THE EFFECT OF MODEL-BASED INQUIRY TEACHING ON STUDENT ENGAGEMENT, AND THE NGSS SCIENCE PRACTICES IN HIGH SCHOOL BIOLOGY

by

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DEDICATION

This capstone is dedicated to my wife Tara who pushes and helps me be the best teacher that I can be. To my parents who have supported my academic journeys in so many ways. To Well Fed Farms for supplying great food and conversation on this journey. To my students past, present and future, thank you for learning with me. To my colleagues, thank you for joining me on this ambitious journey. Special thanks to Walter Woobaugh for his help with project design, Nancy Burritt for her help with finalizing this project, and Scott Conlan for his support and leadership in implementing Ambitious Science teaching.

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ABSTRACT

The Next Generation Science Standards (NGSS) have raised the bar of science education for teachers and students. The three stranded format of Disciplinary Core Ideas, Crosscutting Concepts, and Science Practices will require students to think and engage more deeply in the process of science. Achieving these rigorous standards for all students will require a greater level of motivation and engagement than I currently have in my classes. The purpose of this study is to investigate how model-based inquiry teaching, based on the framework of Ambitious Science Teaching, increases student motivation and engagement as well as how this framework improves student skills with the NGSS science practices.

A model-based inquiry approach to science teaching emphasizes the skills and practices of scientists. During the treatment, students made an initial model to try to explain a scientific phenomenon. Classroom discourse and experiences formed the foundation of instruction, which was then used by students to revise their models.

Data was collected through student surveys, and direct observations of student engagement and classroom discourse. Additionally, data was collected on students' ability to support a claim with evidence and reasoning. The results show that the treatment promoted engagement and that student skills in discourse and argumentation increased. However, students' perception of their motivation and engagement did not change with continued treatment. This study shows that model-based inquiry has significant value for students who have historic academic struggles as it moves science beyond the rote memorization that they struggle with, to explaining what is happening based on experimental evidence and personal experience.

INTRODUCTION AND BACKGROUND

The Next Generation Science Standards (NGSS) have raised the bar of science education for teachers and students. The three strand format of Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices will require students to think and engage more deeply in the process of science. Achieving these rigorous standards for all students will require a greater level of motivation and engagement than I currently have in my classes.

Throughout my teaching career I have had roughly 20% of my students who lacked the engagement and motivation necessary to be successful in biology. While most of my students are motivated by some combination of intrinsic motivation, grade motivation or interest in the subject, approximately 20- 30% of my students lack a reason to engage in the material of biology. I have tried various strategies, such as interactive notebooks and incorporating bioethics all without success for this sub-group of students. Despite my various efforts these students have remained unengaged, and content with grades of D's to C's even though these students are capable of much better work.

The purpose of this study is to investigate how model-based inquiry teaching, based on the framework of Ambitious Science Teaching (AST), increases student motivation and engagement, particularly for this subset of students. I also hope to determine how this framework improves student skills with the NGSS science practices. I hope that this will lead to increased student interest in science for all students as well a desire to deeply understand a phenomenon and the scientific concepts behind it. The primary focus of this action research project is to answer the question, "How will the

AST framework of using a puzzling scientific phenomena and evidence-based explanations to frame a unit of study increase student motivation and engagement in biology?" My secondary questions are: In what ways will students' discourse skills improve? How will students' abilities to provide evidence and reasoning for their ideas change? And how will teacher perception of AST and science teaching change?

Washington State has been a leader in the development and implementation of the NGSS. As such, it is also at the forefront in figuring out the difficult task of how to incorporate and integrate the three dimensions into daily teaching. The University of Washington College of Education has spearheaded the AST project, with the enthusiastic backing of the Washington State Office of the Superintendent of Public Instruction. This model-based inquiry framework is a research supported way to meet the challenge of the NGSS. My research, will provide additional data for this model as it begins to find its way into classrooms throughout the state. In addition, it will support my school district's initiative to meet the NGSS by using the AST Framework, and provide an example for my colleagues to learn from.

CONCEPTUAL FRAMEWORK

Theoretical Framework

For over a century, the logical steps of the scientific method have been the de facto way of teaching the process of science. This shallow and uncritical approach has long had its detractors, but invariably it has been passed on from one generation of science teacher to the next. A new vision of science, and science education, is needed for students to see and comprehend the depth and nature of scientific knowledge (Windschitl, Thompson, & Braaten, 2008). The model-based inquiry approach as described in the AST framework offers a way to realize this vision. This framework is the product of the work of Windschitl, Thompson, Braaten, & Stroupe. Their goal was to apply the literature on effective science teaching and learning for the NGSS to produce a teaching framework that is grounded in research, and develops the skills and dispositions necessary for students to engage in the process of scientific inquiry (2008).

The theoretical underpinnings of AST are founded on a model-based inquiry approach. This approach to science teaching emphasizes the skills and practices of scientists, specifically that scientists, “engage in inquiry other than controlled experiments, use existing models in their inquiries, engage in inquiry that leads to revised models, use models to construct explanations, use models to unify their understanding, and engage in argumentation” (Passmore, Stewart, & Cartier, 2009, p.394).

