THE EFFECT OF ARGUMENT DRIVEN INQUIRY

ON STUDENT UNDERSTANDING OF HIGH SCHOOL BIOLOGY CONCEPTS

by

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INTRODUCTION AND BACKGROUND

Built in 1957, Escambia High School is located on the west side of Pensacola, Florida. It is located in an established neighborhood populated with middle to low income homes, apartments, and trailer parks. The current enrollment is 1,747 students with 61% white, 29% black, and with minority populations of Asian and Hispanic students. Sixty-five percent of students are on free or reduced lunches. The biology classes I teach are composed of approximately twenty-five ninth and tenth grade students. Escambia High School was given a "C" grade for the 2012-2013 school year by the Florida Department of Education. This grade is based on student performance on standardized reading, writing, and math scores as well as attendance, referrals, and graduation rate. The goal of Escambia High School each year is to raise the school grade and to improve performance on achievement tests. However, recent strategies that focus on improving reading comprehension in the science classroom fail to motivate teachers or students to improve their performance.

Biology students at Escambia High School are taught in a traditional classroom approach with teacher lecture and cookbook style labs. Biology teachers feel constrained to cover Florida state benchmarks that will be tested by a state mandated Biology End of Course Exam. The challenge for teachers to address the need for improving student achievement while covering state benchmarks in biology and actively engaging students in learning is a teaching conundrum. Students at Escambia High School need science experiences that involve them in meaningful scientific issues while promoting engagement and learning in science. Many students at Escambia High School will not advance to postsecondary education. Therefore it is important for students to gain skills that will enable them to be scientifically literate citizens. Students need to be able to analyze and interpret data they can apply to real world science problems. Escambia High School students need opportunities to demonstrate scientific literacy beyond reading strategies, which have been issued as a directive by school administrators. By embedding science literacy skills into required state benchmarks in biology it is hoped that students will not only become more proficient in learning biology concepts, but will also, be more actively engaged in their own learning. To address the need for student engagement in science, the need for students to be able to use evidence to make decisions about scientific issues, and address state biology benchmarks, my Action Research will focus on using scientific argumentation in biology.

Focus Question

My action research project focuses around the question“What is the effect of Argument Driven Inquiry on student understanding of high school biology concepts?”

Sub-questions:

1. What are the effects of Argument Driven Inquiry on student engagement?
2. What are the effects of Argument Driven Inquiry on argumentation skills?
3. What are the effects of Argument Driven Inquiry on biology knowledge?

CONCEPTUAL FRAMEWORK

Teachers of biology in Florida, as well as in the U.S. as a nation, have been forced by education policy, to conform their teaching to state mandated achievement tests. This style of teaching to a test rather than teaching for student learning by engaging in the process of science is detrimental to science achievement (Owens, T. 2009). Owens points out that only 18% of 12th graders performed at or above proficiency on the National Assessment of Education Progress (NAEP) test. These scores are lower than 1996 levels indicating students are not improving in scientific literacy. Teachers are encouraged to engage students in the practice of science by using strategies such as scientific inquiry, yet teachers often feel constrained to cover concepts they know students will be required to know on end of course exams. Owens points to several teaching practices in science that could improve student achievement in science including teaching less content with more depth, using inquiry to improve problem solving, and allowing peer to peer interaction to share ideas. (Owens, 2009).

Scientific inquiry is associated with the skills needed in science: critical thinking, reasoning, and habits of mind while doing scientific work. (Llewellyn, 2013). Inquiry can also help students connect their prior knowledge to new experiences, change beliefs in science, and provide students with a platform to discuss science while allowing new learning. According to Llewellyn, scientific argumentation is a teaching strategy that allows meaningful learning of science (Llewellyn, 2013).

Argumentation is a process of “collaborative brainstorming toward the establishment of “truth” or better understanding - the primary goal of science” (Osborne, Erduran, Simon, 2004). Traditional science classrooms are teacher driven and do not provide many opportunities for students to demonstrate argumentation skills (Zohar, Nemet 2002). Research in science education proposes that students should be able to debate science issues that are relevant to them thus improving reading comprehension and achievement if they are engaged in topics they find interesting (Dawson, Venville, 2009). Students have also shown that they have the ability to use argumentation skills even with minimal usage of argumentation lessons (Zohar, Nemet 2002). Additional research has shown that argumentation requires practice and will improve as students are consistently required to justify their claims (Tavares, Jimenez-Aleixandre,Mortimer 2009). These ideas suggest that students are capable of using the skill of argumentation if given the opportunity and the use of argumentation could improve student knowledge, engagement, and literacy.

To enable students to become active participants in their own learning Robert Glaser devised seven principles of instruction which could be used as a guide for implementing argumentation into teaching practice (Duschl & Osborne, 2008). Among the components of Glaser's principles of instruction is actively using knowledge in a way that connects the knowledge with practical application of the knowledge. This would be consistent with embedding argumentation into classroom instruction about specific biological concepts. A second principle outlined by Glaser is to provide an environment for students to learn that involves dialogue between students, where they share, analyze and critique each other to increase their mutual knowledge (Duschl & Osborne, 2008). Students who are involved in the process of argumentation will be collaborating, communicating, and presenting information together to explain a scientific concept. Students who are encouraged to share ideas and understanding of science issues are more likely to be engaged in the learning process as opposed to being passive participants in a teacher directed lecture.

A model for argumentation in science known as TAP or Toumalin's argument pattern, was developed by Toulmin (Venville & Dawson 2010) in 1958 and includes six main parts: (1) claims/assertion, (2) data /evidence, (3) warrants or the relationship between claims and evidence, (4) backings to support the warrants, (5) qualifiers, and (6) rebuttals to discredit the claim. In their research on Australian high school students' informal reasoning and argumentation about biotechnology, Dawson and Venville used TAP as a framework to determine if argumentation was an indicator of scientific literacy. Dawson and Venville concluded that while students were able to make claims and support them with data, their arguments did not match the goals of scientific literacy for the curriculum. Instead they determined that arguments were based on emotion and intuition rather than rational informal reasoning. (Venville & Dawson 2010). This research demonstrates how to classify the level of argumentation on a scale of 1-4 where a Level 1 makes a claim, Level 2 provides evidence to support the claim, Level 3 has a claim, evidence, warrant, backing or qualifier, and Level 4 has a claim,data/warrant, backing and qualifier. The researchers found only 25% of students interviewed about biotechnology questions that generated an argument had Level 4 statements in their arguments. One reason cited for the low number of rational responses may have been related to the topics - cloning, genetic engineering, forensic testing, and genetically modified foods - all of which may have prompted emotional responses.

Sampson and Schleigh (2013), while laying out their rationale for using argumentation as a method of inquiry, emphasize the need to give students the opportunity to make a scientific claim, use evidence to support the claim, then communicate the findings to other students who will critique the claim. In *Scientific Argumentation in Biology* the authors contend that argumentation fulfills four aspects of science proficiency for science education in the United States (Duschl, Schweingruber, & Shouse, 2007). The first aspect of science proficiency is for students to know the key scientific understandings about the natural world and then transfer this understanding to solve new problems. The second aspect of proficiency is for students to be able to evaluate scientific arguments. A final component of science proficiency is for students to be competent in scientific language and to be able to practice using science skills Sampson & Schleigh, 2013)

In reviewing the standards for The Common Core State Standards (CCSS) it is clear that for students to be career ready learners by the end of grade 12, they will need to be proficient in analyzing scientific data and using evidence to support their conclusions. They will need to be able to evaluate claims from opposing positions and then be able to effectively communicate their findings to their peers. The National Research Council in *Framework for K-12 Science Education* has also established practices for high school students that involve using evidence to support or refute scientific phenomenon (NRC, 2012). "A Framework for K-12 Science Education:Practices, Crosscutting Concepts, and Core Ideas" (NRC, 2012) makes a case for using argumentation from scientific evidence to demonstrate to students the reasons for a particular explanation in science. The Framework suggests that an explanation via argumentation will also engage students in the process of science (NRC, 2012). Engaging students with real world data related to biology will also address key Next Generation Sunshine State Standards involving the

Nature of Science-(specifically standard SC.912.N.1- which states: “Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented”)”(Miller & Levine, 2012).

