes clear, accurate data from the given sources that is either/both qualitative and quantitative. 4 individual pieces of evidence	Evidence includes some data, and is appropriate, but may not be entirely sufficient from the sources that is either/both qualitative and quantitative.	Evidence is lacking, inaccurate or presented in vague terms and sources are not used.	No evidence (data) is present.
Reasoning	Reasoning clearly links evidence to the claim and provides coherent justification for it. Relevant disciplinary core ideas are used accurately to provide a solution or explanation of the claim. Discuss what a keystone species is and why your organism is a keystone species	Reasoning is used to show some link between evidence and claim and provides justification for it. Relevant disciplinary core ideas are used to provide a solution or explanation of the claim.	Reasoning provides little or no connection to evidence and/or claim. Minimal use of disciplinary core ideas to provide a solution or explanation of the claim.	Does not provide reasoning.
Ideas	Response includes clear explanation of ideas including cross-cutting concepts and application of them in a real-world situation. Relate this to a real world example	Response includes explanation of ideas including cross-cutting concepts and some application of them in a real-world situation.	Response includes little or no explanation of ideas including cross-cutting concepts and minimal application of them in a real-world situation.	Response does not provide ideas.
Language of Science	The student consistently provides scientific vocabulary and language choices for effective expression of meaning. Used words: Keystone Species Biodiversity Population Affect Ecosystem	The student fluently provides scientific vocabulary and language choices for effective expression of meaning.	The student sometimes provides scientific vocabulary and language choices for effective expression of meaning.	The student never provides scientific vocabulary and language choices for effective expression of meaning.

Total Score = __________/15

Appendix C

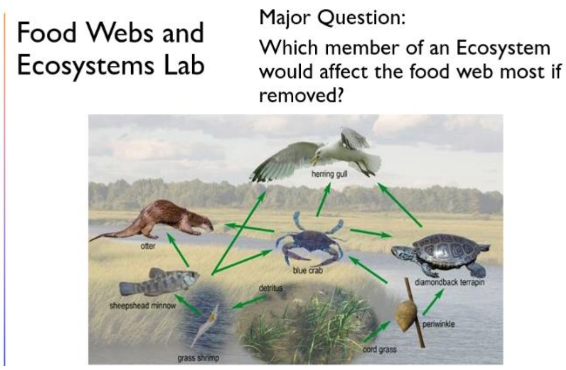
Rubric: Scientific Argumentation Rubric
Michele Barrie

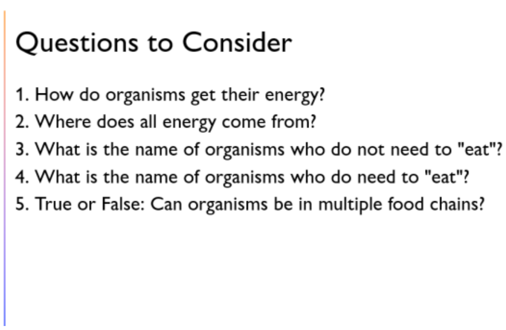
Points	3	2	1	0
Claim	Claim clearly and directly addresses the topic, is accurate and complete. "1 Sentence long"	Claim addresses the topic and is accurate.	Claim includes inaccuracies, is off-topic, vague or incomplete.	The explanation does not make a claim.
Evidence	Thorough evidence is given that includes clear, accurate data from the given sources that is either/both qualitative and quantitative. 4 individual pieces of evidence	Evidence includes some data, and is appropriate, but may not be entirely sufficient from the sources that is either/both qualitative and quantitative.	Evidence is lacking, inaccurate or presented in vague terms and sources are not used.	No evidence (data) is present.
Reasoning	Reasoning clearly links evidence to the claim and provides coherent justification for it. Relevant disciplinary core ideas are used accurately to provide a solution or explanation of the claim. Discuss what a keystone species is and why your organism is a keystone species	Reasoning is used to show some link between evidence and claim and provides justification for it. Relevant disciplinary core ideas are used to provide a solution or explanation of the claim.	Reasoning provides little or no connection to evidence and/or claim. Minimal use of disciplinary core ideas to provide a solution or explanation of the claim.	Does not provide reasoning.
Ideas	Response includes clear explanation of ideas including cross-cutting concepts and application of them in a real-world situation. Relate this to a real world example	Response includes explanation of ideas including cross-cutting concepts and some application of them in a real-world situation.	Response includes little or no explanation of ideas including cross-cutting concepts and minimal application of them in a real-world situation.	Response does not provide ideas.
Language of Science	The student consistently provides scientific vocabulary and language choices for effective expression of meaning. Used words: Keystone Species Biodiversity Population Affect Ecosystem	The student fluently provides scientific vocabulary and language choices for effective expression of meaning.	The student sometimes provides scientific vocabulary and language choices for effective expression of meaning.	The student never provides scientific vocabulary and language choices for effective expression of meaning.