An observational study of 22 chemistry undergraduate students in a model-based inquiry classroom showed a consistent pattern of teacher-student interactions throughout the course where students generated, evaluated, and modified their hypotheses. The outcomes of this pattern were that students were able to construct richer models of molecular structures, and an increased engagement with the inquiry process (Khan, 2007). This shows that the key elements of AST lead not only to an increase in content knowledge, but also to improved skills and engagement with the NGSS practices.

Additionally, White and Frederiksen in a study of nearly 360 seventh through ninth graders, found instruction that focused on the skills of inquiry with a goal of developing a conceptual model of a scientific idea improved, “students' learning of science concepts, laws, and models as well as their ability to use them in analyzing new situations" (p. 74). They hypothesized that science knowledge is better developed through inquiry and modeling (1998). Building on this research, AST makes this well-developed scientific knowledge more useful to students as it places all the learning within the specific meaningful context of the phenomenon.

Discourse about methods, models and data is a vital part of the scientific process. As such, it is a vital part of AST's model-based inquiry approach. A case study of 31 physics students looked at a specific discourse move called the reflective toss. The reflective toss gives students responsibility for their thinking. The goal is for the teacher to catch the meaning of what the student is saying and toss the responsibility for the thinking behind it back to the class. It usually takes the form of a student statement followed by a teacher question and concluded by another student statement. For example, a student says, "Our traits come from our parents." The teacher responds, "So traits like eye color and hair color come from our parents, but how do we know this?" The student would then respond with a more in-depth answer or an attempt to make sense of what she knows. The study showed that the reflective toss puts students in a position to ask questions, which shows that students are engaged and working to make sense of the topic (Van Zee & Minstrell, 1997b). This study provides a clear starting point on how to guide classroom discourse during my action research. In addition, it emphasizes the important role the teacher's questioning plays in guiding and deepening student thinking.

In a comprehensive review of the literature on teacher-student discourse Scott concludes that when it comes to sense-making activities, the way teachers talk about the activity is as important, and sometimes more important, than the activity itself (1998). Through the discursive process, the concept of learning science becomes a matter of learning to “talk science.” To accomplish the goal of having students talk science, the teacher must work to create a dialogic discourse instead of an authoritative discourse. This dialogic discourse is characterized by multiple students contributing ideas to an open- ended discussion. The teacher’s role in this is to encourage thought and debate, by asking for multiple ideas and perspectives. Through dialogic discourse, students are engaged in talking science and are required to make sense of the content they are learning. This promotes a deeper level of understanding and the use of high-order science skills (Scott, 1998). Engaging students in scientific discourse is a primary component of my action research. This research provides a way to analyze and measure the type of discourse that I use in my classes.

Studies that Inform Research Methodologies

The goal of measuring engagement is to determine to what extent students are actively involved in a learning activity (Christenson, Reschly, & Wylie, 2012). Student engagement is a very broad concept that contains many subcomponents. Reeve outlines four dimensions of engagement; behavioral, emotional, cognitive and agentic (2013). Behavioral engagement is a measure of the student’s involvement in the activity. In particular it measures attention, effort, and persistence. Positive emotional engagement is characterized by the presence of emotions like interest and curiosity and a lack of negative emotions like anxiety. Cognitive engagement measures the sophistication of the student’s learning strategies, such as prioritizing tasks like elaboration over tasks like memorization. Finally, agentic engagement is described as how a student positively contributes to the flow of an activity or lesson. This agentic engagement can take the form of a student asking questions, sharing what they are interested in, or making suggestions on how to improve the class (Reeve, 2013). This work of Reeve led to the development of the engagement questions I used in my student survey.

In addition to engagement, I also wanted to learn about the motivation of my students. Glyn et al. (2011) define science motivation, “as an internal state that arouses, directs, and sustains science-learning behavior” (p 1160). Their work shows how the self-efficacy component of motivation is a good predictor of a student’s success in a science classroom. Self-efficacy is a student’s belief that they can achieve success. There are multiple components of motivation beyond self-efficacy that Glyn et al describe. These include intrinsic motivation, which is satisfaction in learning for its own sake, and self-determination which is a student’s belief that they have control over their own learning. The final component of motivation is extrinsic motivation, where a student is compelled to success by outside forces such as grades or a career. They recommend giving a motivation survey at the beginning of a course to identify students with low motivation so the teacher can follow up with these students to provide strategies to increase motivation and success (2011). To that end they developed the Science Motivation Questionnaire II which I used in my student survey.

METHODOLOGY

Treatment

The AST model is designed around four sequential steps. The first is engaging students with a puzzling phenomenon. Ideally this phenomenon will be broad enough that it can span an entire unit, and complex enough that it cannot be answered with an internet search. The second step elicits a student's initial ideas about the cause of the phenomena. These ideas are written or drawn and serve as a reference throughout the unit. The third step will be supporting students in on-going changes in thinking. This occurs through various forms that could include direct instruction, discourse, sense-making activities, labs, data analysis, and revisions of the initial ideas. The final step presses students for evidence-based explanations of the phenomenon. This engages students in authentic scientific discourse around multiple lines of evidence.