Students often have arguments about their favorite trends in pop culture such as music, sports, and movies. In a student’s daily life, claims about products in advertisements are constantly bombarding them and many false claims have been subject to lawsuits. (Llewellyn, 2013). However, a student’s ability to argue and evaluate false claims does not translate into the ability to be adept at scientific argumentation (Ross, Fisher, & Frey, 2009). Llewellyn further adds that by using argumentation, students have the ability to mimic what scientists do, which is to generate ideas, verify these ideas with evidence, discuss with peers, and continually modify their ideas. Llewellyn believes that science teachers have a responsibility to engage students in not only core concepts of science but to understand how scientists formulate these core ideas. In the book *Teaching High School Science through Inquiry and Argumentation* (Corwin, 2013), Llewellyn points to ten habits that students effectively demonstrate by using scientific argumentation. These include:

- formulating claims based on evidence,
- constructing an argument,
- voicing their privately held conceptions,
- forming decisions to justify a position taken,
- improving their abilities to frame an argument,

- having evidence based-discussions
- debriefing and reflecting on another's point of view,
- providing counterclaims to another's position,
- improving their speaking and listening skills.

In a study of 12th grade Brazilian students demonstrating knowledge of evolution through argumentation with small group discussion and oral debate, researchers found that students could articulate their understanding of evolutionary concepts such as function of feathers in dinosaurs and birds. Students were evaluated in their argumentation based on their ability to justify their claims with empirical evidence. After reviewing videotaped sessions of the class debates, the researchers coded student statements with key evolutionary concepts used in the discussions. For example, students may have used a general evolutionary concept such as the fact that feathers arise by chance versus their using empirical evidence to support a claim such as the transmission of the hemoglobin gene to cause speciation (Tavares, Jimenez & Mortimer, 2009). Researchers concluded that students were required to use their knowledge of the concepts of evolution and that by transmitting this knowledge through argumentation their knowledge became a "usable tool" (Tavares, Jimenez & Mortimer 2009).

In a two-year study in England, researchers studied the quality of argumentation in grade 8 science students using two sets of data from the beginning of the year to the end of the year with both an experimental group and a comparison group. Based on TAP, researchers analyzed the quality of argumentation about such topics as the merits of zoos. Level 1 arguments were a simple claim versus a counterclaim or a claim versus a claim.

Level 2 arguments were claims with data, warrants, or backings. Level 3 arguments were a series of claims with either data, warrants or backings. Level 4 arguments were arguments with a claim and a clear rebuttal. Level 5 arguments included an extended argument with more than one rebuttal (Osborne, Erduran & Simon, 2004). Researchers found that from the beginning to the end of the year the largest number of arguments were at Level 2. However, they also noted students increased their Level 3 or above arguments from 40% at the beginning of the year to 55% by the end of the year showing development in the quality of student argumentation.

One study which supports using an intervention such as an argument driven inquiry approach is that of Chung and Behan (2010). In a two- year study using traditional scientific inquiry and a pop culture medium, Chung and Behan concluded that inquiry based projects improved group work and students' ability to critique other's work. In the first project students in groups were asked to create a proposal investigating a genetic disease by individually writing a paper or creating a poster display about a genetic disease. For the second project, students working in small groups analyzed and critiqued for accuracy a sci-fi movie about genetics or genetic engineering. The researchers polled students to determine project preference and found 95% favored a group project. A different poll asked students to rate the value of different types of assessment and all preferred a group project as part of their overall assessment. A major finding of their work shows that student science learning improved by making the projects relevant to authentic science experiences. They noted that by sharing their work among peers the learning process was further enhanced. This study demonstrates the benefits of inquiry based projects on attitudes towards learning biology and the value of peer communication.

In another study on increasing student knowledge and argumentation skills through dilemmas in human genetics, researchers found approximately 90% of students were successful in making simple arguments (Zohar & Nemet, 2001). Ninth grade students in two schools in Israel were taught a unit on genetics and given dilemmas related to genetic issues that required them to apply their biological knowledge. Comparisons were made between the experimental and control groups with written worksheets on genetic problems, pre-post tests on knowledge, along with audiotaped discussions to measure their use of biological knowledge in argumentation. To evaluate student application of knowledge while involved in written responses the researchers used the following four categories:

1. The student's answer did not include any biological knowledge
2. The student's answer considered false biological knowledge
3. The student's answer included nonspecific knowledge
4. The student's answer included correct specific biological knowledge.

In addition, the researchers also analyzed student arguments during classroom discussion on genetic dilemmas. Categories used for evaluation of arguments included explicit conclusion, justification, concession, implicit conclusion, opposition, and counter opposition. The results were compared between two discussions and it was determined that there was a decrease in the total frequency of conclusions but there was an increase in the frequency of conclusions classified as explicit. The researchers determined that students were more thoughtful in justifying their conclusions in the second discussion, demonstrating that practicing argumentation skills improves with multiple sessions.

In order to determine if argumentation would improve students' reasoning, conceptual knowledge, ability to understand the epistemic nature of science, and to actively engage students in science, researchers studied four urban schools in the UK for two years to determine their ability to imbed argumentation into their curriculum with grade school students "(Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013)" Researchers used data from nationalized science tests to measure science knowledge and a Likert scale to measure student understanding of science epistemology or nature of science. Beliefs about science were addressed in four areas: (1) source of knowledge, (2) certainty of knowledge, (3) development of knowledge, and (4) justification of knowledge where the higher the number the higher the level of student understanding. To measure student attitudes and engagement a 74 item instrument measuring 11 constructs was employed. Some of the constructs included work aversion, satisfaction with learning, interest in learning, science enjoyment, and difficulty in science (Osborne et al, 2013). Researchers found negative effects on interest and engagement in students age 7-9, while 10-11 year old students showed improvement in their level of interest in science.

In an effort to determine if students using argumentation were successful in achieving three goals in "constructing and defending scientific explanations", Berland and Reiser found positive results in both sense-making "(students construct an argument) and articulating scientific arguments "("students present their arguments). However, the researchers found that students were unable to effectively persuade others of their arguments (Berland & Reiser 2008). The researchers attributed this lack of persuasion to the fact that students are restricted in their social interactions in a traditional classroom. In this case the social interaction is for students to consider the worthiness of competing scientific ideas and then to create a consensus about the meaning of the ideas under study. Students in traditional science classes are often given limited opportunities for participating in scientific practices, which is a key to science learning.