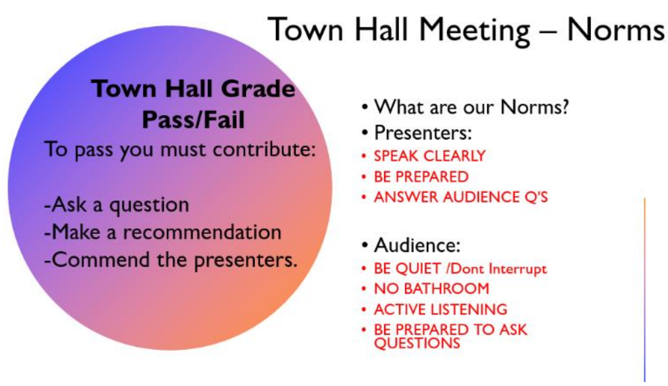
Total Score = __________/15

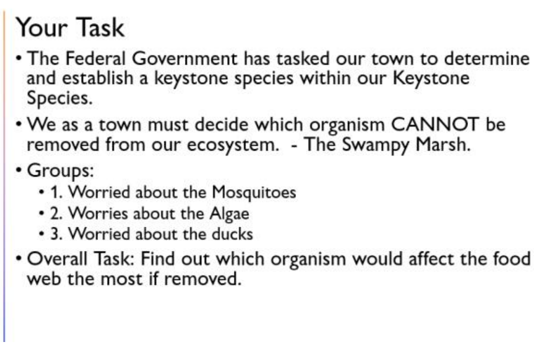
Appendix D

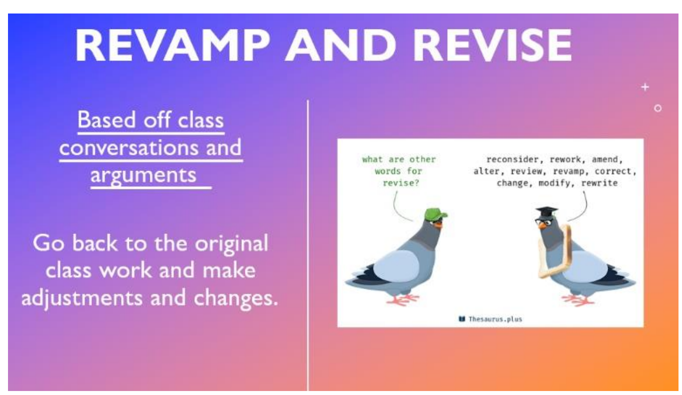
Scientific Argumentation PowerPoint
Michele Barrie











Appendix E
ADI Student Data Organizer
Michele Barrie

Use this Space to create the Marsh Food Web

Based off your food web answer the following questions.

Questions	Answers
Based off the above food web – Which organisms is most important. Why?	
Which organism is the least important? Why?	
What would happen in the ecosystem if we got rid of the algae? (Be sure to discuss how this effects each species)	
What would happen in the ecosystem if we got rid of the Mosquitoes? (be sure to discuss how this effects each species)	
What would happen in the ecosystem if we got rid of the ducks? (be sure to discuss how this effects each species)	
Based off your above answers – which member of this ecosystem would affect the food web the most if	

Prepare for you Argument Presentation

Questions	Answers
What is the Guiding Question?	
What is your Claim?	
What is your Evidence?	
What counter arguments are you expecting?	