For the treatment, all units of study were taught using the framework and vision of AST, which is described below:

> The ambitious teacher is someone who 'works with students' ideas' over time. What would you experience in classrooms where ambitious teaching was the focus? You would see and hear:
>
> - Teachers anchoring their instruction in complex and puzzling natural events
> - Students engaging in multiple rounds of creating and revising scientific models, explanations and evidence-based arguments
> - Teachers using a variety of discourse strategies with students to get them to think deeply and to respond to each other's thinking
> - Students prompting each other to engage in sense-making talk during investigations and other activities
> - Students' ideas being represented publicly and worked on by the class
> - Teachers using specialized tools and routines to support students who are not willing or able to participate without help
> - Students speaking up about what information or experiences they need to move their thinking forward (AST, 2016, Get Started section, n.p.)

An example of this was my first AST unit that focused on ecology and analyzed the phenomenon of why the southern resident orca population in the Salish Sea had not grown, despite 10 years of recovery efforts after being listed as an endangered species. The unit started with an introductory video and article about this population, focusing on the death of a pregnant orca, J32. After these activities, students wrote down and shared observations and questions they had. The next step was for students to make an initial model to explain why J32 died. This model guided students to communicate what factors would contribute to a healthy population of orcas, and what could cause a population of orcas to be unhealthy. The following lessons and activities included a web quest to learn more about the Salish Sea and its inhabitants. Analyzing and constructing the orcas' food web, reading an article about PCB poisoning in orcas, playing a game, to model bioaccumulation and the effects of boat noise on echolocation. Finally, we analyzed the preliminary necropsy report for the orca J32. After each of these activities we worked as a class to complete a summary table. The summary table included what we observed and learned from each activity and how it helps to explain the phenomenon of why J32 died. The goal of the summary table was for students to share their ideas and engage in discourse to help them synthesize and connect what they learned in regards to the phenomenon. At the conclusion of the unit, students revisited and revised their initial models to better explain this phenomenon. This unit ran for 6 weeks, while the other treatment units took an average of 4 weeks to complete.

Data Collection Methods

In this study I used four instruments to collect data. The relationship of each instrument to the research questions is summarized in Table 1.

Table 1
Data Triangulation Matrix

	Instruments				
Research Question	At Task Observation Instrument	Peer Evaluation of Discourse	Student Survey	Claim, Evidence, Reasoning Rubric	Teacher Notes
Main Question How will the Ambitious Science Teaching framework of using a puzzling scientific phenomena and evidence based explanations to frame a unit of study increase student motivation and engagement in biology?	1,2,4	1,4	1,2,3 4		
Sub-question #1 In what ways will students' discourse skills improve?	1	1,4	3	2,4	
Sub-question #2 How will students' abilities to provide evidence and reasoning for their ideas change?	1	1,4	3	2	
Sub-question #3 How will teacher perception of AST and Science teaching change?					1, 4

Key used to identify the reasons why the data method selected is suited to gather data for the question it is matched to.

1. Will give qualitative data.
2. Will give quantitative data.
3. Data will show detailed student opinions and perceptions.
4. Will show baseline data and progress during the treatment.

The sample for this study are the teacher's five general biology classes (N=106) at Sedro-Woolley High School. These five classes are a mix of 9th and 10th grade students. The high school has approximately 1,200 students, 76% are white, 16% Hispanic. The remaining students are a mix of Black, Asian, and American Indian (OSPI, 2016). The classes that were a part of this study follow the school's demographic trends. In addition, there are eight English Language Learners in these classes. Sedro-Woolley is a rural community with a wide range of socio-economic status, 41% of students qualify for free and reduced lunch. Students range from upper middle class to below the poverty line and experiencing homelessness.

The student survey was a compilation of the Science Motivation Questionnaire II (Glyn et al., 2011) (See Appendix A) and Reeve's multidimensional engagement questionnaire (2013) (See Appendix B). These two questionnaires were combined into a single Google Form survey that was administered during the second AST unit, and at the end of the 5th AST unit. All classes completed the survey, however due to absences, the total number of students who completed the initial survey was 89, while 86 students completed the final survey. The motivation portion of the survey was composed of 25 Likert questions to assess five components of motivation; Intrinsic Motivation, Self-Efficacy, Self-Determination, Grade Motivation, and Career Motivation. The engagement portion of the survey contained 22 Likert items to assess four dimensions of engagement; Behavioral Engagement, Agentic Engagement, Cognitive Engagement, and Emotional Engagement. The survey concluded with three open response questions; What activities have helped you learn the most in biology?" "Why have these activities been helpful to you?" "What has been your favorite part of biology this year?" The validity and reliability of this survey is established by the extensive work of Glyn et al. in 2011 and Reeve in 2013.

