THE EFFECTS OF ARGUMENTATION STRATEGIES, INTEGRATED IN GUIDED-INQUIRY ACTIVITIES, ON EIGHT-GRADE PHYSICS STUDENTS' UNDERSTANDING OF CONCEPTS.

by

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

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2015

DEDICATION

It is important to recognize the team of people that dedicated their own time for consultation throughout my project. My instructor and advisor Eric Brunsell, Ed.D., critical friends and research librarian Katie Nedved, fellow MSSE students, and MSSE board members have all provided tangible support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The focus of the action research was to determine the impact integrating argumentation within guided-inquiry instruction had on students' understanding of concepts. The results of the implementation recorded significant student growth indicating argumentation can increase students' achievement and understanding of science concepts.

INTRODUCTION AND BACKGROUND

In 2010, Evergreen School District made available an opportunity for students to enroll in a Physics 1-2 course for high school credit at the eighth-grade level. I instructed this course using best practice; teaching the science standards from Washington State Learning Standards that had little emphasis on argumentation within the inquiry process. Since the start of the program, I have collected both informal and formal data that indicates students struggle with developing and maintaining of key understanding of key scientific concepts. Since then, Washington State has adopted the Common Core State Standards (CCSS), a set of standards for math and English, in 2011 and Next Generation Science Standards (NGSS), a set of standards for science, in 2013, which clearly has more emphasis on students engaging in argumentation.

In the wake of the adoptions of both CCSS and NGSS in Washington State, I have expanded my instruction to include the task of engaging students in scientific argumentation. My intent of incorporating more argumentation was not to be compliant, but to investigate its ability to enhance students' understanding of scientific concepts. Recently, I finished reading an article about how argumentation can transform a student from being exclusively a system 1 thinker, who thinks fast without much evaluation or analysis, to also a system 2 thinker, who is slow, methodical, and analytical (Covitt, Harris, & Anderson, 2013). Although the evolutionary importance of being a system 1 thinker should not be neglected, we do need to recognize the hazards irrational thinking can have around high-stakes issues that students will indeed confront.

To produce informed thinkers in the 21st century, it is vital that our students receive instructional strategies, such as argumentation, which promote analytical thinking. Previous to Washington State's adoption of the CCSS and NGSS there was no deliberate instruction of students to practice scientific argumentation that has students evaluate, advocate or defend results through either a written or oral response. Students practiced the traditional skills of experimentation where they were expected to created a hypothesis from a given question, developed a model and procedures, collected and analyzed data and constructed an objective conclusion with limited higher order thinking. In order to get students to achieve this level of engagement leads to the focus question of my project: what are the effects of argumentation strategies, integrated within guided inquiry, on eighth-grade physics students' understanding of concepts? The focus of this project will utilize the same guided inquiry processes with the integration of argumentative strategies that will challenge students to engage in oral and/or written activities.

Interestingly enough, as I collect preliminary data on students' skills of argumentation alone, it is clear the students lack the ability to tie a conceptual understanding, as in reasoning, with the evidence to support their claim. This analysis ties nicely to the following subquestions: what are the effects of argumentation strategies on eighth-grade physics students' argumentation skills?; what are the effects of argumentation strategies on eighth-grade physics students' attitude and motivation? Aside from focusing on the progression of my students, I have the following subquestion:

what are the effects of argumentation strategies on my attitude and motivation as a teacher?

I conducted my project with highly academic physics students at Frontier Middle School, which has a population of 798 students and is one of six middle schools within Evergreen School District in Vancouver, Washington. Frontier is home to a majority of lower middle class working families. The student body consists of 70.2% Caucasian, 13.4% Hispanic/Latino and 16.4% dispersed from American Indian to having two or more races/ethnicities (Office of Superintendent of Public Instruction, 2014). My focus population consisted of 32 students; 23 of which are female and 9 are male. The Physics course is a high school credited course, so in order to enroll, students must be in Algebra or higher and have earned a B or higher the previous year in math and science.

As a science educator, it has been my objective and responsibility to excite students to act like, think like, and to be a scientist. After reviewing the recently adopted CCSS and NGSS, I feel I have cheated my past students of the opportunity to engage in argumentation. The project in part was developed to mitigate the gaps of the old state standards by enhancing guided inquiry with the integration of argumentation strategies of both written and oral. I want to provide strategies and the results from this project as evidence to fellow science educators about the value argumentation on not only enhancing students' understanding of the concepts but also the opportunity for them to act, think and now communicate like a scientist.

Research Questions

My primary research question is, 'What are the effects of argumentation strategies, integrated within guided inquiry, on eighth-grade physics students' understanding of concepts?' My sub questions include:

- What are the effects of argumentation strategies on eighth-grade physics students' argumentation skills?
- What are the effects of argumentation strategies on eighth-grade physics students' attitude and motivation?
- What are the effects of argumentation strategies on my attitude and motivation as a teacher?

CONCEPTUAL FRAMEWORK

The intent of my capstone project's is to reveal the research and studies that acknowledge the direct impact argumentation strategies, within guided inquiry, will have on students' conceptual understanding of physics, argumentative skills, attitude and motivation. My research will also examine what effects argumentation strategies will have on my own attitude and motivation as an educator.

The theory of inquiry-based instruction is not a new way of instructing science, as it has been a process that has been around for nearly a century (NRC, 2000). The basic principles of inquiry-based instruction challenges the traditional method of drill and practice, like rote learning, where the teacher dictates the learning and the student is responsible for memorizing the facts. The premise of inquiry-based instruction is simple; it harnesses the students' natural instinct to question and their thirst to understand why. It allows the students to engage in their own learning while also learning the methods of science. There is an abundance of literature and supporting evidence indicating the effectiveness of inquiry-based instruction in its ability to increase student comprehension. For example, 38 studies carried out over 23 years reported significant increases in performances of students receiving inquiry-based instruction versus similar students experiencing traditional text-book instruction (Lott, 1983).

Inquiry-based instruction can have a huge impact on student success, but without purposeful planning and guidance students may not walk away with the intended learning. Investigations need to be organized in way that is purposeful and appropriate for the learner. An investigation that is active and rigorous can significantly enhance the students' level of understanding (NRC, 2000). This implies that if an activity is minimally rigorous, it can put the students' depth of understanding at risk. To help prescribe the ideal rigor of inquiry-based instruction, a learning progression exists from confirmation, structure, guided on to open inquiry (Branchi & Bell, 2008).

Inquiry is not only a way of instructing, but can also be viewed as a strategy or variety of practices which can foster exceptional inquiry-based thinking. The National Research Council (NRC) indicates that for a student to obtain a mastery level understanding of the concepts, the students must engage in the practices of inquiry (NRC Framework, 2012). Within the new release of the NGSS the NRC includes eight science and engineering practices that's intent will help scaffold students' conceptual understanding of scientific knowledge. Of the eight science practices, "engaging in argument from evidence" (NRC Framework, 2012, p.42) parallels closely to my focus question looking at the effect argumentation has on understanding concepts. Although the old Washington State Science Standards did not have a clear emphasis on argumentation, the newly adopted NGSS clearly stresses the impact argumentation can have on students. Argumentation refers to a form of "logical discourse whose goal is to tease out the relationship between ideas and evidence" (Duschl, Schweingruber, & Shouse, 2007, p.33). The practice of argumentation requires students to be skilled at being analytical and evaluative of data to then rationalize it for its use as evidence to support a claim. Erduran (2008) believes argumentation is one of the greatest ways to measure one's competency and that the ability alone to engage characterizes true citizenship. Osborne, Erduran, and Simon (2004) state that argumentation "is a critically important epistemic task and discourse in science." (p. 995). Osborne et al., (2004) went on to say that argumentation is the central element in the learning of science; "…it engages learners in the coordination of conceptual goals."(p. 995). Duschl (2008) stresses that if a student engages in the practice of argumentation via written and/or oral and practice, defending and refuting their claims, then they are gaining the fundamental knowledge they need to learn inside the science classroom. An eight week study by Chen, Hand and McDowell (2013) focused on engaging 835 fourth-graders collaboratively with 416 11th-graders practicing and exchanging argumentative writing between grades to teach concepts showed considerable gains on tests of their conceptual understanding. Again implicating that argumentation greatly increases students' depth of conceptual understanding simply because of the frequency of higher order thinking associated with. Another study by Sampson, Enderle, Grooms and White (2013) took six separate classrooms, two middle and four high school science classes, with a total test population of 294 students. Testing the effect an Argument-Driven Inquiry (ADI) instructional model not only on students' conceptual understanding but also their ability to express and write scientific arguments. The ADI instructional model preserves the authentic practice of science inquiry with an emphasis on argumentative writing to promote students to develop, defend and critique results like real scientists. (Sampson et al., 2013). The results of the study indicated five out of the six courses not only showed significant gains around students' conceptual understanding but also showed parallel effects on their ability to write scientific arguments.

Using instructional models like the ADI not only support growth of students' conceptual understanding but also their argumentative skills, which leads to the effects argumentation strategies has on students' argumentative skills. According to the research of Sampson et al. (2013) no matter the model, implementing argumentation strategies within instruction gives students more exposure to higher order thinking. Higher order thinking such as analyzing, evaluating and synthesizing that in turn will result in more effective argumentative writing. When students are given amble opportunity, provided modeling with clear expectations and receive immediate feedback, students will become proficient in their argumentative skills. The results from a study conducted by Khishfe (2013) supports such research when she identified the effects integration of argumentation strategies had on a group of seventh grade students' augmentative skills within unfamiliar content. Sampson et al. (2013) also collected evidence within the same study of six classrooms, two middle and four high schools, of the effect multiple opportunities argumentative strategies had on students' argumentative skills. The results from the study indicated multiple opportunities of engagement in argumentation showed significant gains within the major criterions of argumentation such as claims, evidence, reasoning, style, and organization of writing.