In a study to observe the effects of an eighteen- week intervention using Argument-Driven Inquiry in a chemistry lab, researchers found that students were more willing to talk about, critique, and challenge one another's ideas after learning the practice of argumentation from fifteen different lab investigations. (Sampson, Grooms & Walker, 2010) The researchers also found more balance in the participation level of students in each group along with more students making better contributions to the discussion. The investigators also noted an improvement in the ability of students to use more rigorous criteria for evaluating claims and justifying their ideas after the ADI intervention. In addition, the researchers saw a higher quality in the written arguments of students after the ADI lab experiences where students had a better understanding of "what counts" as evidence to support their reasoning in science, (Sampson, Grooms & Walker, 2010)

In summary, the review of literature regarding argumentation revealed the following: (1) argumentation is effective in promoting learning of science; (2) argumentation can be used as a springboard for engaging students in real world science, promoting a positive attitude toward science and (3) argumentation can improve scientific literacy. Thus, I believe that using Argument Driven Inquiry will be effective in increasing student understanding of high school biology concepts, increasing student motivation in biology, improving argumentation skills, and promoting knowledge of biology.

METHODOLOGY

The primary research question I will be investigating is "What is the effect of Argument Driven Inquiry on student understanding of high school biology concepts?" In addition I will be asking three subquestions: 1)What is the effect of ADI on student motivation/engagement? 2) What is the effect of ADI on argumentation skills and 3) What is the effect of ADI on student knowledge of biology?

The participants of my study will be an Honors Biology class at Escambia High School in Pensacola, Florida. The class consists of nine 9^{th} grade students and fifteen 10^{th} grade students. The class has twenty- four students with thirteen females and eleven males. The students have a range of academic abilities with eleven students reporting standardized reading scores of 4 or 5, nine students at level 3, and three students at level 2. The mean value for the class is level 3. One student did not have a report.

The class is not ethnically diverse with twenty- two of the students being Caucasian, with one Hispanic student, and one Asian student. Fifty percent of students in the class are on free or reduced lunches.

The intervention I used in my Honors Biology class was argument driven inquiry (ADI)dealing with two key concepts: evolution and ecology. In order to see improvement over time the ADI intervention was implemented on three separate occasions in class using three different biological concepts.

Using the instructional model presented by Sampson and Schleigh in *Scientific Argumentation in Biology* (2013) students used the process of argumentation. Students were given instruction about the steps to make their argument along with the method they needed to showcase their findings. Students presented the research question, their claim, the evidence to support their claim and the justification for that evidence on a whiteboard measuring approximately 2ft. x 3 ft. Students began their work in small groups by analyzing the data they were given about the research question. Together the students made a claim to answer the question. The claim the group made was the answer to the question. The research question along with the claim was written at the top of the whiteboard. The lower two thirds of the whiteboard was divided into two distinct sections for displaying the evidence for the students' claim and the justification for the evidence. The evidence was presented in a visual form such as a chart or graph. The justification was a written explanation of why the evidence they selected was important to their argument. The teacher circulated throughout the class to guide students in their understanding of the data and their argument. Upon completion of the argument whiteboards, the students had the opportunity to critique the findings of other groups. One student from each group was the presenter for the group while the other group members did a round robin review of their classmates' argument presented on their whiteboards. This is known as the argumentation session (Sampson & Schleigh, 2013). Each student presenter had a few minutes to explain the claim formulated by their group and justification of the evidence. Other groups served as the audience and critics of each group presentation. Students asked questions and dissected the argument of the presenter while evaluating the validity of the argument. The teacher also moved about the classroom during this phase of presentation to keep student groups on task and engaged. After a set time limit student critics rotated to the next presentation until all groups moved around the room to each presenter. After the argumentation session student groups went back to their original groups and discussed anything they learned from the round robin session. The entire class then debriefed about the major conclusions that were drawn from the argumentation activity. Students were given Checkout Questions as an evaluation of their understanding of their argumentation activity. The students produced a written argument about their understanding of the scientific claim along with supporting evidence and justification of the evidence. The teacher provided a writing prompt to guide students to present their findings as if they were trying to convince another scientist about their claim. A rubric was used to assess student performance on their final written argument. See Appendix H. Finally, students were placed back into their groups to evaluate the reports of three other students. They followed a peer review guide rubric to aid the evaluations of the reports.

The first ADI investigation was about the mechanisms of evolution specifically: Why do Venezuelan guppies have variation in coloration? (Sampson & Schleigh, 2013) This lesson is based on data from biologist John Endler and his studies of natural selection in the 1970's. Students will analyze information about the pools where the Venezuelan guppies were found. The data shows differences in location in the stream, turbidity of water, predatory fish in the pool, and drab/bright male and female guppies found in the pool. The students were also given a reference sheet about the four parts of Natural Selection.

The second intervention was about the interdependence of organisms where students investigated why populations of sport fish are decreasing in size in a fictitious lake. This was an application of knowledge about food webs, nutrient cycling, and interdependence of living things. Students not only analyzed data about the history and geography of the town surrounding the lake, as well as the history and characteristics of the sport fish in the lake, but also did water quality tests that mimic the conditions around the lake. Students followed the same format for previous ADI sessions.

The third intervention followed a teacher lecture about biogeochemical cycles. Students investigated global climate change in an argumentation session utilizing NASA satellite images of the North Pole from 1979 and 2003, photographs of Columbia glaciers over twenty-five years and one hundred years, NASA time-temperature graphs, data measuring atmospheric carbon dioxide concentrations and surface temperature changes from 1880-2003, global fossil fuel emissions, and sunspot photographs. The same procedure was followed for the previous ADI sessions.

The timeline for the three argumentation sessions lessons was seven weeks. The lesson began with the unit on Evolution. The unit required two weeks including the first argumentation session. The next two weeks covered Ecology concepts. This was not a part of the intervention. The next three weeks focused on human impact on the environment including the final two argumentation sessions.

Table 1
Data Triangulation Matrix

Questions	Data Source		
Focus Question: What is the effect of Argument Driven Inquiry on student understanding of high school biology concepts?	Pre-post questions	Student survey	Documentation of comments on peer reviewed papers
Sub-question 1: What is the effect of Argument Driven Inquiry on student engagement?	Motivation survey	Video of student presentations.	Student interviews
Sub-question 2: What is the effect of Argument Driven Inquiry on argumentation skills?	Rubric for presentation of argument	Student papers on argumentation Peer reviewed	Student papers on argumentation Instructor scored
Sub-question 3: What is the effect of Argument Driven Inquiry on biology knowledge?	Pre-post formative assessment.	Teacher Journaling	Check out questions.

DATA AND ANALYSIS

ADI lessons demonstrated a high level of student engagement from beginning to end. Students were excited to work with their peers and share their insights. As expected, students displayed varying strengths in their groups and this enabled some to dissect data, describe data, and display data on their whiteboards. ADI lessons also provided an opportunity for students to communicate their results while their peers listened to their arguments, which proved highly engaging for both presenters and audience members. Students did not show a remarkable improvement in their argumentation skills based on their argumentation papers however written arguments do not provide a complete picture of their progress. Based on teacher observations, students did display strong argumentation skills during oral argumentation sessions and the skill level improved over the course of the three argumentation sessions. Student assessments also revealed ADI lessons improved student knowledge of biology concepts. It is unclear if student knowledge improved solely based on the intervention.