The Claim Evidence Reasoning (CER) rubric was based on the work of Rewitz (n.d.) and the Scientific Explanation Rubric from McNeil (2009) (See Appendix C). The teacher then modified the rubric to clarify the evidence expectations. This instrument was administered in the first, second, fourth and fifth AST units. Students were given a scenario, then asked to make a claim to explain the scenario, and to defend their claim with evidence and reasoning. Their responses were then evaluated by the teacher using the CER rubric. During the first two implementations of this assessment 93 students completed the prompt. For the third implementation, 75 students completed the prompt, while 79 students completed the fourth and final prompt. The validity of this instrument comes from the work of McNeil on measuring student explanations and argumentation. The reliability comes from the teacher being the evaluator of all work, and using similarly structured prompts for each implementation of the instrument.

The At Task Observation instrument was adapted from the work of Morgan (2008) (See Appendix D). This tool was selected as a systematic way to gather objective data on how well students use class time during foundational AST activities such as introducing and discussing a phenomenon. Data was collected from all classes at the beginning of the sixth AST unit to get a final picture of student engagement. This instrument was implemented during a standard lesson of notes and practice, as well as during an AST style lesson where students were introduced to a new phenomenon, discussed their observations and questions as a class, and made an initial model to explain their current ideas. To ensure reliability, I conducted all of the observations and did each ‘sweep’ roughly every five minutes. The validity of systematic direct observation as a tool to measure classroom behaviors is supported by numerous research studies (Morgan, 2008).

> The observation tool was used to manually record data concerning appropriate at-task student behaviors reflecting student engagement and specified off-task behaviors during classroom lessons. The observation instrument included space to record at/off-task behaviors for each student using momentary time-sampling at five minute intervals during each class period. At each sweep of the classroom, a coding symbol designating at-task or a specific off-task behavior was recorded for each subject. Conventional engagement behaviors, including listening to instructions, participating in the class activity, looking at the teacher or board, following directions, and seeking help properly were categorized as at-task. Off-task behaviors which were tallied included being turned around in the seat, making noises/faces, doing schoolwork other than assignment, stalling (daydreaming, doodling, looking out the window, digging through purse or backpack), out of seat, head down, or talking out off-topic (Morgan 2008, p. 41).

One modification I made to this instrument was that I did not note the type of off-task behavior, I only recorded if a student was on-task, or off-task. In my analysis of this data, I looked at the whole class picture of engagement and did not look for outlier students.

The Peer Observation of Discourse instrument was designed by the teacher (See Appendix E). Its purpose was to collect data on specific types of discourse that students use. In addition, it provides for three overall scores for the participant; a participation score, a self-assessment score, and an engagement score. It was administered in the first, fourth, and fifth AST units. For each unit it was administered over two different discussions. In the first discussion, half of the class participated in the discussion, and the other half observed them. The roles were then reversed for the second discussion so all students participated. During these discussions the class discussed what they observed and learned in the activity, and how it connected to the phenomenon they were studying. All classes participated in the implementation of this instrument, however only 24 students participated in all three discussions. The data for this instrument comes from the 24 students who participated in all 3 rounds of discussion. An analysis of the entire data for this instrument showed no clear trends, but when I analyzed the data for only the 24 students who completed all three rounds to control for variation between students, a pattern of growth became much clearer. The validity of this instrument was increased through several iterations of class discussion and rubric revision, prior to the first implementation, until I felt the rubric accurately measured the aspects of discourse that I was looking for. The maximum participant score was capped at 15, as students who scored 15 or higher demonstrated the highest level of participation, and scores over 15 skewed the average.

The final data that was collected was notes that I wrote over the course of the year. These notes consisted of reflections on and anecdotes of teaching using the AST framework. I recorded these perceptions and thoughts one to two times during each unit.

The research methodology used during this Action Research project received an exemption by Montana State University's Institutional Review Board (IRB) on November 17, 2016 and compliance for working with human subjects was maintained (see Appendix F).

DATA AND ANALYSIS

Engagement and Motivation

The data is conflicted for my primary research question, “How will the AST framework of using a puzzling scientific phenomena and evidence based explanations to frame a unit of study increase student motivation and engagement in biology?” The results of the student survey indicate student motivation and engagement did not show a significant increase after the first two units of AST (see Figure 1). The initial survey was given 8 weeks into the school year, after the implementation of two units designed around the AST framework. The final survey was given in mid-March after the completion of the fifth AST unit. While initially there were low levels of disengagement, 6% of responses indicated behavioral disengagement, and 20% of responses indicated Agentic, Cognitive, and 19% Emotional disengagement. The final survey showed that amount of disengagement changed very little with continued implementation of the AST framework..