An increase in conceptual understanding and argumentative skills are not the only potential outcomes of increased argumentation practices. One subquestion examined the effect argumentation had on students' attitudes and motivation. Washington State's 2013 National Teacher of the Year, Jeff Charbonneau, who teaches, chemistry, physics, and engineering said the content is not the hardest thing he teaches, it is students' confidence. Charbonneau argues that we as educators need to view our students as "people" instead of "students". Charbonneau feels the term "students" gives the perception that all students go to class on time, sit in a perfect row, and will always be eager to learn. When the reality is they are just as reluctant as you and I were when we were a student. Charbonneau engages his students in activities that require "doing" that he feels give his students the confidence to be the problem solvers of the next generation (Washington STEM, 2014, min. 1:00). Like Charbonneau, Rancer, Whitecap, Kosberg, and Avtgis (1997) also believe through "doing" students' attitude and motivation will rise. A study with 239 seventh-graders confirms such thinking that engaging in argumentation significantly increases students' attitudes and motivation. Research indicates teachers who integrate argumentative strategies within their curriculum not only promote higher order thinking but also shows there is a strong correlation between students' self-esteem and the mastery of argumentation (Rancer, Kosberg, & Silvestri, 1992). Nolen and

Haladyna (1990) claim an increase in student motivation does not simply rely on inspiring teachers, but more on teachers who instruct using strategies that require high level thinking.

Similar to my previous subquestion of investigating into the effects on students' attitude and motivation, I was also intrigued what effects I will embrace. A recent study dove into identifying the impact integration of argumentative strategies has on teacher attitude and motivation. The results of the study conducted on 24 physic teachers showed the integration of argumentative strategies had a positive impact on teachers. Teachers reported that not only did the strategies engage students in meaningful learning, but they indicated as a result of the processes a higher motivation to teach science (Ogan-Bekiroglu & Aydeniz, 2013). Guo, Connor, Yang, Roehrig and Morrison (2012) hypothesize that teachers with a higher sense of motivation show more support and provide a better environment that promotes student learning than teachers who have a lower sense of motivation. Ultimately classroom practices are influenced by teachers' attitudes and motivation (Ball & Cohen, 1996) and which have a direct correlation if students can successfully engage within the practices of science (Driver, Newton & Osborne, 2000). An article written by Chacon (2005) brings it full circle in suggesting there is significant relationship between engaged students and teacher attitude and motivation.

With the focus shifting towards producing graduates to be "doers" or "real-world problem solvers" and to be nimble thinkers, the model of instruction needs to shift as well. The immensity of literature around implementing argumentation strategies within guided-inquiry provides evidence that suggests students will gain experiences and create ownership of their own learning that will pay dividends for the students themselves and for society as a whole.

METHODOLOGY

To determine the magnitude of which argumentation had on students' conceptual understanding, skills of engaging in argumentation, attitude and motivation, and my own attitude and motivation an intentional treatment was implemented.

Participants

For my project I used one section of my eighth-grade Physics 1-2, for both the nontreatment and as the treatment. This section of eigth-grade Physics 1-2 started at 1:25 p.m. and went to 2:45 p.m. daily and consisted of 23 female and 9 male participants. The class consists of highly academic and engaged students. The Physics course is a high school credited course, so in order to enroll, students must be in Algebra or higher and have earned a B or higher the previous year in math and science. There are no IEPs or section 504 plans.

Intervention

My capstone project was comprised of three units, one nontreatment and two treatments. The nontreatment unit modeled best practice reflecting the old Washington State Standards using guided-inquiry as the primary instructional method. The treatment units modeled best practices from the newly adopted NGSS that incorporates argumentation strategies within the guided-inquiry process. The final two treatment units focused on the introduction of proper argumentative discourse and the integration of argumentative strategies within guided-inquiry. Multiple methods of assessments were collected, a triangulation of data, to provide evidence and allow comparison between the nontreatment and treatment units to determine effectiveness of incorporating argumentation strategies.

Within the nontreatment unit, students were primarily engaged through guided-inquiry as the medium for which students' would acquire and build upon their depth of understanding. The nontreatment unit lasted for two weeks and often had students working in small groups focused around a teacher provided research question to promote inquiry. Washington's interpretation of the inquiry process expected student to be able to plan and conduct an investigation, purpose a hypothesis, develop procedures, collect, analyze and display results, and generate a scientific conclusion (Washington State Science Standards, 2010). Within Washington State's standards there is only a brief mention that students should be able to work collaboratively throughout the investigative process. The state standards as they be, clearly lacks any depth or rigor of engaging students in argumentation, such as developing a claim, citing evidence, providing reasoning, and defending or refuting via oral or written. Through all of the investigations within the nontreatment, the focus or objective was about students being able to complete the process and writing an objective scientific conclusion that required no extensive higher order thinking. No effort was put on the students to use any argumentation strategies within to help build a conceptual understanding.

In comparison the latter two treatment units focused on the introduction and practice of argumentation. The first treatment unit consisted of six phases educating students how to be effective at argumentative discourse. The third and final treatment unit engaged students in full implementation of argumentative discourse within guided-inquiry investigations.

The first of six phases consisted of identifying students' prior knowledge of the five criterions of an argument. A pretreatment assessment consisting of four questions was used to elicit students' thinking to determine appropriate instructional needs in phase two and as a data point to measure student growth (Appendix A). The second phase was instruction that was data-driven based off student responses from the first phase. The intent of the second phase was to give students a deeper understanding of the criterions of an argument by referencing an argumentative scoring rubric (Appendix B). Students were expected to develop, adjust and/or confirm their own conceptual understanding of proper argumentative discourse. The last three phases of the treatment unit consisted of having the students participate in a continuum or learning progression of argumentative discourse. The phases progressed from simple to complex or more specifically from teacher-guided to teacher-facilitated to student-led. The start of the progression consisted of having the students practice argumentative writing from a simple prompt that required students to read, analyze, and gather relevant data from a text and provided reasoning that explain how the data supported their claim. The prompt was defined with only one or two possible claims. The data, the supporting evidence, within the text was limited and contained no outliers. The sufficient reasoning was provided within the text. By the end of the learning progression students engaged in more complex argumentative discourse developing claims independently to prompts that were more open ended. Drawing evidence from student generated data that were large and contained outliers. Students had to supply reasoning that supported why the evidence was relevant and important to their claim.

Table 1
Argumentative Discourse Learning Progression

Treatment Unit 1 Argumentative Discourse Learning Progression			
Criterion	**Teacher Guided**	**Teacher facilitated**	**Student-Led**
Claim	Prompt is limited to 1-2 possible right answers	Prompts has multiple possible right answers	Prompts are open ended with several possible right answers
Evidence	Small data set made available with no outliers	Large data set with no outliers	Large student generated data set with outliers
Reasoning	Reasoning is teacher provided	Reasoning is supplied within notes or text	Reasoning is student generated from research

Treatment unit 2 consisted of full implementation of argumentative discourse within guided-inquiry labs. The following lesson is an example of what was implemented throughout the treatment unit. The intent of this activity was for students to collectively build a conceptual understanding of Newton's First Law through a guided inquiry activity (Appendix C) with the incorporation of an argumentation strategy. Through this activity students were given a prompt to develop an investigation that would clearly define the problem. The students incorporated the traditional components of the inquiry process but were also required engage in argumentative strategies both written and oral. Students were expected to state a claim of what types of motion caused spillage of water and defend using evidence and logical reasoning. Student also engaged in oral argumentation with peers to defend and refute. A quick analysis of the students' learning was built into the activity at the end to measure the students' conceptual understanding around what they just investigated, observed, and argued within the activity.

I believe these treatment units will effectively help answer my focus and subquestions. The activity is an introductory lab used to develop an understanding of Newton's First Law of Motion. Through this treatment activity students will not only build their own conceptual understanding from the evidence collected but also get practice using argumentation strategies. In comparison to a nontreatment activity where no intervention will be used should show results within the analysis making it evident or not the impact argumentation strategies has on students' conceptual understanding and argumentative skills.

Data Collection Instruments

To effectively answer the focus and subquestions within my project, several methods of assessment were used, for both the nontreatment and treatment units, in order to gather sufficient evidence to validate the results. Using several methods such as, preunit and postunit assessments, student interviews, and preunit and postunit surveys allowed multiple approaches or a triangulation of data to confirm the results of the project. Table 2 is a data triangulation matrix.