Impact of Argument Driven Inquiry on Student Engagement

The intervention had a positive impact on student engagement and this is supported by the results of the Biology Motivation Questionnaire. The Biology Motivation Questionnaire had twentyfive statements pertaining to level of preparation for biology class, level of interest in biology, and level of achievement in biology. Student responses included Never (0), Rarely(1),

Sometimes (2), Often (3), and Always (4). Five questions were analyzed for determining student levels of engagement in biology. Responses were compiled for both "often'(3)"and 'always'(4)" to demonstrate a greater degree of certainty to each statement. The survey was used before and after the intervention to ascertain the level of interest generated by the three ADI lessons. Prior to the ADI lesson 33% of students reported "I can master biology knowledge and skills" compared with 75% of students post intervention. Before ADI lessons 43% of students reported "Learning biology is interesting", in contrast to 60% of students post intervention. In addition, 33% of students responded, "I enjoy learning biology", prior to ADI lessons compared to 50% of students who reported this post intervention. The data also revealed 57% of students believe "Biology I learn is relevant", while 70% of students agreed with this statement post ADI lesson. One of the five statements showed a decrease from 33% before the intervention to 25% post intervention. The low scores may be attributed to the wording of the statement which was "I will use biology problem solving skills in my career" suggesting most students perceived this question to be applicable only if they planned a future career in biology. Figure 1 summarizes student survey responses.

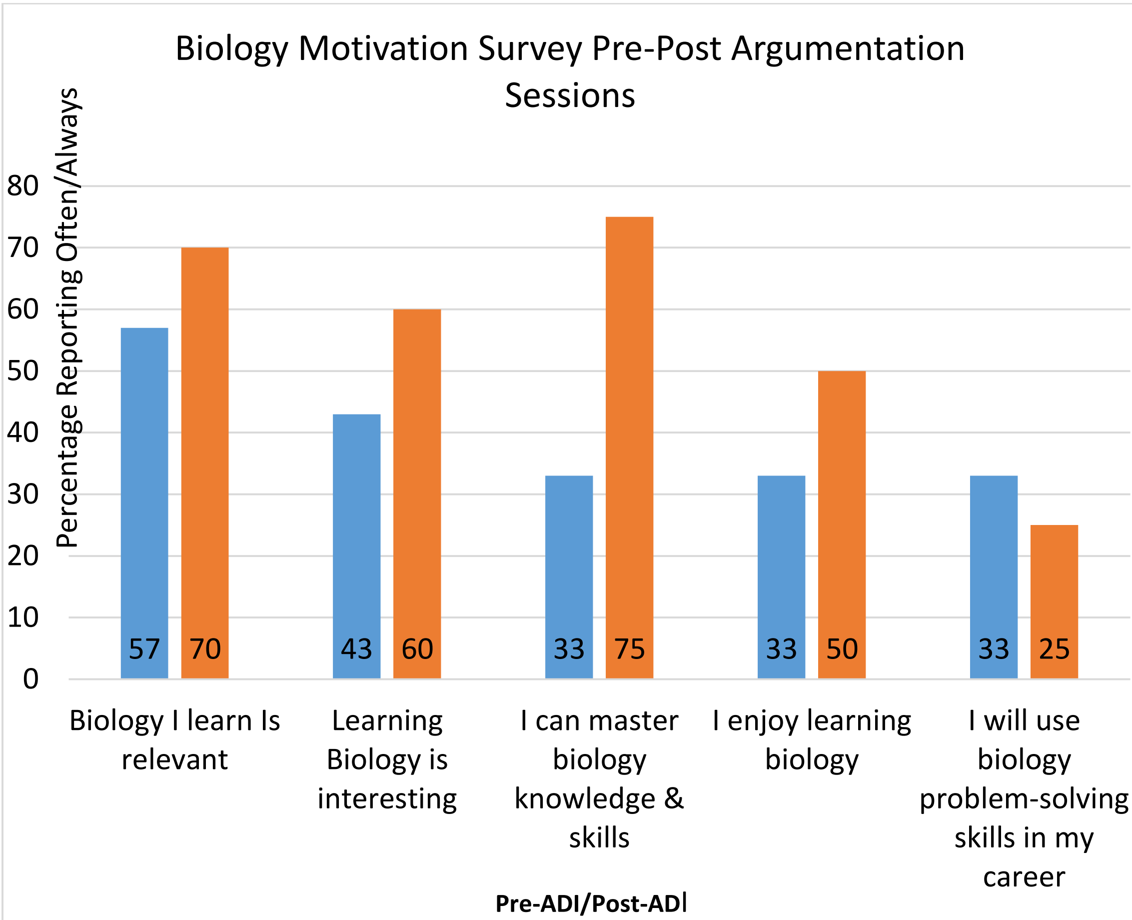

Figure 1. Survey scores pre and post treatment.

The ADI intervention also had a positive impact on levels of engagement as demonstrated by student interview comments. Eight students were interviewed with a battery of ten questions focusing on the eight C's of engagement: competition, challenge, cooperation, curiosity, controversy, choice, creativity, and connections (Silver & Perini, 2010). Students unanimously agree that ADI lessons allowed them to see more than one perspective in science. One example from a male response indicating a respect for other perspectives in science was noted by the remark “you have to look at the data yourself and come up with your own opinion and compare to others, so it opens your eyes to a wider range of ideas”. A female student made a similar remark when she stated “it is not where everyone is getting the same result so it allows people to branch off to their own ideas.” When asked if ADI stimulates curiosity about biology, one female reported, “you become curious about data and how it is working today and it makes you want to know more about how it affects the future”. A male interviewee revealed a positive impact on engagement when questioned if ADI improves your ability to collaborate with others he stated “yes, in groups you are able to bounce ideas off each other to get the best result”. A female student had a similar response when she reported “you can get ideas of others and expand on your own for a wider range of influence”. Additionally, students were asked if ADI lessons allow choices and a male student responded “yes, the display of data and justification can be creative”. A female student agreed that ADI allows choices when she stated “You can choose your argument and viable resources to support any argument”. In response to the question do you think ADI makes learning biology enjoyable, a female student respondent stated “yes it is enjoyable getting to see how peers present data to see different ways of thinking”. A male student also found ADI made learning biology enjoyable when he responded “yes working in groups made it enjoyable”. In addition to questions about levels of engagement one question that all eight students agreed on was that ADI helped them understand biology concepts better.

Impact of Argument Driven Inquiry on Student Argumentation Skills

The intervention had a mixed impact on student argumentation skills demonstrated by student written arguments. Students were asked to write an argument paper following each argumentation session. In the argumentation paper, students were to make a claim to answer the question under study, support the claim with evidence from the lesson, and justify their claim. A rubric was utilized to evaluate the strength of the student argument. The rubric consisted of seven categories and used a three-point range for scoring the argument. Scores ranged from 0 to 2. A score of 0 meant the student did not meet the criteria for the argument; a score of 1 meant the student partially met the criteria for the argument; and a score of 2 meant the student met the criteria for the argument. The seven categories for the argument rubric from *Argument Driven Inquiry in Biology* by Victor Sampson (2014) were as follows:

1. Did the author provide a claim that answers the guiding question?
2. Did the author include high quality evidence in his/her argument?
3. Did the author present evidence in an appropriate manner?
4. Is the claim consistent with the evidence?
5. Did the author include a justification of the evidence?
6. Is the justification of the evidence acceptable?
7. Did the author use scientific terms?