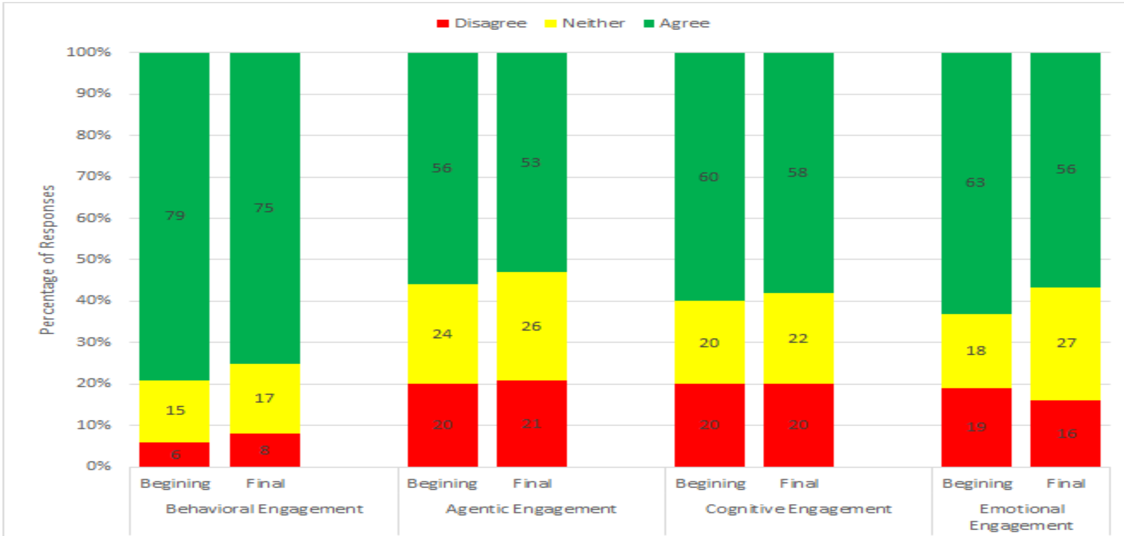

Figure 1. Student engagement survey results, (*N*=86).

Additionally, the number of responses that indicate a lack of motivation, while low at the beginning, 16% for Intrinsic motivation, 10% for Self-Efficacy, and 17% for Self Determination did not show a meaningful change from continued implementation of the AST framework (see Figure 2).

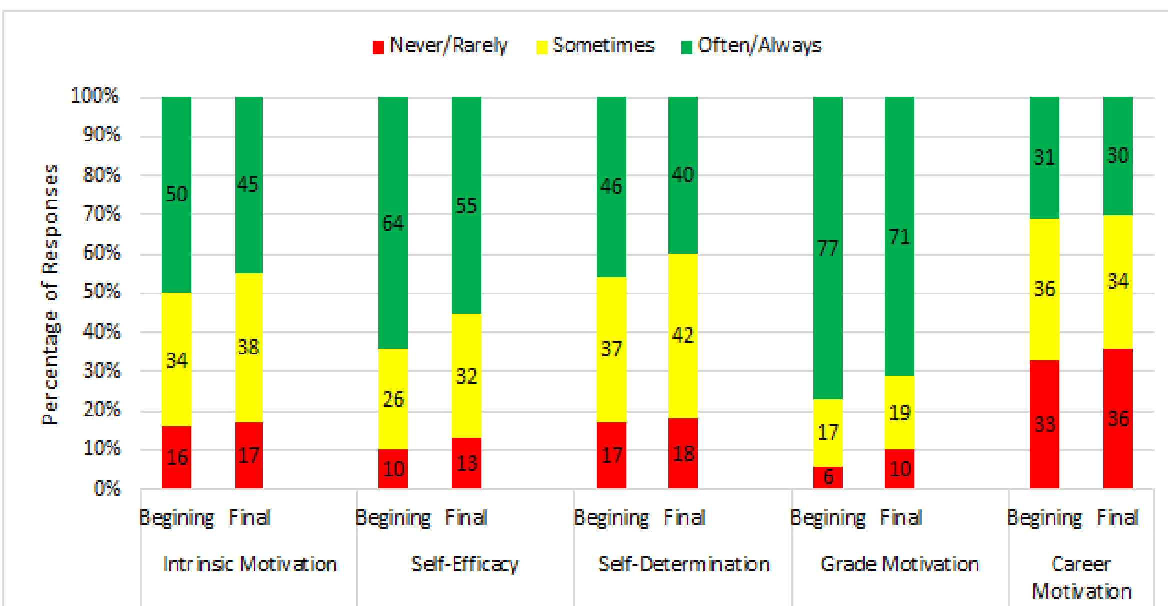

Figure 2. Student motivation survey results, *(N*=86).

While the survey did not show a change in student engagement and motivation, open response questions show that key elements of the AST framework are helping students learn, and are some of their favorite things about the class. When asked, the questions, “What activities have helped you learn the most in biology? Why have these activities been helpful to you?” Several responses included; “Doing experiments with partners,”, “You can learn from others and get a visual of what we are learning about.”, and “discussions with the whole class, it’s more broken down into simpler explanations.” These responses are summarized in Figure 3. It is notable that 70% of the responses of what has helped students learn the most; a phenomenon that is the focus of the unit, observation, experiments that are the foundation for sense-making activities, and discussion that helps students process their learning, are essential features of AST. The remaining 30% of responses to this prompt state that notes or some other feature of the class are what helps them learn best.