Appendix F
ADI Organism Cards
Michele Barrie

Algae

Photo: WikiCommons
http://www.larousse.fr/encyclopedie/media/Algues/11000970

- Producer – uses photosynthesis to produce energy from absorbed sunlight using chlorophyll
- Many kinds of algae (see image)
- Some algae are made of one cell, while others are made of many cells
- Algae can "bloom" which means they reproduce quickly and in large numbers
  - Algal blooms can be harmful to water ecosystems
  - Blooms mean that the algae are getting most of the nutrients, including oxygen, in the water, which means other organisms are not
  - Often happen during warmer weather and when excess nutrients present in the water
- Can live in fresh water or salt water

Lab 11

Milkweed

Photo:
http://commons.wikimedia.org/wiki/File:Asclepias_incarnata_-_Swamp_Milkweed_2.jpg

- Producer – uses photosynthesis to produce energy from sunlight
- Flowers produce nectar that attracts insects that help spread pollen
- Seed pods form that can be scattered by the wind
  - Some organisms will eat only the seed pods
- "Milk" part of name refers to the milky white liquid that comes out of the plant when its surface is broken
- Often found in wet areas like swamps and marshes

Cattails

Photo:
http://commons.wikimedia.org/wiki/Typha_latifolia#mediaviewer/File:Typha_latifolia_02_bgiu.jpg

- Producer – uses photosynthesis to produce energy
- "Cattail" part looks like velvet and is the flowering part of the whole plant
- Found in many different climates
- Always found in or near water, mostly freshwater but some brackish marshes as well
- Absorbs pollutants from surrounding wet areas
- Can be eaten if grown in non-polluted water areas

Mosquito

http://commons.wikimedia.org/wiki/Mosquito#mediaviewer/File:CulexNil.jpg

http://commons.wikimedia.org/wiki/Mosquito#mediaviewer/File:Culex_sp_larvae.png

- Consumer
  - Adult Females – Mammal Blood (They are the ones that bite)
  - Adult Males – Flower nectar
  - Larvae – Filter feed food particles, algae, bacteria
- Females lay many eggs at one time
  - Eggs hatch into larvae in a few days, then emerge as adults in about a week
- Typically found near moist areas, especially marshes, ponds, and swamps
- Some species of mosquitos transmit disease through their bite
  - Ex. – Malaria, Yellow Fever

Milkweed Beetles

http://commons.wikimedia.org/wiki/Category:Labidomera_clivicollis
#mediaviewer/File:LabidomeraClivicollis2.jpg

- Consumer
  - Adults and Larvae – feed on leaves of marsh plants, such as milkweed
- Usually found near marshes and streams
- Adults lay eggs on the underside of leaves of milkweed plant
- Small insect – average adult length ranges from 0.5-1.0 cm

Spring Peeper

http://commons.wikimedia.org/wiki/File:Spring_Peeper_l.jpg

- Consumer
  - Usually eats beetles, ants, and flies
- Typically tan or dark brown color
- Foot pads large enough so they can climb trees, but usually stay closer to the ground
- Found in forests that are near wetlands such as swamps and marshes
- Makes short peeping sound for its call

Red-Winged Blackbird

http://commons.wikimedia.org/wiki/File:Red-winged_Blackbird_(7125591575).jpg

http://upload.wikimedia.org/wikipedia/commons/2/20/Red-winged_Blackbird_female_4105.jpg

- Consumer
  - Eats mosquitoes, dragonflies, moths and also plant material including cattail seeds, corn, and some berries
- Male birds are black with red shoulder feathers; Female birds are patchy brown color
- Females lay a few eggs at several times during the year
- Migrates to warmer southern regions during winter months
- Typically found in wetlands, both fresh and salt water marshes, and meadows

Little Brown Bat

http://upload.wikimedia.org/wikipedia/commons/thumb/3/33/Little_Brown_Bat_FWS.jpg/800px-Little_Brown_Bat_FWS.jpg

http://upload.wikimedia.org/wikipedia/commons/thumb/b/b9/Healthy_little_brown_bat_%286950595524%29.jpg/400px-Healthy_little_brown_bat_%286950595524%29.jpg

- Consumer
  - Usually eats insects, including mosquitoes, beetles, moths, and others
  - Likes to eat insect larvae that are typically found near water
- Catches food by grabbing insects during flight with its tail
- Mammalian animal, so it reproduces in lower numbers, mostly once a year
- Has several types of “roosts” where they live
  - Day roosts usually in buildings, trees, or caves
  - Night roosts near day roosts, but have space to allow many bats to pack in together for warmth