Table 2
Triangulation Matrix

Research Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: What are the effects of argumentation strategies, such as guided inquiry, on eighth-grade physics students' understanding of concepts?	Preunit assessment of students' depth of knowledge of concept.	Postunit assessment of students' depth of knowledge of concept.	Posttreatment skill interview of students' depth of knowledge of concept.
Subquestions:			
What are the effects of argumentation strategies on eighth-grade physics students' argumentation skills?	Pretreatment assessment of students'understanding of argumentative discourse	Posttreatment assessment of students'understanding of argumentative discourse	Posttreatment skill interview of students' knowledge of argumentative discourse and ability to engage in argumentative discourse
What are the effects of argumentation strategies on eighth-grade physics students' attitude and motivation?	Instructor field observations with prompts	Pretreatment student survey	Posttreatment student survey
What are the effects of argumentation strategies on my attitude and motivation as a teacher?	Nontreatment and treatment observations by colleagues with prompts	Treatment observations by colleagues with prompts	Instructor weekly reflection journaling with prompts

To measure the growth and depth of students' conceptual understanding a preunit and postunit assessment were administered to all students. The assessments contained a progression of questions that elevated in cognitive rigor for each unit's conceptual objectives to assess and measure students' depth of knowledge. (See Appendix D of Student Assessment) A posttreatment skill interview was conducted with six students, two high, middle and low achieving, after the completion of the treatment unit. Of the six students interviewed, three were male and three were female. The students were given the prompts five minutes ahead of their interview to be allowed time to develop sufficient responses. The level of cognitive rigor obtained by the students was used to determine the effectiveness argumentation integrated within guided-inquiry instruction by comparing the results between the treatment and nontreatment units.

In order to assess the effectiveness the intervention had on developing students' argumentative skills, a pretreatment and posttreatment assessment was conducted. The assessments were implemented at the beginning of the nontreatment and end of the treatment unit to provide clear evidence for comparison of the subquestion. The assessment can be found under Appendix A. A Posttreatment skill interview were also conducted. For the posttreatment I interviewed the same six students, two high, middle and low achieving, after the completion of the lab within the class period. Of the six students interviewed, three were male and three were female. The students were given the prompts five minutes ahead of their interview to be allowed time to develop sufficient responses. The interview questions intended to assess the students' ability to identify and define the criterions of an argument. The interview was also designed to assess students' ability to orally construct an argument. The posttreatment skill interview can be found under Appendix E.

To attend to determining how argumentation affected students' attitudes and motivation a pre and posttreatment survey were given. The pre and posttreatment attitudes and motivation survey questions can be referenced under Appendix F and G. Both surveys used several Likert scale questions to determine students' attitude and motivation towards science. The Likert scale questions were the same questions used in the pretreatment and were used for comparison. Two questions were added to the posttreatment only that intended to elicit the subjective affects learning argumentation strategies had on their attitude and motivation as a student. All students completed the surveys and were an important aspect of the project to gain better insight of the students thinking around the affects of incorporating argumentation strategies. Throughout both the nontreatment and treatment units instructor field observations were recorded on students attitudes and motivations.

The duration of the project lasted seven weeks starting in the beginning of January 2015 through the end of February, see Appendix H for a more detailed timeline. The nontreatment, using just guided learning, and treatment units one and two, incorporating argumentation strategies, each lasted two weeks.

DATA AND ANALYSIS

My action research was driven by the curiosity of what effects engaging in argumentation, within guided-inquiry, had on improving students' understanding of concepts. The following is an analysis of both quantitative and qualitative data collected in an attempt to definitively answer the primary and sub-questions of the action research.

Effects Argumentation has on Student's Depth of Knowledge

To address my primary question three assessments were implemented, two written and one oral interview, using a guided-inquiry lab which was developed specifically to measure students' competence at each of the Depth of Knowledge (DOK) levels. The Projectile Through a Hoop Challenge had a range of rigorous tasks that required the students to demonstrate their knowledge at each of the four levels: recall and reproduction (DOK Level 1), skills and concepts (DOK Level 2), Strategic thinking (DOK Level 3), and extended thinking (DOK Level 4). The following images are examples of a student's work demonstrating each of the DOK levels. Figure 1 shows the student identifying all the known variables and properties of motion in the horizontal and vertical as clear demonstration of DOK Level 1. Figure 2 shows the student demonstrating their skills and understanding of the concepts through data collection, organization data and make two step calculations to solve for unknown values as a clear demonstration of DOK Level 2. Figure 3 shows the student's strategic thinking through an analysis where the student communicated the results of their findings, connecting concepts with evidence as a clear demonstration of DOK Level 3. Figure 4 shows the student's ability to extend their thinking past the lab objective into the challenge as a demonstration of DOK Level 4.

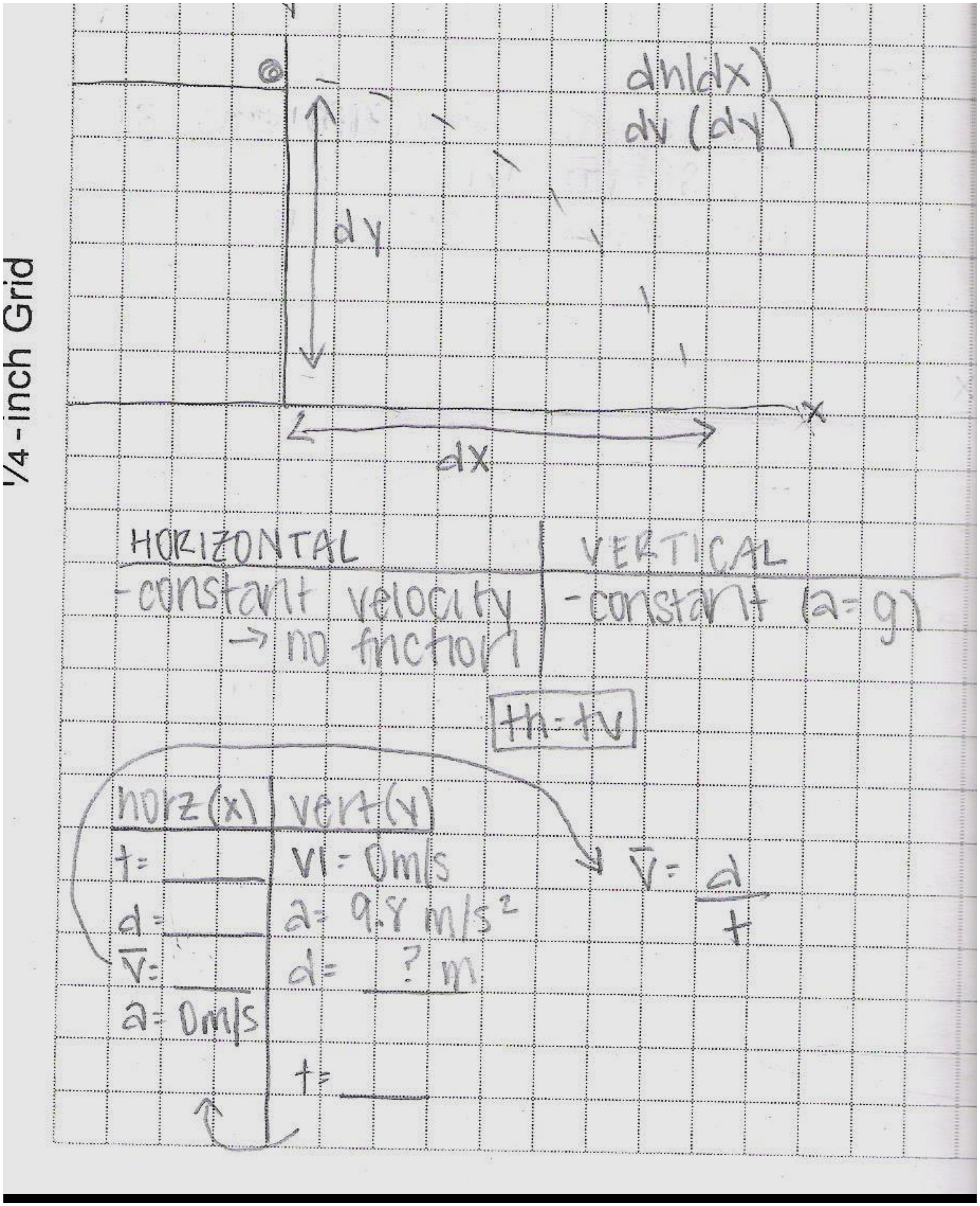


Figure 1. Student work demonstrating DOK Level 1.