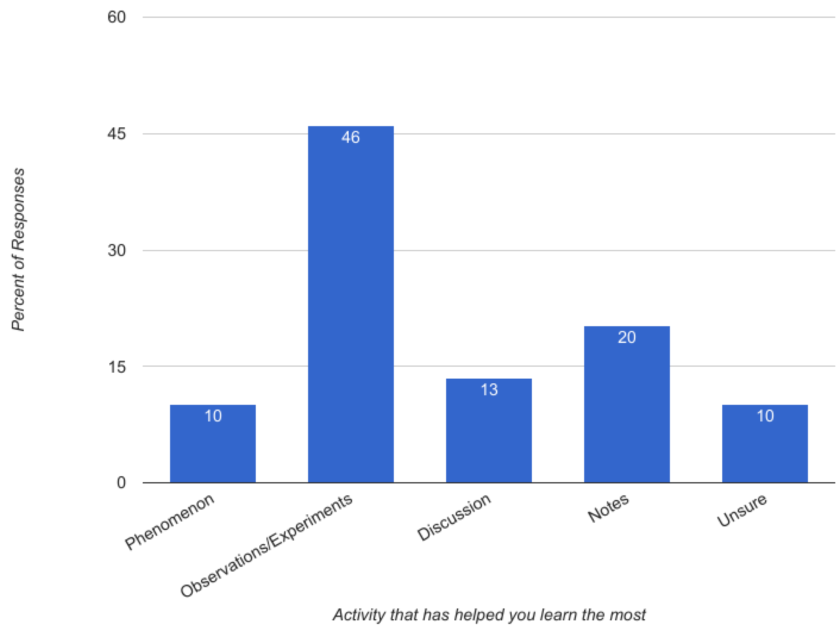

Figure 3. Student survey responses: What activities have helped you learn the most in biology? (*N*=86).

Not only have students found that the elements of the AST framework helped them learn, its key features are what students enjoy most about the class. Student responses to the question, "What has been your favorite part of biology this year?" include, "Probably the southern resident killer whales.", "The enzyme lab.", and "Learning about cells and the way the body processes different substances." These responses, 66% of the total, indicate that the key elements of AST, a phenomenon, experiments and hand-on activities, and deeply understanding a concept, are their favorite part of biology (see Figure 4). A further 15% of students said the teacher, or the classroom community are their favorite part of biology, "The people and the teacher!!" I attribute these responses to the highly interactive nature of AST where students are frequently interacting with the teacher and their peers to make sense of what they are learning.

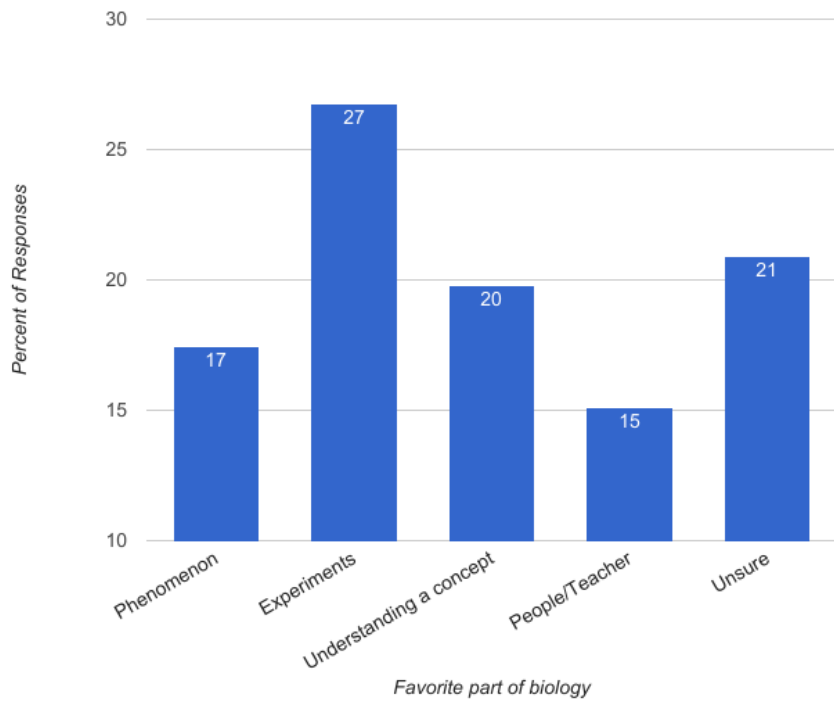

Figure 4. Student survey responses: What has been your favorite part of Biology this year? (*N*=86).

The Peer-Observation of Discourse instrument engagement scores show that student engagement in class discussions increased with continued implementation of the AST Framework, (see Figure 5). The initial average engagement score, as measured by their observing partner was 3.33 indicating that students were engaged in the discussion 60-70% of the time. After the final discussion, the average engagement score had risen to 4.71 showing that students were engaged in the discussion over 90% of the time. Initially, when observers were evaluating their participants engagement they tended to score the participant's engagement based on their contributions to the discussion, but when I asked the observer if their participant was paying attention and following the discussion, their responses were typically, "Yeah, he paid attention, but he didn't say anything.", or "I could tell she was thinking a lot about what was being said." This further confirms that engagement increased.