Students could achieve a maximum score of 14 points from the Argument rubric. Students were scored for each of the three papers and percent change from paper one to paper two was calculated along with percent change from paper one to paper three. Eight students in the class completed all three papers. It is not uncommon for students in this class to neglect to complete assigned class work, however this prohibited a large sampling of student scores. Of the students that did complete all three papers one student made significant gains between each paper. This student scored only 1 point out of 14 possible points on the first paper, improved to 10 points on the second paper, and received 12 points on paper three (Figure 2). This could be attributed to a low first score or a greater understanding of how to write an argumentation paper through the intervention. In a comparison of scores between the first and second argumentation papers, six students showed a slight improvement in scores, one student had the same score, and one student decreased in his score. In a comparison between the first and final argumentation papers one student made substantial gains, five students showed a slight increase in scores, and three students showed a decline in scores (Figure 3).

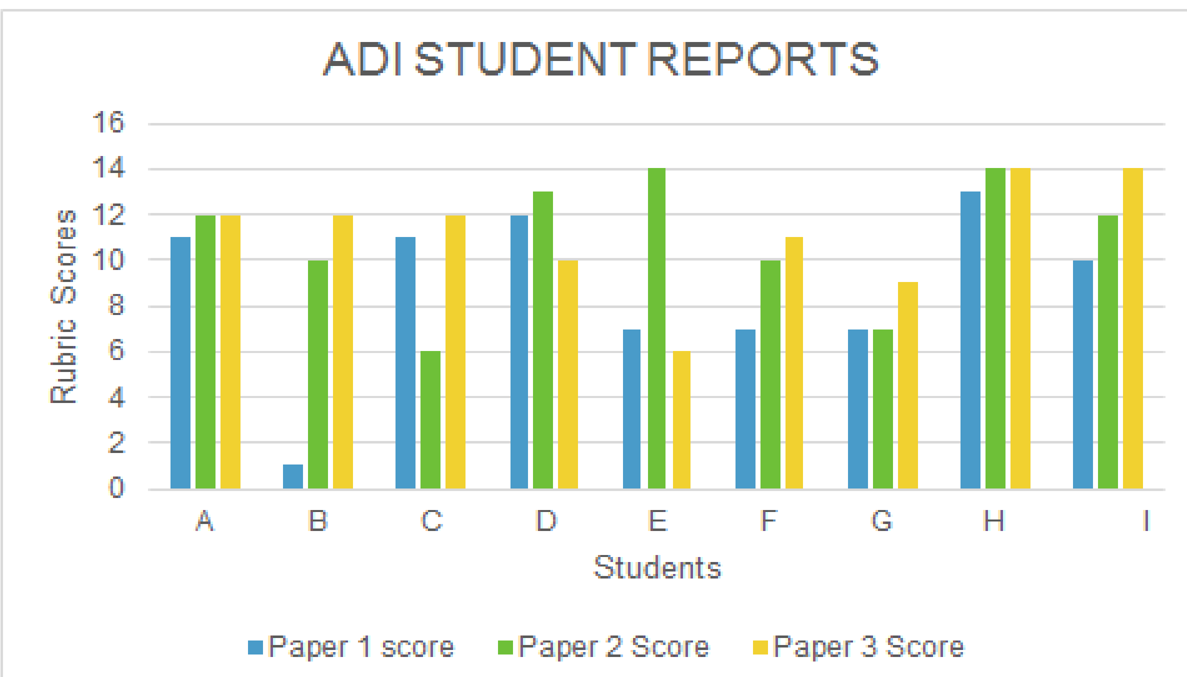

Figure 2. Student scores for argumentation reports.

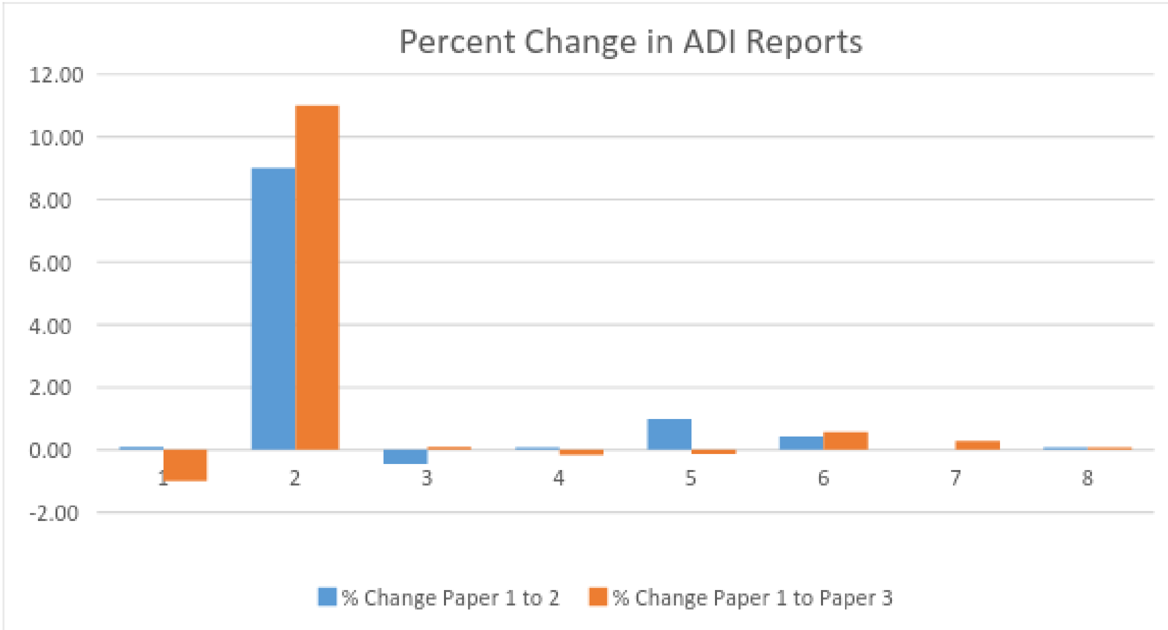

Figure 3. Percent change in student argumentation report scores 1 to 2 and 2 to 3.

In an effort to see the effect of ADI on student argumentation skills, student groups were asked to critique one of their classmates' papers in a double blind format. Student comments on the Peer Review Report revealed an increased level of understanding of the process of argumentation. After the first argumentation paper, five of eight reviewers made comments suggesting improvements for the author's argument. An example from one student reviewer demonstrated this understanding when he wrote, "Just explain how you found the data, what you thought of it, and how it helped you make your claim." After the second argumentation paper two reviewers wrote "clearly state the question and how your evidence answers it". Additionally, after the third argumentation paper, student reviewers suggested using more data such as graphs to support the claim.

Despite the lack of significant improvement in student argumentation papers students did display improvement in their argumentation skills during the argumentation sessions based on teacher observations.

Impact of Argument Driven Inquiry on Biology Knowledge

In order to see the effect of ADI on biology knowledge, students completed exit questions for each of the three argumentation sessions. For the first argumentation session on Natural Selection the checkout question was asked in the format of "I agree with this statement" or" I disagree with this statement and explain why using examples from his investigation. The statement was that "natural selection can affect the traits of a population in different habitats over time." Post intervention 94% of students agree with the statement and 67% of students used a specific example from the ADI lesson to support their answer. One student's post intervention response revealed a high level of understanding when he wrote that "Creatures with a trait that helps them survive will pass on their traits while others die. The bright guppies in water with low turbidity survived because they didn't stand out while drab guppies got killed by predators."