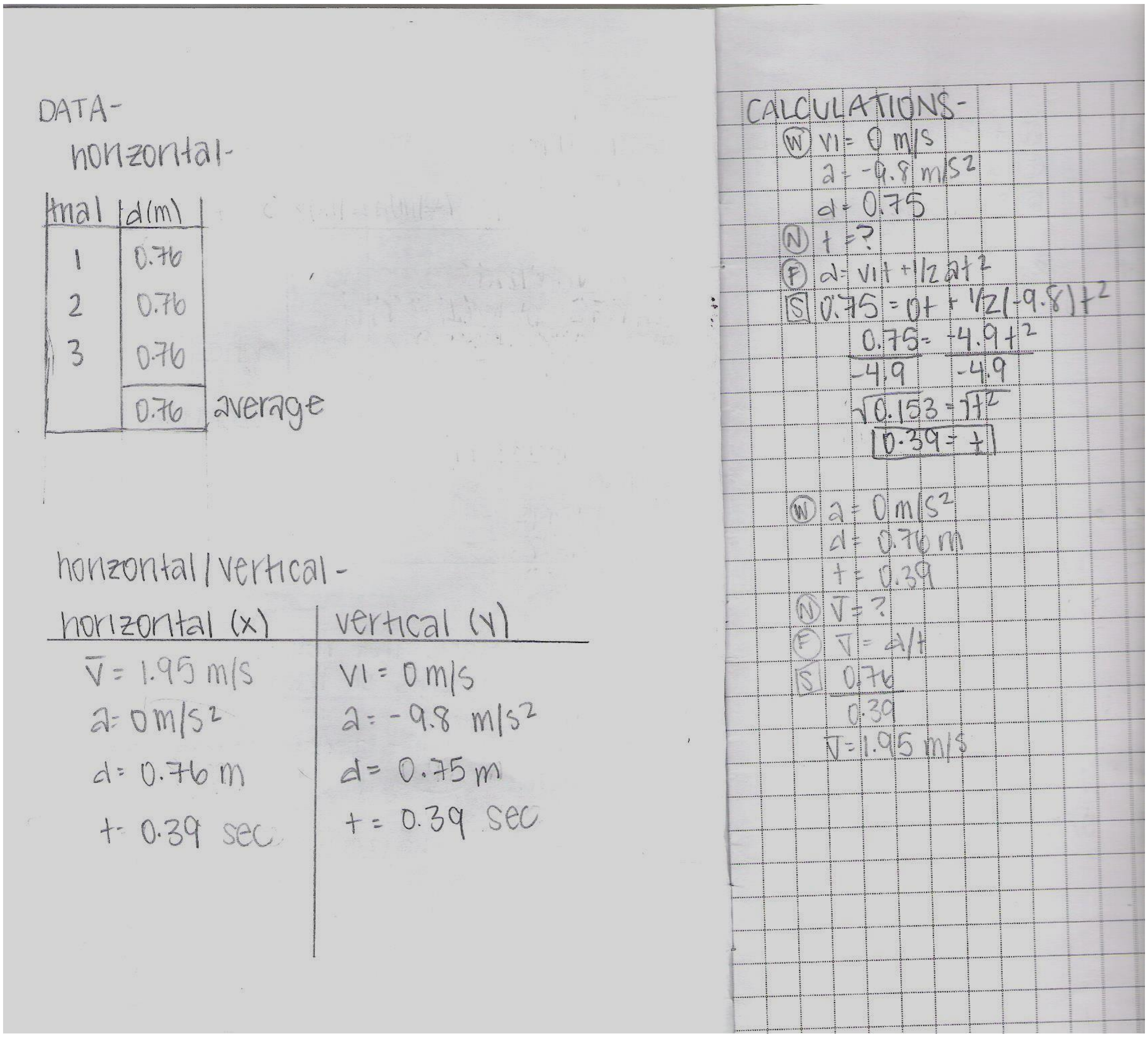
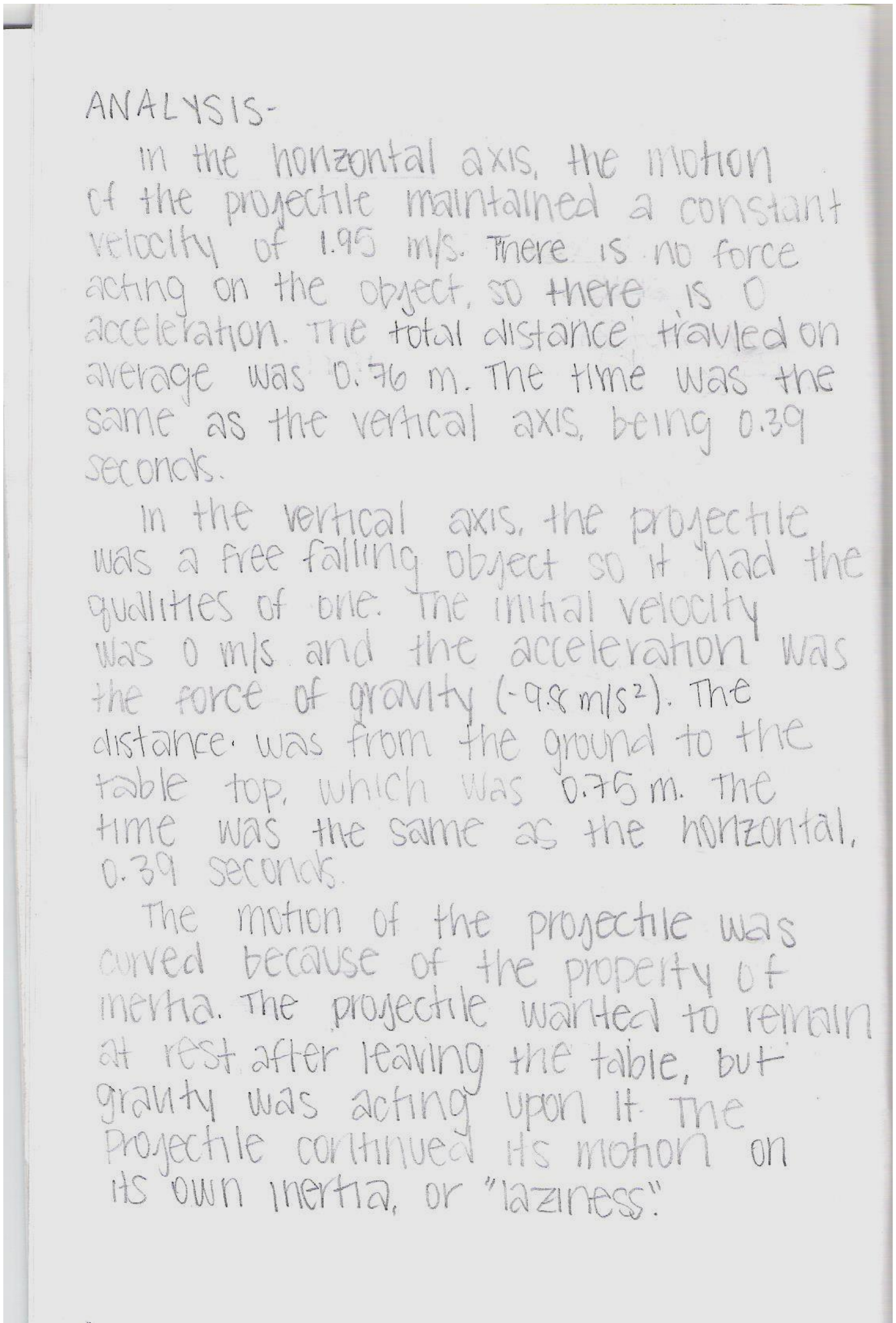


Figure 2. Student work demonstrating DOK Level 2.



ANALYSIS-

In the horizontal axis, the motion of the projectile maintained a constant velocity of 1.95 m/s. There is no force acting on the object, so there is 0 acceleration. The total distance traveled on average was 0.76 m. The time was the same as the vertical axis, being 0.39 seconds.

In the vertical axis, the projectile was a free falling object so it had the qualities of one. The initial velocity was 0 m/s and the acceleration was the force of gravity (-9.8 m/s²). The distance was from the ground to the table top, which was 0.75 m. The time was the same as the horizontal, 0.39 seconds.

The motion of the projectile was curved because of the property of inertia. The projectile wanted to remain at rest after leaving the table, but gravity was acting upon it. The projectile continued its motion on its own inertia, or "laziness".

Figure 3. Student work demonstrating DOK Level 3.

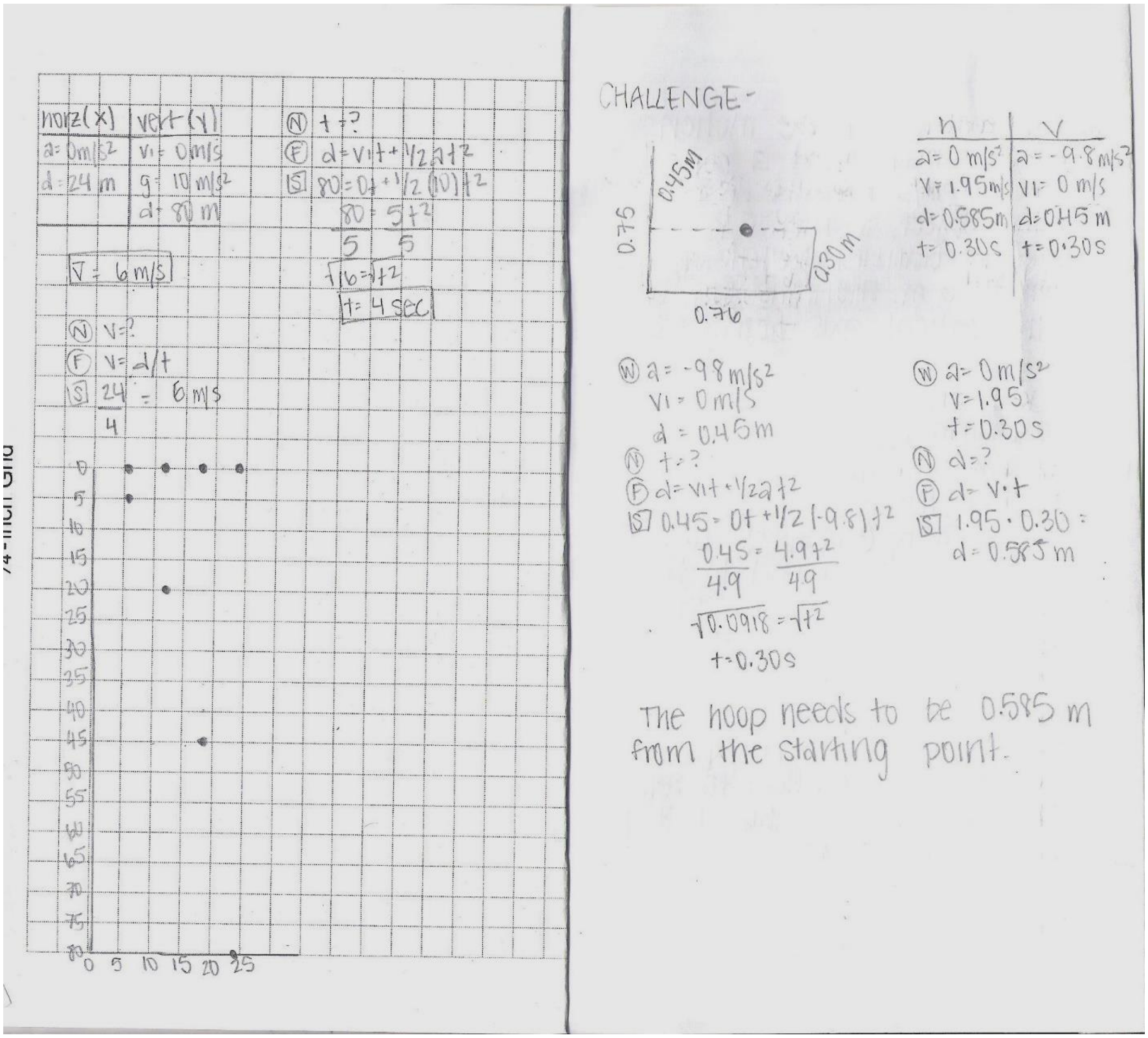


Figure 4. Student work demonstrating DOK Level 4.