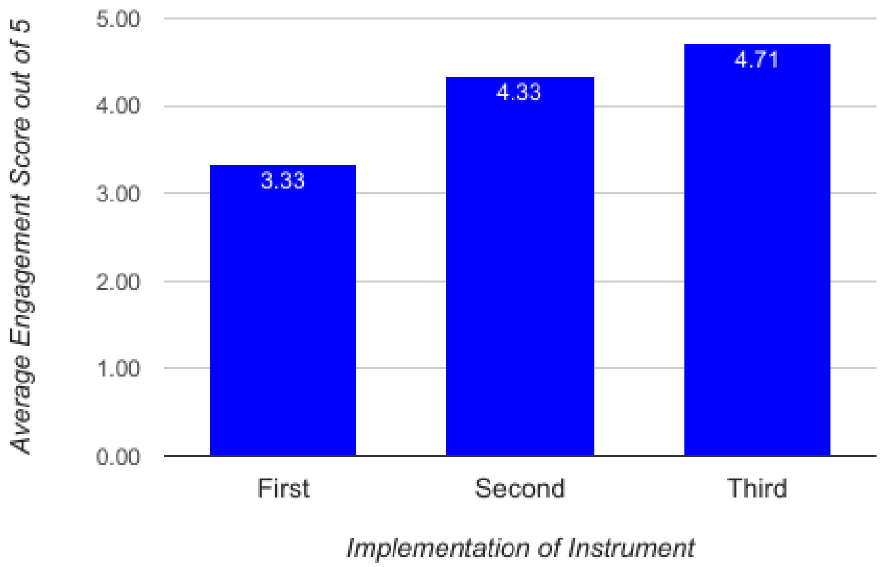

Figure 5. Peer observation of discourse instrument. average engagement score, (*N*=24).

Finally, the At-Task Observation instrument shows that there is an incredibly high level of engagement during foundational AST activities (see Figure 6). During a standard lesson of notes and practice, students were on-task 73.7% of the time. While during a lesson to introduce a phenomenon, discussing student ideas as a class, and constructing initial models, they were on-task over 93% of the time. This demonstrates that individual lessons based on the AST framework significantly improve student engagement. As the

AST framed lesson for this data was from the beginning of a unit, this initial engagement can only help student engagement for the remainder of the unit, especially considering that most of the activities in the unit are contextualized and referenced back to this initial lesson.

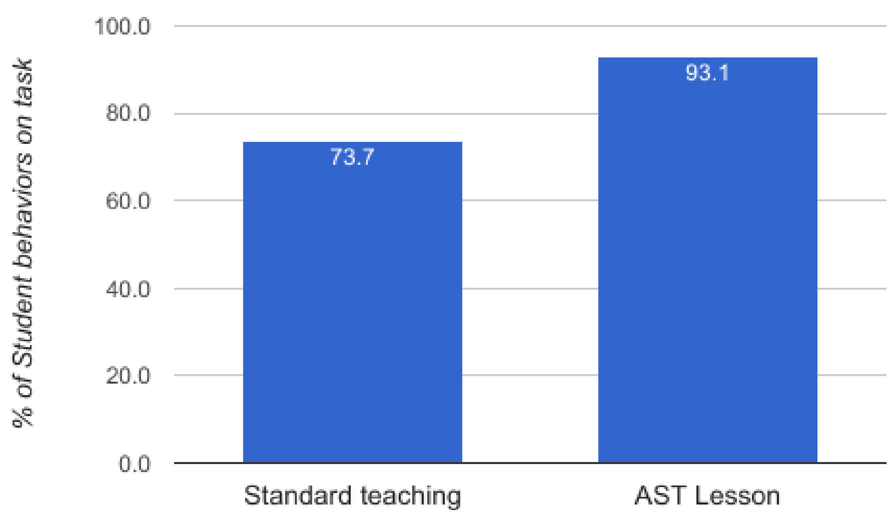

Figure 6. At-task observation instrument - percentage of on task behaviors, (*N*=89).

<u>Student Discourse</u>

Implementation of the AST Framework had a positive impact on students' discourse skills. The participation scores from the Peer Observation of Discourse Instrument indicate that over time students who participated in all three implementations of this instrument increased their median score from 2 to 5, (see Figure 7). This shows that students increased their number and or quality of their participations by either contributing more frequently or including more sophisticated elements to their contributions such as providing evidence or referencing a text.