For the second ADI session the checkout question was related to interdependence of living organisms. Again, students were given the choice of "I agree with this statement" or "I disagree with this statement" then they explained their answer using examples from their investigation of Sport Fish in Lake Grace. The statement was as follows:" Living organisms in an ecosystem interact with each other. If one of those organisms is removed the other organisms are impacted." All students agreed with the statement while 68% showed a clear understanding of interdependence and 32% gave a specific example from the Sport Fish in Lake Grace lesson. For example, one female response post intervention demonstrated a direct connection to the lesson when she wrote that “The algae in the water was being affected by chemicals causing them to die. With the decrease of algae there was a decrease of oxygen in the water causing the fish to die. With less fish, animals that depend on fish will start to die off.” For the third argumentation session the checkout question was related to Global Climate Change. The students again were asked to agree or disagree with the statement and explain their answer using examples from the investigation of Global Climate Change. All but one student agreed with the statement and 81% of students used an example from the ADI investigation. One female student showed the relationship between using fossil fuels and climate change when she wrote that “I agree with this statement due to the levels of coal used throughout the decades. During the increase of coal use, the temperature of the planet’s surface has gone up. Observing this provides evidence for one to believe that humans are influencing global climate change.”

In order to measure the effect of ADI on biology knowledge, students were given pre-post formative assessments related to each ADI lesson. The first assessment was titled “Why is it Like That?” (Keely) Students were asked to select one of five student explanations for why giraffes developed a long neck. The correct response is from student Gene who stated that a long neck gave giraffes the best chance to survive, reproduce, and pass the trait along to offspring. Over time, this trait became evolutionary change.” Prior to the ADI lesson on Natural Selection 48% of students selected Gene as the person they agreed with the most. After the intervention 79% of students selected

Gene as the person they agreed with about the change in neck length in giraffes. One male student selected Sammy's response prior to the intervention. Sammy states that "evolution is goal directed. The goal was to survive in drought and be able to reach higher food sources, while smaller animals died and starved." The student thought that "Sammy is correct because the giraffe's main food sources are leaves and he needs to be able to reach higher leaves to survive." One male student's response post intervention revealed a greater knowledge of natural selection when he wrote: "I agree with Gene because it follows the rules of natural selection. Giraffes who had long necks survived while others died out allowing them to pass on their traits to their offspring." For ADI lesson two, students were asked to write a "One Minute Paper" answering the following question: "How can the environment be negatively impacted by humans?" Prior to the intervention 24% of students cited toxins in the water as a negative impact by humans while post intervention 33% of students specifically mentioned water pollution as observed in the ADI lesson entitled:" Why is the Sport Fishing population of Lake Grace decreasing in size?" One female student showed a high level of understanding when she reported the following in her One Minute Paper: "In Lake Grace, the nitrates and phosphates increased due to pesticides used on the farm and golf course, which killed the fish." Additionally, a male student showed his understanding of interdependence from the lesson when he wrote that "all organisms in an environment depend on one another. When one is removed all of the organisms are affected. For example, when the herbicide started killing off the plants in the water, that left fish without food, which caused those fish that relied on those fish for food to also die off." Before and after the third ADI lesson, students completed a Venn diagram in reference to how human activity has caused the world's climate to change over the past 100 years. Prior to the intervention, 90% of students provided a reason for climate change related to human pollutants. Before the third ADI session 30% of students used facts to support their perspective and 30% of students stated that natural events caused the climate to change as a reason why people said "no" to human activity causing climate change. Following the ADI intervention, 90% of students reported that a reason for people to respond "yes" to human activity as a cause of climate change was related to human pollutants. Post intervention 70% of students used facts to reinforce their perspective demonstrating an understanding that their claim should be supported by evidence. An example given by one female student that showed the use of facts after the ADI lesson was shown by his statement that "those who say 'yes' feel this way because of NASA's data. This clearly shows the Earth is warming". Another male student cited data that was used to support his claim when he wrote that "coal burning has increased over the past fifty years and is adding a lot of CO_2 to the atmosphere". Both students used data directly from the argumentation session.

INTERPRETATION AND CONCLUSION

As a teacher, I was not overwhelmed by the results of the intervention because the results did not match my experience in the classroom. The students displayed strong and well-supported arguments orally and this did not translate into higher scores in their written arguments over the course of three argumentation sessions. I attribute this primarily to the fact that students lack experience in writing scientific arguments and many students are not motivated to write. Students at Escambia High School are given limited opportunities for participating in scientific practices due to the traditional teaching practices used in ninth grade classes. Practice doing science is key to learning science (Beland, Reiser 2008). I do not think low writing scores are an indication of the overall benefits of using argumentation in science. Based on data from the Motivation Survey where 75% of students responded post ADI, “they can master biology knowledge and skills” compared to 33% before ADI lessons, this indicates students believe they can understand high school biology concepts after participating in ADI lessons. Students also showed gains in their post argumentation formative assessment scores. In the formative assessment evaluating understanding of natural selection, 48% of students answered correctly while after the argumentation session on Natural Selection in Venezuelan Guppies, 79% selected the correct response. Also, prior to ADI sessions on Global Climate Change 30% of students used facts to support their argument and post ADI sessions this number increased to 70%. In addition, all students interviewed stated they believe ADI lessons did help them understand biology concepts better. This data agrees with the idea that ADI lessons cover biology standards and help students with scientific literacy by analyzing data while problem solving and sharing their ideas with their peers (Owens, 2009). The data also support the effect of ADI on student understanding of high school biology concepts because all students did successfully construct an argument, discuss the argument with evidence, and improve their speaking and listening skills which is part of the ten habits that demonstrate effective use of scientific argumentation (Corwin, 2013).

The data indicate ADI lessons have a positive effect on student engagement. Based on the Biology Motivation Questionnaire, prior to ADI lessons 43% of students reported “learning biology is interesting” and after ADI lessons this number increased to 60%. Students also showed a greater enjoyment of learning biology after ADI session with 50 % of students reporting this to be true often or always in comparison to only 33% before ADI lessons. Also students reported an increase from 33% to 50% that “the biology I learn is relevant” pre-post ADI intervention. This supports the idea that if students are engaged in inquiry based projects that are relevant to authentic science experiences and share their work among peers, it increases their enjoyment of science (Chung & Behan, 2010).

Although the written arguments did not show significant gains, the oral arguments did show improvement over the three sessions based on teacher observations. Students showed an improvement in transferring their knowledge to new problems by using better evidence to support their arguments, justifying their evidence, and communicating their findings to their peers. This agrees with the findings that practicing argumentation skill improves with multiple sessions (Zohar & Nemet, 2001). In addition, the participation by students from the beginning planning stages to creating the argument board along with the argumentation session, and the critiquing of student argumentation papers was higher than observed in traditional teaching practices. ADI sessions created opportunities for some students to share their findings with peers, something that is not offered in traditional classroom approaches. This enabled more students to make contributions in science than in any other modality offered during biology class for the year which supports ideas that ADI will provide more balance in participation level with more students contributing to discussion (Sampson, Grooms & Walker 2010).

The next step for continuing implementation of ADI is to begin using argumentation earlier in the year and incorporate ADI lessons into more state standards. The use of argumentation could be used in teaching about the Nature of Science - especially the Next Generation Sunshine State Standard benchmark which is to "recognize the strength or usefulness of a scientific claim evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative explanations to explain the data" (Miller & Levine, 2012).

It may also be helpful to collaborate with English teachers on the writing portion of the argumentation lesson. If English teachers are willing to work on the written portion of the assignment, it would allow students more time to practice science writing skills. English teachers can help with revisions that would allow students multiple times to improve their argument. Also, students may be more compelled to complete the written assignment if they have class time to work on their papers.