The data collected from the pre and post treatment written assessments clearly suggests argumentative strategies within guided-inquiry had a positive impact on the depth of knowledge by recording significant growth in three of the four DOK levels. Figure 5 and Table 3 compare and contrast the results from both the pre and posttreatment units. Of the 32 students assessed the baseline values showed 96% of the students could demonstrate or achieve a DOK Level 1 thinking, 84% at DOK Level 2, 59% at DOK Level 3, and 68% at DOK Level 4. Compared that to the Post assessment where 100% demonstrated at DOK Level 1, 81% at Level 2, 87% at DOK Level 3, and 81% at Level 4. Again clearly showing growth, if not significant growth, in three of the four DOK components. DOK Level 3 recorded the greatest growth, from pre to post argumentative strategies, of 28% where DOK Level 2 actually showed a negative growth, with the inclusion of argumentative strategies, of -3%. DOK Level 1 showed growth of 4% and DOK Level 4 showed a respectful 13% growth.

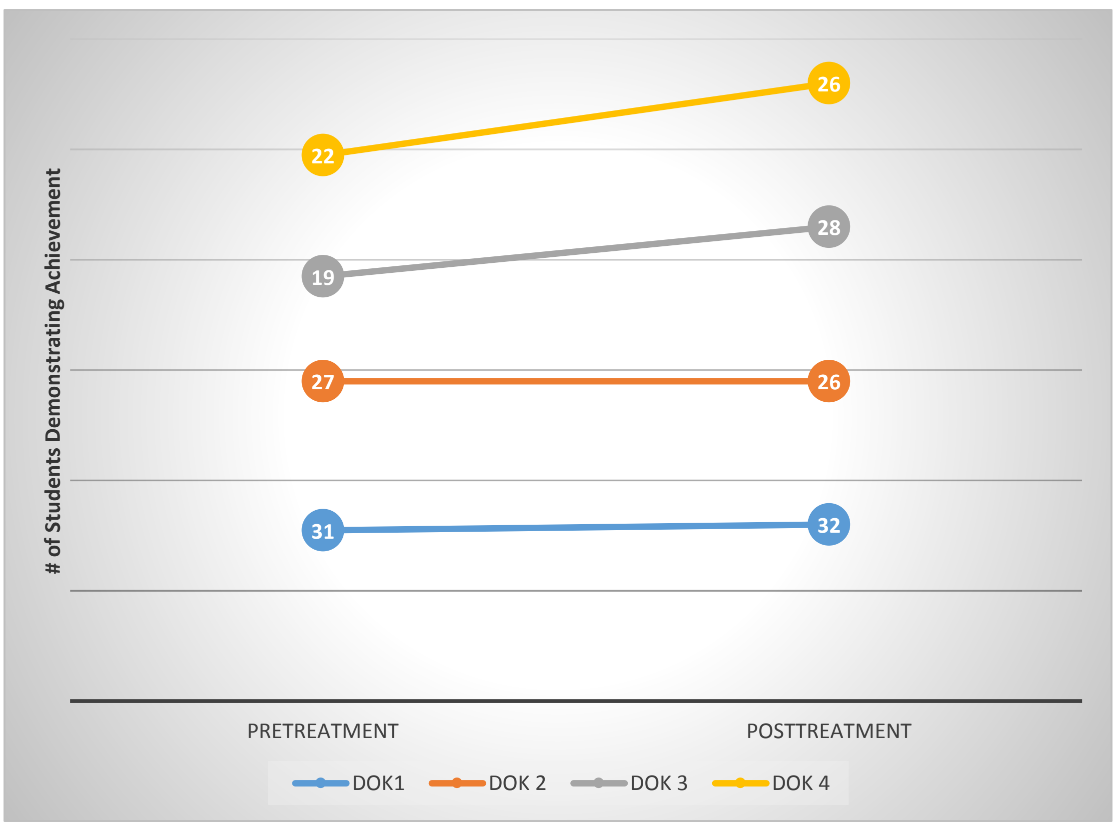


Figure 5. Pretreatment and posttreament depth of knowledge components achieved scores, (*N*=32).

Table 3
Pretreatment and Posttreament Assessment of Students' Depth of Knowledge Components Achieved Percentages

	Depth of Knowledge Components			
(*N*)=32	DOK Level 1	DOK Level 2	DOK Level 3	DOK Level 4
Pretreatment % Achieved	96%	84%	59%	68%
Posttreatment % Achieved	100%	81%	87%	81%
Growth % (+/-)	**+4%**	**-3%**	**+28%**	**+13%**

The Post student interview, like the written assessment, again aimed at asking and measuring students' competence in respects to each of the DOK Levels. Six students were interviewed, two high, middle and low achieving, and their results, shown in table 4, reflected very similar values from the post written assessment for three out of the four DOK Levels. The results indicate argumentation had a positive impact up to a DOK Level 3 but limited if no affect beyond to a DOK Level 4 orally. Of the six students interviewed 100% achieved a DOK Level 1, 83% at DOK Level 2, 83% at DOK Level 3 and 50% at DOK Level 4. If compared to the written post assessment results DOK Levels 1-3 magnitudes are relative. However, compare DOK Level 4 from post written to post interview there is a 31% difference in achievement. If comparing the pre written assessment to the post interview the results actually show a negative growth of 18%. Again indicating argumentation may only have a positive influence on students' up to a DOK 3. Table four summarizes the Depth of Knowledge results found during interviews.

Table 4
Interview Assessment of Students' Understanding of Argumentative Discourse Skills

Depth of Knowledge Component Interview Questions

	Level 1	Level 2	Level 3	Level 4
Student #	What are known values of projectile motion?	Compare the motions of projectile 1, 2 and 3 in the horizontal component.	What conclusion can you make of the states of motion for both the horizontal and vertical components of all three projectiles? Support with evidence.	If Projectile three happened to be on the surface of the Moon, would its overall motion remain the same? Why or why not? If not, construct a new picture of motion that more accurately defines the actual path of motion that would be observed.
1	✓	✓	✓	✓
2	✓	✓	✓	×
3	✓	✓	✓	✓
4	✓	✓	✓	×
5	✓	×	×	×
6	✓	✓	✓	✓
Overall % Achieved	**100%**	**83%**	**83%**	**50%**

Key: ✓= Demonstrates competence × = Did not demonstrate competence (*N*=6)

Effects Argumentation Activities have on Argumentation Skills

Of the three subquestions one logical question to delve into was how does engaging in argumentation effect the overall skills or practice of argumentation. Students were assessed in a similar fashion to that of the primary questions. Of the 32 students assessed four were not included in this analysis because they did not complete the pretest (remove from table).Students work was analyzed and scored in reflection to the Science Argumentation Writing Rubric (Appendix B) that was based off a 4 point scale (proficient, developing, emerging and not evident). There were five components to the students writing that was analyzed: claim, evidence, reasoning, style and organization, and conclusive statement. The results of both the pre and posttreatment assessments can be seen in table 5. It is evident that engaging in argumentation increases argumentation skills as shown by increases across each category.