Freshwater Clam

http://upload.wikimedia.org/wikipedia/commons/thumb/d/d6/Sphaerium_corneum.jpg/1280px-Sphaerium_corneum.jpg

http://upload.wikimedia.org/wikipedia/commons/1/13/Sphaerium_corneum3pl.jpg

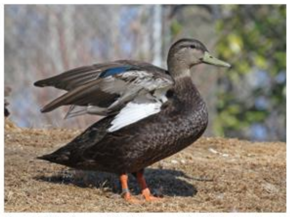
- Consumer
  - Eats algae and insect larvae
- Shell has distinct rings that show phases of growth for the clam
- Shell is translucent, which makes it sparkle underwater
- Can be found in ponds, lakes, and rivers
  - Sometimes found in brackish water as well
- Clams are hermaphrodites, which means they can fertilize the eggs they produce
  - Clam will then deposit fertilized eggs on the bottom of the water body to continue to develop

Fallfish

http://upload.wikimedia.org/wikipedia/commons/d/db/Fallfish.jpg

- Consumer
  - Eats insect larvae
- Found in streams, rivers, and edges of lakes
- Grouped together with other fish as “minnows”
- Upper scales are colored but outlined in black
- Lay eggs in pits they dig out in stream beds during spring

American Black Duck



http://upload.wikimedia.org/wikipedia/commons/thumb/a/a4/American_Black_Duck_male_RWD4.jpg/1280px-American_Black_Duck_male_RWD4.jpg

http://upload.wikimedia.org/wikipedia/commons/thumb/3/3d/American_Black_Duck_female_RWD6.jpg/1280px-American_Black_Duck_female_RWD6.jpg

- Consumer
  - Eats a variety of things, mainly plants and plant seeds (like cattail seeds), but also clams, frogs, and smaller fish
- Partially migratory but will stay in cooler climates
- Interbreeds with more common mallard duck species
- Males typically have lighter colored bill than the females
- Reproduce once a year, laying 6-14 eggs each time
- Found in ponds, lakes, swamps, and marshes

Spotted Turtle

http://upload.wikimedia.org/wikipedia/commons/thumb/1/19/Clemmys_guttata_-_Buffalo_Zoo.jpg/1280px-Clemmys_guttata_-_Buffalo_Zoo.jpg

- Consumer
  - Usually eats algae, insect larvae, insects, clams, frogs, and some small fish
- Found in shallow bodies of water, including marshes and swamps
  - Hibernates in the muddy bottoms of marshes during winter
- Distinct yellow spots form on a turtle's outer shell
  - More spots on the shell shows that a turtle has lived a longer life
- Reproduction is influenced by temperature of the environment

Sora

http://upload.wikimedia.org/wikipedia/commons/2/2d/Sora_%28Porzana_carolina%29.jpg

- Consumer
  - Eats seeds, insects, clams, and snails
- Migratory bird
  - Found throughout North America, but spend winter months in the southern US and South America
- Often found in marshes
  - Uses water and mud around the base of plants like cattails to make their nests
- Lays 10-12 eggs once a year
- Can walk, fly, and swim

Muskrat

http://upload.wikimedia.org/wikipedia/commons/thumb/c/c1/Bisam_122.jpg/1280px-Bisam_122.jpg

- Consumer
  - Usually eat cattails and other aquatic vegetation, also some clams, mussels, frogs, and fish
- Typically found in marshes, lakes, and ponds
  - Prefers areas with cattails, which they also use a spots for building their dens
  - Spend most of their time in water
- Very territorial
- Reproduce about three times per year

Ribbon Snake

http://upload.wikimedia.org/wikipedia/commons/thumb/7/77/Eastern_Ribbon_Snake.jpg/800px-Eastern_Ribbon_Snake.jpg

- Consumer
  - Eats frogs, worms, slugs, small mice, and fish
- Three stripes present on the body, usually yellow in color
- Found in swamps, marshes, and bogs
  - Usually lives near the water edges in brush vegetation where it can hide
- Give birth to live offspring once a year

Marsh Hawk

http://upload.wikimedia.org/wikipedia/commons/thumb/8/87/Wow2_filtered.jpg/800px-Wow2_filtered.jpg

- Consumer
  - Eats mostly small rodents, but also frogs, snakes, and some birds
- Typically found in large open country, but breeds in various wetlands, including bogs, marshes, and swamps
- Migratory bird that moves to southern US during winter
- Reproduces once a year, laying 4-8 eggs
  - Female usually incubates them, male will bring food to the nest
- Also called a "Hen Harrier" – hunts low to the ground