The data suggests a need for students to practice argumentation skills in earlier science classes so they may benefit from increased exposure to using science skills. Teaching ADI lessons to other science teachers interested in improving science argumentation skills and student engagement in the ninth grade or even middle school could help in allowing students opportunities to practice science which is critical to learning science.

VALUE

The students were very enthusiastic about doing ADI lessons. I did not have to ask students to cooperate because they were engaged in the learning process. They enjoyed collaborating with peers and seemed stimulated by the challenge of problem solving with different types of scientific data. This made the teaching process much more enjoyable for me too. I was actively engaged with brainstorming and clarifying their own ideas. I found I was not as focused on what I was doing but rather on what they were doing which was refreshing. This actually increased my energy level because I witnessed the creative process of scientific thinking. I was encouraged by the level of effort students made in making charts and graphs from the data. The most gratifying part of the lesson however, was in the argumentation sessions itself where the students were animated and articulate in presenting their findings while audience members were respectful of the student presenters.

This action research experience has made me more aware of how important it is to place education back into the hands of the learner. Due to state mandated end of course exams biology teachers are tied to teaching a prescribed set of benchmarks; however; by doing ADI lessons, teachers can incorporate many benchmarks into the lesson simultaneously. Utilizing ADI lessons repeatedly is the key for both students and teachers to become more comfortable and confident with the practice.

In conclusion, the use of ADI in biology is effective at teaching high school biology concepts, engaging students in learning, improving argumentation skills, and improving biology knowledge.

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APPENDICES

APPENDIX A

BIOLOGY MOTIVATION QUESTIONNAIRE

BIOLOGY MOTIVATION QUESTIONNAIRE II (SMQ-II)

 In order to better understand what you think and how you feel about your biology courses, please respond to each of the following statements from the perspective of "When I am in a biology course…"

Statements	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
01. The biology I learn is relevant to my life.					
02. I like to do better than other students on biology tests.					
03. Learning biology is interesting.					
04. Getting a good biology grade is important to me.					
05. I put enough effort into learning biology.					
06. I use strategies to learn biology well.					
07. Learning biology will help me get a good job.					
08. It is important that I get an "A" in biology.					
09. I am confident I will do well on biology tests.					
10. Knowing biology will give me a career advantage.					
11. I spend a lot of time learning biology.					
12. Learning biology makes my life more meaningful.					
13. Understanding biology will benefit me in my career.					
14. I am confident I will do well on biology labs and projects.					
15. I believe I can master biology knowledge and skills.					
16. I prepare well for biology tests and labs.					
17. I am curious about discoveries in biology.					
18. I believe I can earn a grade of "A" in biology.					
19. I enjoy learning biology.					
20. I think about the grade I will get in biology.					
21. I am sure I can understand biology.					
22. I study hard to learn biology.					
23. My career will involve biology.					
24. Scoring high on biology tests and labs matters to me.					
25. I will use biology problem-solving skills in my career.					

APPENDIX B

STUDENT ENGAGEMENT RUBRIC

STUDENT ENGAGEMENT RUBRIC

CATEGORY	4	3	2	1
Contributions	Routinely provides useful ideas when participating in the group and in classroom discussion. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in the group and in classroom discussion. A strong group member who tries hard!	Sometimes provides useful ideas when participating in the group and in classroom discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group and in classroom discussion. May refuse to participate.
Attitude	Never is publicly critical of the project or the work of others. Always has a positive attitude about the task(s).	Rarely is publicly critical of the project or the work of others. Often has a positive attitude about the task(s).	Occasionally is publicly critical of the project or the work of other members of the group. Usually has a positive attitude about the task(s).	Often is publicly critical of the project or the work of other members of the group. Often has a negative attitude about the task(s).
Focus on the task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes nag, prod, and remind to keep this person on-task.	Rarely focuses on the task and what needs to be done. Lets others do the work.
Working with Others	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together.	Usually listens to, shares, with, and supports the efforts of others. Does not cause "waves" in the group.	Often listens to, shares with, and supports the efforts of others, but sometimes is not a good team member.	Rarely listens to, shares with, and supports the efforts of others. Often is not a good team player.
Pride	Work reflects this student's best efforts.	Work reflects a strong effort from this student.	Work reflects some effort from this student.	Work reflects very little effort on the part of this student.

APPENDIX C

PRESENTATION OF ARGUMENT RUBRIC

ARGUMENTATION PRESENTATION RUBRIC

Undeveloped (1 pt.)	Beginning (2 pts.)	Progressing (3 pts.)
	Claim	
Claim is not clearly defined or remains vague.	Claim becomes more descriptive over time. Claim uses scientific language.	Clarity of claim increases over time. Claim may begin to have predictive or model-like qualities.
	Evidence	
Evidence remains anecdotal or stays at the level of personal experience. Evidence over time remains irrelevant.	Labeled and relevant data, facts, or scientific observations are offered and described as evidence supporting claim.	Patterns and connections among evidence are explained. Evidence over time becomes more relevant, sufficient, and coherent.
	Reasoning	
Focus remains on being right or wrong instead of the thinking and reasoning.	Thinking is made visible or explained. Inferences and reasoning make sense and have logical or scientific qualities.	Reasoning justifies why or how the evidence supports the claim. Reasoning is based on scientific principles; is convincing or persuasive; and may address counterarguments, exceptions, or doubts.
	Socially constructed meaning	
Group collaboration remains limited to dividing work, turn taking, or distributing tasks.	Students listen to, question, and respond to each other about the science content. Groups consider more than one interpretation of evidence. Groups use collaborative scientific discourse.	Students socially reconstruct, alter, fine-tune, and defend their scientific ideas repeatedly over time. Students initiate, direct, and fluently use the language and discourse of science.

APPENDIX D

STUDENT SURVEY QUESTIONS

STUDENT SURVEY QUESTIONS

*Note to students before each interview “Participation is voluntary, and you can choose to not answer any question you do not want to answer, and you can stop at any time.” “Your participation or nonparticipation will not affect your grade or class standing.”

Data Source 3 Student Interview Questions

1. What is one thing you learned by doing ADI lessons?
2. Do you think ADI makes learning Biology more relevant?
3. Do you think learning ADI makes learning challenging?
4. Do you think ADI allows you to be creative?
5. Do you think ADI allows you choices?
6. Do you think ADI improves your ability to collaborate with others?
7. Do you think ADI stimulates your curiosity about Biology?
8. Do you think ADI allows you to see more than one perspective in science?
9. Do you think ADI helps you understand Biology concepts better?
10. Do you think ADI makes learning Biology enjoyable?