Table 5
Pretreatment and Posttreament Assessment of Students' Understanding of Argumentative Discourse Skills, (n=29)

	Claim		**Evidence**		**Reasoning**		**Style and organization**		**Conclusive Statement**	
Student #	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
01	1	3	1	3	1	3	1	2	0	3
02	2	3	1	3	1	3	1	3	0	2
03	2	3	1	3	1	3	1	3	0	3
04	2	3	0	3	0	2	0	3	0	2
05	2	3	1	3	1	3	1	2	1	3
06	1	2	0	2	0	2	0	2	0	2
07	2	2	1	2	1	2	1	2	0	2
08	2	3	1	3	1	2	0	3	0	3
09	1	2	0	2	0	2	0	2	0	2
10	1	3	0	2	0	1	0	1	0	1
11	2	3	0	3	0	3	0	3	0	3
12	2	3	1	3	0	3	0	3	0	3
13	1	2	0	3	1	3	0	3	0	3
14	2	3	1	3	1	3	1	3	0	3
15	1	3	1	3	1	3	1	3	2	3
16	2	3	2	3	2	3	2	3	0	3
17	2	3	0	3	1	3	1	3	0	3
18	2	3	0	2	1	3	1	2	0	1
19	2	3	1	3	1	3	1	2	0	1
20	2	3	1	3	1	3	1	2	0	3

21	2	2	1	2	1	2	1	2	0	1
22	2	3	0	3	0	3	0	1	0	1
23	2	3	1	3	0	3	1	2	1	1
24	2	3	2	3	1	3	1	3	1	3
25	2	3	2	3	2	3	1	3	1	3
26	2	3	2	2	1	2	1	2	2	1
27	2	2	2	2	1	2	1	2	1	2
28	1	3	0	2	0	3	1	2	0	2
29	2	3	1	3	1	3	1	2	1	3
Std. Deviation	0.4	0.4	0.7	0.5	0.6	0.5	0.5	0.6	0.6	0.8
Mean	1.8	**2.8**	0.8	2.7	0.8	**2.7**	0.7	**2.4**	0.3	**2.3**
Growth +/-	**1**		**1.9**		**1.9**		**1.7**		**2**	

Key: Pre = Pretreatment, Post = Posttreatment, 3 = Proficient, 2 = Developing, 1 = Emerging, NC = No Count

The first component scored was their ability to state a claim. In order to achieve a level of proficiency students needed to establish a convincing position in relation to the prompt that was logical and distinguishes from alternate or opposing claims. The pre unit assessment recorded zero students being proficient. Students were either categorized as proficient of emerging. Developing, students could establish only a convincing position that answered the prompt but did not distinguish their claim. 22 of the students demonstrated this quality of writing. Leaving 7 students at an emerging level when their claim was either unclear or irrelevant in regards to the prompt. Overall the mean score for the pretreatment assessment for claim was 1.8.

The second component students attempted to demonstrate their skills at providing evidence. To be distinguished as proficient students had to provide accurate and sufficient sources of evidence that fully supported their positions against opposing claims. Again, not one student in the pre demonstrated proficiency. To be developing students only support one position, likely their position neglecting to state the opposing claim, sufficiently. Evidence may not be entirely accurate or linked appropriately. Only five students were at this level of detail in the argumentative writing. If a student was scored emerging then evidence was wrong, repetitive and/or irrelevant. This is where 13 of the students were prior to the treatment unit. Students who did not provide any evidence to support their claim were scored as not evident. Ten student fell into this category. Overall the mean score for the pretreatment assessment for evidence was 0.8.

The third component to be assessed was reasoning. If students were scored as proficient they could formulate a statement that was laden with relevant scientific principals explaining how the evidence supported their claim and also explained how the opposing evidence doesn't. Like the first two components, zero students demonstrated this level of writing. To be considered developing in their writing students had gaps in connecting how exactly the evidence supported their claim or opposing claim. With only two students proving to write be able to write at this level proved reasoning initially to be a challenging task. Students who provided some form of scientific principles but was irrelevant to their claim would be classified as emerging which in the pre assessment has 18 students at this level. If no reasoning of any nature was stated within their writing students received a score of not evident. There were nine students who were scored as not evident. Overall the mean score for reasoning on the pre assessment was 0.8.

Students' argumentative writing was also assessed in terms of their style and organization. Proficiency indicates students organized their writing with a logical structure, complete sentences, transitions and proper grammar. Zero students were scored at a proficient level in their argumentative writing. If students sentence structure started to stray leaving out clear transitions, had minor grammatical errors they likely were scored as developing which only one student achieved. When complete sentence were rarely used, writing had no focus, no transitional sentences and/or lacked clarity then students would be scored at a level of emerging. Emerging is the level where a bulk of the students were scored at with a total amount of 19 students. If students writing lacked all major criteria of style and organization, then like nine students did, they would be scored at not evident. The overall mean value for style and organization for the pre assessment as 0.7.

The last component of argumentative writing students were assessed at was producing a concluding statement. If a student provided a concluding statement confirming their position with a rich understanding of how it all relates then the student would be scored as proficient. On the pre assessment zero student were categorized as proficient. Students who provided a concluding statement but was viewed as too brief then they would be scored as developing. Only two students demonstrated this level of writing. To be scored as emerging in their argumentative writing students wrote a concluding statement but it was irrelevant to their claim. Six students were scored at a level 1 developing. If students did not provide any writing that resembled a concluding statement, like 21 students did, then they were scored at a level 0 not evident. The overall mean score for conclusive statement was the lowest of the five components of argumentative writing at 0.3.

It was clear that by implementing argumentative strategies in both treatment units, where the students were guided through a learning progression and engaged in argumentative discourse within their guided-inquiry labs, that it had a direct impact on student learning from the results of the post treatment assessment. Prior to the treatment units the mean score for all five components of argumentative writing was 0.88. Compare that to after the treatment units were the mean score for all five components of argumentative writing raise up to 2.58. That is a growth increase of 1.7. To break that down by component students increased the mean from 1.8 to 2.8 from pre to post assessment for writing a claim arising to a growth value of 1. For the component of evidence students increased from a 0.8 to 2.7 with a growth value of 1.9. The component of reasoning again saw a positive jump from a mean of 0.7 to 2.7 for another growth value of 1.9. Style and organization also saw an increase in the mean score from a 0.7 to a 2.4 for a growth in mean by 1.7. The greatest growth came in the concluding statement component with an initial mean value of 0.3 going up to a final mean of 2.3 recording a positive 2.0 in growth.

Effects Argumentation has on Students' Attitude and Motivation

The data collected addressing student attitude and motivation showed that the intervention did not have a measureable impact on student attitude and motivation. The majority of the population showed little to no shifts and maintained an overall positive outlook on all responses (Strongly Agree and/or Agree). The shifts recorded were largely small, if any, deviating only one category left or right within the Likert Scale. The pre and posttreatment unit surveys, found in Appendix F and G, asked the same questions except for the addition of question six on the posttreatment survey which included a question specific to argumentative writing. All responses were answered using a Likert scale of: Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. The results of the student responses from both the pre and posttreatment surveys are summarized in table 6.

The first statement asked students to respond to “I like science”. The responses showed no major change in students’ attitude and motivation from the pre and posttreatment. Between responses Strongly Agree and Agree there was only an increase by one student (3%). There was however a 12% shift from pre to posttreatment surveys of the number of students who indicated Neutral changing to a response of Disagree. Overall though 25 of 32 (78%) of the students remained in a state of Strongly Agree or Agree and only the slight shift of four students (12%) from Neutral to Disagree. Statement two, “I like doing science.” saw a large portion of the population maintain a response of Strongly Agree or Agree. With only a loss of 4 student responses overall between the two categories. Neutral recorded no change in response for both the pre and posttreatment remaining with three total. There was an increase from zero to four response (12%) for Disagree and a zero responses for Strongly Disagree between both surveys. Again overall the bulk of the student population, 25 of 32 students (78%) responses remain within Strongly Agree and Agree. Statement three, “I like school.” showed lowest initial responses for Strongly Agree and Agree along with the most negative growth. Strongly Agree originally had 18 responses and Agree originally had five responses for total of 23 out of 32 (71%). The post survey saw the combined total response between Strongly Agree and Agree drop by five response to a total of 19 of 32 students (59%). A shift of 12% between Strongly Agree and Agree may look significant but still a majority of the student population remained positive. Neutral saw a slight increase of student response of 9% while Disagree and Strongly Disagree only increased by 3% in student responses. Overall statement three recorded the most percentage change, however, there was no dramatic deviated shifts in Likert values. Again 19 of 32 (59%) posttreatment responses were still among Strongly Agree and Agree. The fourth statement, “I want to take science classes in the future.” recorded only a 9% change in responses in Strongly Agree and Agree, lowering from a total of 28 to 25 student response between the two. Neutral recorded the largest change of four (12%) going from one to five total responses in the post survey. Disagree and Strongly Disagree decreased by one response (3%) from pre to posttreatment survey. Overall again there was no drastic shifts in responses and 25 of the 32 (78%) responses still remained within Strongly Agree and Agree. The fifth response, “I want to have a science related career in the future.” saw similar results with Strongly Agree and Agree originally having a total of 22 responses drop only 3% to 21 total responses. Neutral recorded zero change with a total of five responses. Disagree and Strongly Disagree increased by only 3% from a total between the two from five to six student responses. Overall 21 of 32 (65%) responses were within Strongly Agree and Agree. Slightly lower overall population density for the two categories but again there were no major deviating shifts observed within the Likert scale. The last response, “I can engage in scientific arguments.” which has no comparison value but the student population distribution values mirrored closely to the other responses with 25 of 32 (78%) students responses within Strongly Agree and Agree, six (19%) Neutral and only one (3%) between Disagree Strongly Disagree.

Table 6
Student Attitude and Motivation Pretreatment and Posttreament Survey, (*N*=32)

	Response				
Statement	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
I like science. (Pre)	10 (31%)	14 (43%)	7 (21%)	0 (0%)	1 (3%)
I like science. (Post)	10 (31%)	15 (46%)	3 (9%)	4 (12%)	0 (0%)
Change in Magnitude (%) Pre-Post	**0 (0%)**	**+1 (+3%)**	**-4 (-12%)**	**+4 (+12%)**	**- 1 (-3%)**
I like doing science.	19 (59%)	10 (31%)	3 (9%)	0 (0%)	0 (0%)
I like doing science.	13 (40%)	12 (38%)	3 (9%)	4 (12%)	0 (0%)
Change in Magnitude (%) Pre-Post	**-6 (-19%)**	**+2 (+6%)**	**0 (0%)**	**+4 (+12%)**	**0 (0%)**
I like school. (Pre)	18 (56%)	5 (15%)	7 (22%)	1 (3%)	1 (3%)
I like school. (Post)	4 (12%)	15 (46%)	10 (31%)	2 (6%)	1 (3%)
Change in Magnitude (%) Pre-Post	**-14 (-44%)**	**+10 (+31%)**	**+3 (+9%)**	**+1 (+3%)**	**0 (0%)**
I want to take science classes in the future. (Pre)	21 (65%)	7 (22%)	1 (3%)	3 (9%)	0 (0%)
I want to take science classes in the future. (Post)	19 (59%)	6 (19%)	5 (15%)	2 (6%)	0 (0%)
Change in Magnitude (%) Pre-Post	**-2 (-6%)**	**-1 (-3%)**	**+4 (+12%)**	**-1 (-3%)**	**0 (0%)**
I want to have a science related career in the future. (Pre)	17 (53%)	5 (15%)	5 (15%)	3 (9%)	2 (6%)
I want to have a science related career in the future. (Post)	10 (31%)	11 (34%)	5 (15%)	6 (19%)	0 (0%)
Change in Magnitude (%) Pre-Post	**-7 (-22%)**	**+6 (+19%)**	**0 (0%)**	**+3 (+9%)**	**-2 (-6%)**
I can engage in scientific arguments. (Post Only)	11 (34%)	14 (43%)	6 (19%)	1 (3%)	0 (0%)
Change in Magnitude (%) Pre-Post	**NA**	**NA**	**NA**	**NA**	**NA**
Key: Pre = Pretreatment, Post = Posttreatment					

Overall the students' attitude and motivation, with the exception of one response, remained fairly positive and overall recorded not drastic deviation in response. An overview of all the statements reports that 78% of the students indicated Strongly Agree or Agree on the pre survey. The posttreatment survey overview only recorded a slight decrease overall of 6% to a total 72% student responses of Strongly Agree and Agree. The same overview of all statements reported only 7% of the students responding to Disagree and Strongly Disagree in the pre survey and increasing only by 3% to 10% in the posttreatment survey. These values again indicate that implementing argumentative strategies has little to no impact on student attitudes and motivation.

INTERPRETATION AND CONCLUSION

The results of this action research was exciting to collect and analyze. The student evidence for my primary question and subquestions provided not only validation of thinking but promoted the development of new questions to drive the next steps in my inquiry of improving instruction and student learning.

What I found most impressive and promising to observe was the magnitude of response (student growth) from the implementation of argumentative discourse in such a short duration of not just students' DOK but also their skills of engaging in writing arguments. The results supporting my primary question of how argumentation effects students DOK clearly showed that an increase in exposure and frequency to higher order thinking will produce significant growth in student achievement of higher order tasks. This echoes the results of a study completed by Chen, Hand and McDowell (2013) who state in their results that the practice of argumentative writing will show considerable gains on tests of their conceptual understanding. My results may mirror that of Chen, Hand and McDowell results, validating that engaging in argumentation will increase students’ conceptual understanding, but their study didn’t discuss how it would affect students’ ability to engage in higher order tasks. So it was shocking after completing the analysis of my results, producing results I was not expecting to observe. I predicted that growth would be more uniform across the DOK levels, which was not the case. Student growth was stagnant within the first two DOK levels and but then significant growth in the latter two DOK levels. After further analysis and reflection of the results of the achievement at each of the DOK levels was fairly logical. Concluding the stagnant growth at DOK 1 and 2 is pretty straight forward. The obvious interpretation was that there was little room for growth and the less obvious there was no new skills sets that students acquired that applied to these cognitive levels. Both the pre and posttreatment units had students engaged in inquiry-based instruction requiring students in not only my opinion, but also the opinion of the NRC's, to demonstrate at or near a mastery of DOK 1 and 2 without the implementation of argumentation. NRC advises the inquiry process is an excellent medium to facilitate a mastery level understanding of concepts for students (NRC Framework, 2012). So to have students demonstrating achievement of 96% and 84% for DOK 1 and 2 is in alignment with interpretation that inquiry skills alone foster quality thinking for DOK 1 and 2. I would have hoped to see an increase or at least sustained a value of 84%. As for DOK levels 3 and 4 I determined that the skills, thinking, and reasoning necessary of a student to demonstrate competence at DOK 3 were very alike to the skills, thinking, and reasoning necessary to engage in argumentation. So logically as students confidence and ability to engage in argumentation increased from the treatment units, than their increased ability to demonstrate achievement at DOK 3 likely increased. DOK 4 showed growth but not at a factor similar to DOK 3. Again to demonstrate achievement at DOK 4, students' must possess the same analytical skills, but now be able to amplify or extend their thinking beyond that of DOK 3. I believe that, evidence of students' work suggests this as well, students were on the verge of demonstrating at a higher cognitive level than the results indicate. I feel that in order to measure students' achievement at DOK 4 correctly, more time is needed for students to adequately perform and demonstrate their cognitive ability and the short duration of the treatment units was not conducive to recording the actual effects implementing argumentation strategies can have.

Equally impressive to students' achievement in DOK, was their ability to show significant growth in their skills of argumentative writing. It is logical and not at all hard believe that as students engage in argumentative writing gains will be made in not only their ability to engage in higher order thinking, but also provide significant gains within the major components of argumentative writing. Such as claims, evidence, reasoning, style, and organization. What is most profound was their ability to gain competence in each of the argumentative writing components in again such a short unit of time. Using a four point rubric and recording and 1.7 point increase overall was impressive again for the short duration of the treatment units. The results of my study parallel closely to the results of several studies I came across in my literature review. Sampson et al. recorded similar results in their study where significant gains were made not only of students DOK but also reflecting similar growth in students' ability to write scientific arguments.

I hope I am not the only one that finds the results of my action research validating from an instructional standpoint. I hope other teachers find the results empowering and motivating to engage and increase efforts of implementing argumentative strategies within their own inquiry-based instruction. Even though I am satisfied with the results, there are several points of interest that leave me questioning to further investigate. I believe, results also indicate this as well, there are still several ways to improve my instruction and increase student learning when it comes to implementing argumentation. As I continue to investigate the dendritic paths within my own inquiry, I will continue to research and identify the variables that will provide the greatest effects on students' DOK.

VALUE

The entire process from identifying my focus question to the conclusion of my results has and will have several implications on my immediate teaching and the upcoming years of service as a teacher. The action research forced me to get an in-depth look of the new NGSS, putting myself in a position ahead in understanding and how to navigate the document before they are in full implementation in 2016-17. It helped hone my knowledge of how to question, collect and analyze both qualitative and quantitative data to track individual student growth. Most importantly it has made me realize that up until recently I have not been pushing or engaging my students to their potential. As a result the action research project has provided evidence that validates best practice, such as argumentation, which will foster higher order thinking, drive students to perform to their potential, and better prepare them to be competitive in the 21st century.

Like I mentioned before, our previous state science standards lacked any explicit expectations of students to engage in any real discourse, let alone engage in what are regarded as best practices like argumentation. My previous instruction provided very limited exposure to higher order activities like strategic or extended thinking where students would have to analyze and/or evaluate information either written or oral. If students happened to engage in such activities, then it likely was unintentional. The positive results or impacts this action research and other studies of similar nature, where student are exposed more frequently to higher order tasks such as argumentation, has on student learning is hard to ignore. But what is not as evident within my results or analysis is the impact engaging orally in argumentation alone had on students' conceptual understanding. If we as teachers do not provide students the opportunity or time to engage in proper discourse then we are effectively stifling what I, and most experts believe, as the most excellent opportunity for learning to take place within the classroom. Throughout many of the informal observations of students engaging orally in argumentation with other peers, presenting their claim, evidence and reasoning, there were several moments of observable paradigm shifts had by students. The shifts in thinking were not a function of reading a text book or listening to direct instruction, they happened as a result of engaging in a simple discussion had with other peers. What likely could have been a classic example of a misconception impeding a student from gaining and demonstrating the necessary conceptual understanding, was flushed out by engaging in argumentative discourse. So a shift in thinking not only from the participants within the discussions, but of the observer myself.

As I retool my instruction to parallel the demands of the NGSS and needs of my students, the results of my action research have stimulated my thinking and will for others who are looking to achieve a more effective and efficient level of instruction.

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APPENDICES

APPENDIX A

PRETREATMENT AND POSTTREATMENTUNIT ARGUMENTATIVE DISCOURSE ASSESSMENT

Please provide your thinking for the following questions	My Thinking
What is the purpose of a Scientific Argument?	
What is a claim?	
What is evidence?	
What is reasoning?	

APPENDIX B

ARGUMENTATIVE SCORING RUBRIC

Science Argumentative Writing Rubric

Write arguments to support claims using valid reason, relevant and sufficient evidence.