APPENDIX E

PRE-POST FORMATIVE ASSESSMENT

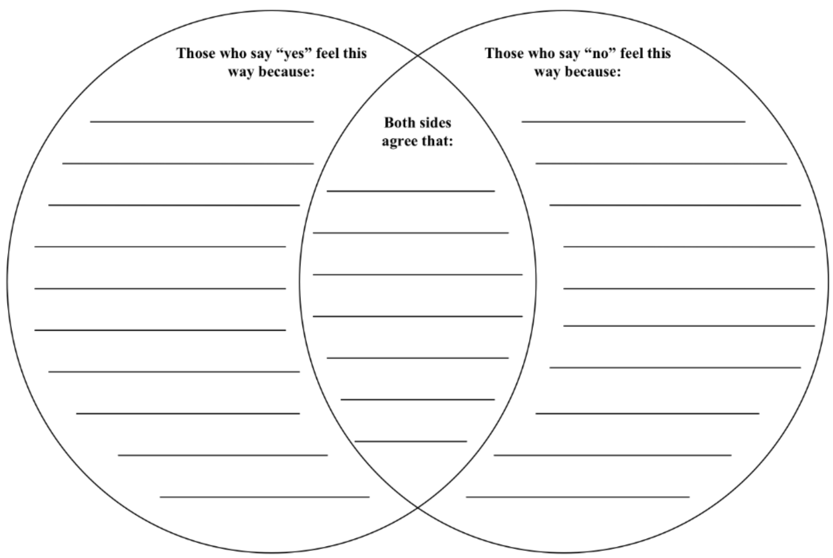
PRE-POST FORMATIVE ASSESSMENT

Paige Keely Probe – Why is it Like That? Used before and after Natural Selection ADI
One minute paper -How can the environment be negatively impacted by humans?
In your opinion has human activity caused the world's climate to change over the past 100 years? Explain your answer using the Venn diagram from PBS NOW lesson on Global Warming

Global Warming Venn Diagram

Directions: Answer the question below using the Venn Diagram to record what people on both sides of the global warming debate say about human responsibility for this issue. Be sure to note specific facts that support the different perspectives, and use the back of this paper to record more in-depth details as needed.

Question: Has human activity caused the world's climate to change over the past 100 years?



APPENDIX F

BIOLOGY KNOWLEDGE SURVEY QUESTIONS

BIOLOGY KNOWLEDGE SURVEY QUESTIONS

Note Participation is voluntary, and you can choose to not answer any question that you do not want to answer. Your participation or nonparticipation will not affect your grade or class standing.

Biology Knowledge Survey Students will mark A, B, or C with the following directions: Mark an “A” response to the question if you feel confident that you could answer the question completely for test purposes Mark a “B” response to the question if can truly answer at least 50% of it. Mark a “C” response to the question if you don’t know the answer or are not confident you could answer the question

Evolution Unit

1. What is an inherited characteristic that increases an organism’s ability to survive and reproduce in its specific environment?
2. What is fitness?
3. How does natural variation affect evolution?
4. What are the four conditions needed for natural selection to occur?
5. How does the process of natural selection account for the diversity of life on Earth?
6. How is the theory of evolution supported by evidence?

Ecology Unit

1. Why is the transfer of energy in a food chain us
2. What would be the result on Earth in an increase in the greenhouse effect?
3. How does the loss of biodiversity affect humans?
4. What is the best explanation for the large increase in atmospheric carbon dioxide since about 1800?
5. Name one evidence of global climate change.

APPENDIX G

BIOLOGY EXIT QUESTIONS

BIOLOGY EXIT QUESTIONS

Note Participation is voluntary, and you can choose to not answer any question that you do not want to answer. Your participation or nonparticipation will not affect your grade or class standing.

Exit Cards

ADI Lesson 1 - Natural selection can affect the traits of a population in different habitats over time. I agree with this statement I disagree with this statement

Explain your answer, using examples from your investigation of Venezuelan Guppies

ADI Lesson 2 – Living organisms in an ecosystem interact with each other. If one of those organisms is removed from the ecosystem the other organisms are impacted. I agree with this statement I disagree with this statement

Explain your answer, using examples from your investigation of Sport Fish in Lake Grace

ADI Lesson 3- Humans are influencing global climate change. I agree with this statement I disagree with this statement

Explain your answer, using examples from your investigation of Global Climate Change

APPENDIX H

PEER REVIEWED AND INSTRUCTOR RUBRIC FOR ARGUMENTATION PAPER

ADI Investigation Report Peer Review Guide - High School Version

Report By: ID Number ID Number ID Number

Author: Did the reviewers do a good job? 1 2 3 4 5
Rate the overall quality of the peer review

Reviewed By: ID Number

Section 1: Introduction and Guiding Question	Reviewer Rating			Instructor Score
1. Did the author provide enough ***background information***?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
2. Is the background information ***accurate***?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
3. Did the author ***describe the goal*** of the study?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
4. Did the author make the ***guiding question*** explicit and explain how the guiding question is related to the background information?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2

Reviewers: If your group made any “No” or “Partially” marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.

Section 2: Method	Reviewer Rating			Instructor Score
1. Did the author describe ***the procedure*** he/she used to gather data and then explain why he/she used this procedure?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
2. Did the author explain ***what data*** were collected (or used) during the investigation and why they were collected (or used)?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
3. Did the author describe ***how he/she analyzed the data*** and explain why the analysis helped him/her answer the guiding question?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
4. Did the author use the ***correct term*** to describe his/her investigation (e.g., experiment, observations, interpretation of a data set)?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2

Reviewers: If your group made any “No” or “Partially” marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.

Section 3: The Argument	Reviewer Rating			Instructor Score
1. Did the author provide a ***claim*** that answers the guiding question?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
2. Did the author include ***high quality evidence*** in his/her argument? ▪▪ Were the data collected in an appropriate manner? ▪▪ Is the analysis of the data appropriate and free from errors? ▪▪ Is the author’s interpretation of the analysis (what it means) valid?	☐☐ No ☐☐ No ☐☐ No	☐☐ Partially ☐☐ Partially ☐☐ Partially	☐☐ Yes ☐☐ Yes ☐☐ Yes	0 1 2 0 1 2 0 1 2
3. Did the author ***present the evidence*** in an appropriate manner by***:*** ▪▪ using a correctly formatted and labeled graph (or table); ▪▪ including correct metric units (e.g., m/s, g, ml, etc.); and, ▪▪ referencing the graph or table in the body of the text?	☐☐ No ☐☐ No ☐☐ No	☐☐ Partially ☐☐ Partially ☐☐ Partially	☐☐ Yes ☐☐ Yes ☐☐ Yes	0 1 2 0 1 2 0 1 2
4. Is the claim ***consistent with the evidence***?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
5. Did the author include a ***justification of the evidence*** that: ▪▪ explains why the evidence is important (why it matters) and ▪▪ defends the inclusion of the evidence with a specific science concept or by discussing his/her underlying assumptions?	☐☐ No ☐☐ No	☐☐ Partially ☐☐ Partially	☐☐ Yes ☐☐ Yes	0 1 2 0 1 2
6. Is the ***justification of the evidence*** acceptable?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
7. Did the author discuss ***how well his/her claim agrees with the claims made by other groups*** and explain any disagreements?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
8. Did the author **use scientific terms correctly** (e.g., *hypothesis* vs. *prediction, data* vs. *evidence*) and **reference the evidence in an appropriate manner** (e.g., *supports* or *suggests* vs. *proves*)?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2

Reviewers: If your group made any "No" or "Partially" marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.

Mechanics	Reviewer Rating			Instructor Score
1. ***Organization:*** Is each section easy to follow? Do paragraphs include multiple sentences? Do paragraphs begin with a topic sentence?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
2. ***Grammar:*** Are the sentences complete? Is there proper subject-verb agreement in each sentence? Are there run-on sentences?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
3. ***Conventions:*** Did the author use appropriate spelling, punctuation, paragraphing and capitalization?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
4. ***Word Choice:*** Did the author use the appropriate word (e.g., there vs. their, to vs. too, than vs. then, etc.)?	☐☐ No	☐☐ Partially	☐☐ Yes	0 1 2
Instructor Comments:				

Total: _____/50