Component	Proficient 3	Developing 2	Emerging 1	Not Evident 0
Claim (Takes a Position)	Establishes a convincing claim (position) that's logical and that answers the prompt and distinguished from alternate or opposing claims	Establishes convincing claim (position) that answers the prompt	Claim (position) may be unclear or irrelevant, and/or may not answer prompt	No claim (position) was provided.
Evidence	Provides accurate and sufficient sources of evidence to fully support the stated position. Analyzes the relevance and validity of evidence for and against the stated position.	Some positions are supported more than others. Evidence has minor mistakes and is not explained in detail.	Specific evidence for the claim is not stated. Evidence is wrong, repetitive and/or irrelevant.	No evidence was provided.
Reasoning	Uses scientific knowledge and principles to explain how the evidence supports the claim (and opposing claim if applicable)	Has difficulty linking scientific knowledge and principles to explain how the evidence supports the claim (no mention of opposing claim)	Scientific knowledge and principles are irrelevant to how the evidence supports the claim (no mention of opposing claim)	No reasoning was provided.
Style and Organization	Creates a logical structure with complete sentences and paragraphs. Focus is always on the claim. Grammar is used correctly. Transitions clarify relationships.	Complete sentences are used but informal language is present. Main ideas are clear, but stray from the claim. Some grammatical mistakes are made. Transitions are used but do not connect ideas.	Complete sentences are not used. There is no specific focus. There are major grammatical mistakes. There are no transitions between ideas. There is no clarity in the writing.	Lacked any style or organization.
Concluding Statement	Concluding statement demonstrates understanding of the heart of the argument and presents the reader with insight into why the position on this topic matters.	Introduces the topic, though it may be too brief or distract from the central claim. Concluding statement confirms the writer's position on the topic.	Provides a conclusion that does not connect to the central claim.	No concluding statement.

APPENDIX C

PRETREATMENT UNIT ASSESSMENT SPILLAGE LAB

Spillage

I can: -develop a complete investigation that clearly defines the following prompt: What types of motion effect spillage of water in a cup?

Analysis:

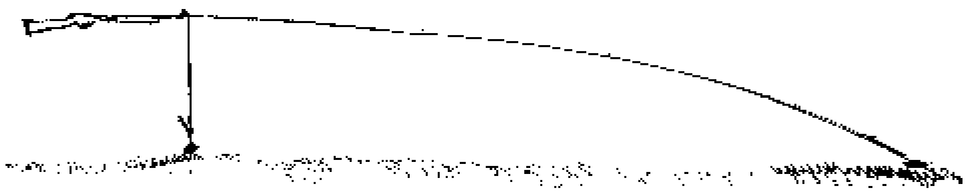
1.) Can you identify what scientific concept is being investigated?
2.) Describe and explain how this investigation demonstrates the above scientific concept.
3.) Create your own POM that is at least 15 seconds long and includes at least one example of each of the following states of motion: ΔDir, constant motion, increase acceleration, decrease acceleration and no motion. Predict on the POM where spillage would occur and state your reasoning.
4.) Identify another scenario from your life experience that this concept applies to. Write a clear explanation of how this concept applies to the scenario.

APPENDIX D

POSTTREATMENT UNIT ASSESSMENT

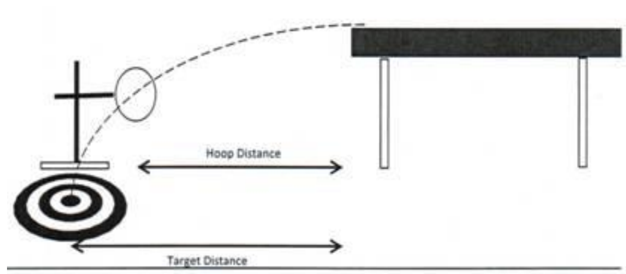
Projectile Through a Hoop Challenge

Pre-Lab Questions:
With two bullets, both starting at the same height of 5 m, one is dropped from rest and the other is shot horizontally with a muzzle velocity of 375m/s. Which bullet will hit the ground first?



1. Identify the scientific concepts that apply to this situation.
2. What similarities and or differences do the motions of the two projectiles have?
3. What evidence supports your statement in questions 1?
4. Complete the lab objective/challenge.

Objective:
I CAN: determine the launch velocity$_x$ of the projectile launcher.



A complete lab write-up includes a Title, an Objective, the Plan, a Data section, and an Analysis. The Plan should include a detailed description of how you are going to solve for the question/objective. The Data section should include a diagram of the experimental setup with measured distances indicated on the diagram. There should be several trials of good d_x data values; units should be indicated. An average d_x value should be reported and subsequently used to calculate the launch velocity. The calculations should be organized and clear, using your <u>problem solving techniques</u>. The Analysis should be a detailed examination of the data collected, clearly defining the calculated values (horizontal and vertical), what the values mean, and state the relationship of the values to actual motion (why is the projectile moving the way it is?).

CHALLENGE:
To predict the position of where a hoop in space will need to be in order for your projectile travel through safely and successfully!

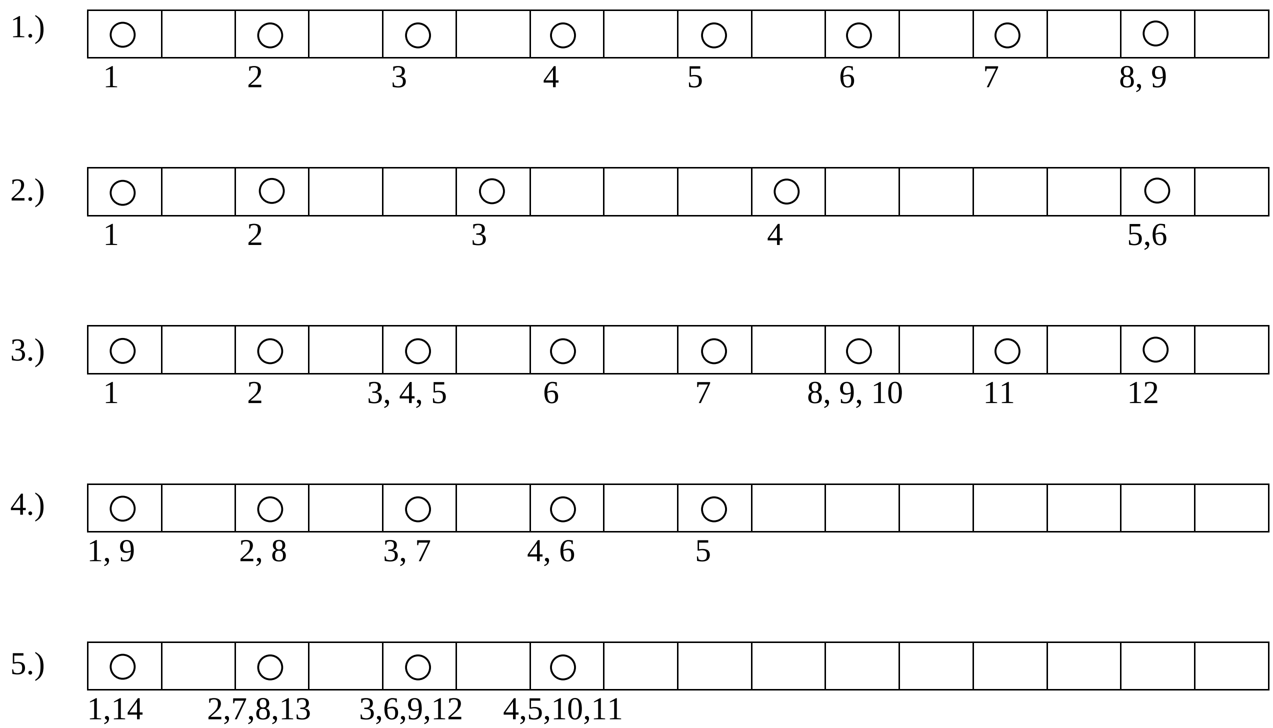
APPENDIX E

POSTTREATMENT UNIT SKILLS INTERVIEW QUESTIONS

Spillage Interview

What effects do “different” types of motion have on the spillage of water in a cup?

1. Identify each of the key components of an argument and define the purpose of each.
2. From the prompt above and PoMs below present an argument.
3. Is there anything else you think I should have asked? Please state and answer.



APPENDIX F

PRETTREATMENT UNIT ATTITUDES AND MOTIVATION SURVEY QUESTIONS

<u>Student Survey</u>

Please put an ‘X’ in the box indicating how much you agree or disagree with each statement.

	Responses				
Statement	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
▪ I like science.					
▪ I like doing science.					
▪ I like school.					
▪ I want to take science classes in the future.					
▪ I want to have a science related career in the future.					

APPENDIX G

POSTTREATMENT UNIT ATTITUDES AND MOTIVATION SURVEY QUESTIONS

Student Survey

Please put an 'X' in the box indicating how much you agree or disagree with each statement.

	Responses				
Statement	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
▪ I like science.					
▪ I like doing science.					
▪ I like school.					
▪ I want to take science classes in the future.					
▪ I want to have a science related career in the future.					
▪ I can engage in scientific arguments					

APPENDIX H

ACTION RESEARCH TIMELINE

Action Research Timeline

January

5th **Nontreatment and Phase 1 Treatment Preunit Assessment**
Student assessment
Student survey
Student observations
Teacher survey

7th **Nontreatment Guided Inquiry (2 weeks)**
Newton's 1st Law of Motion

23rd **Treatment Unit 1 Guided-Inquiry & Intervention (2 weeks)**
Newton's 1st/3rd Laws of Motion
Phase 2 Treatment Unit 1 Intervention
Phase 2 Treatment Unit 1 Intervention
Phase 3 Treatment Unit 1 Intervention
Phase 4 Treatment Unit 1 Intervention
Phase 5 Treatment Unit 1 Intervention
Phase 6 Treatment Unit 1 Intervention

February

4th **Nontreatment and Treatment Unit 1 Postunit assessment**
Skill interview
Student survey
Teacher Survey

6th **Treatment Unit 2 Preunit Assessment**

6th **Treatment Unit 2 Guided Inquiry & Intervention (2 weeks)**
Newton's 3rd/2nd Laws of Motion

20th **Treatment Unit 2 Postunit Assessment**

20th **End Project Implementation—**