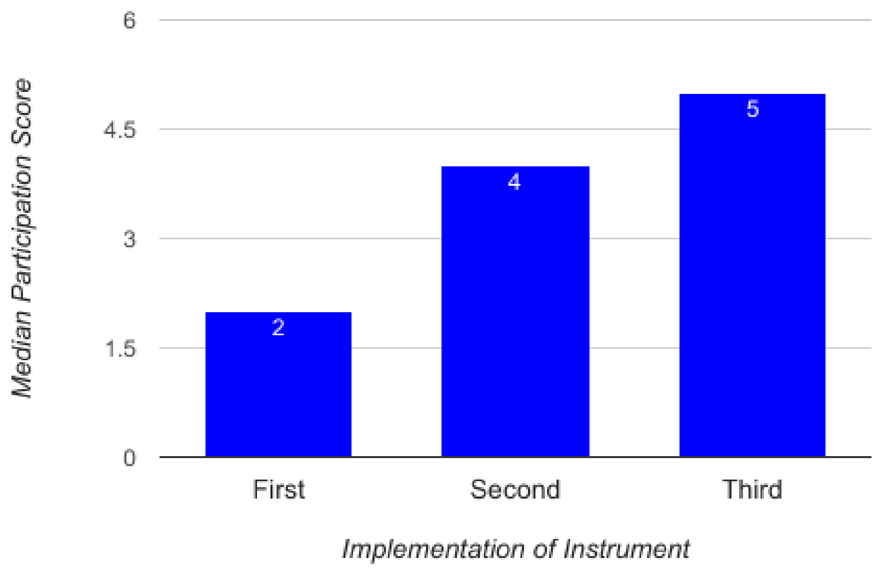

Figure 7. Peer observation of discourse instrument - median participation score, (*N*=24).

A contributing factor to this improvement was supporting students in scientific discourse by providing scaffolding in the form of sentence starters. These sentence starters, which were developed by the class at the beginning of the year, helped students communicate their ideas. Examples of sentence starters include, "Where did you get your evidence for________________," and, "I would like to add onto ______'s idea,_____________." As we went through multiple rounds of discussions, students became more comfortable with using sentence starters, and I observed that they used them more frequently in the final discussion. This led to a second observation that I made which is that the final discussion was the most successful discussion in terms of flow and depth.

Additionally, the self-assessment scores from the Peer Observation of Discourse Instrument indicate that students feel more confident in their ability to participate and engage in classroom discourse, (see Figure 8). The average self-assessment score initially was 2.39 showing that students felt they were "emerging participants." By the end of the treatment the average score had grown to 2.83, indicating that students felt like they were getting closer to being a "Satisfactory participant." In calculating these averages, I removed the final self-assessment scores of three students who missed the majority of this unit, and therefore did not feel confident in their ability to contribute to this discussion. As with the date on participation in discussions, continued use of the sentence starters and practice of these discourse skills in nearly every class helped students feel more comfortable in contributing to class discussions. Participating in the talk of science is a new skill for these students. As such, it took them nearly ¾ of a year to get comfortable with the language and purpose of this type of classroom talk. With our middle school also implementing AST, in future years students should be arriving in biology with more comfort and skills in contributing to scientific discussion.

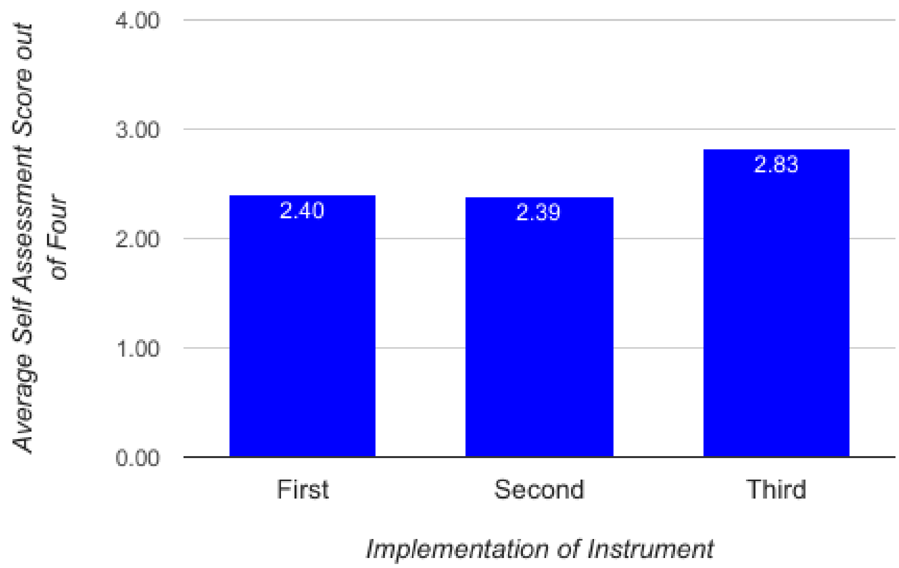

Figure 8. Peer observation of discourse instrument - average self-assessment score, (*N*=24).

<u>Claim Evidence and Reasoning</u>

The results of Claim Evidence Reasoning assessments show that students made significant gains in their ability to construct a claim, provide valid evidence for their claim, and use reasoning to support their claim, (see Figure 9). In particular, the average Evidence and Reasoning scores from the first implementation were 5 and 5.4, while the final Evidence and reasoning scores were 10.7 and 13, showing students made significant gains in these areas.

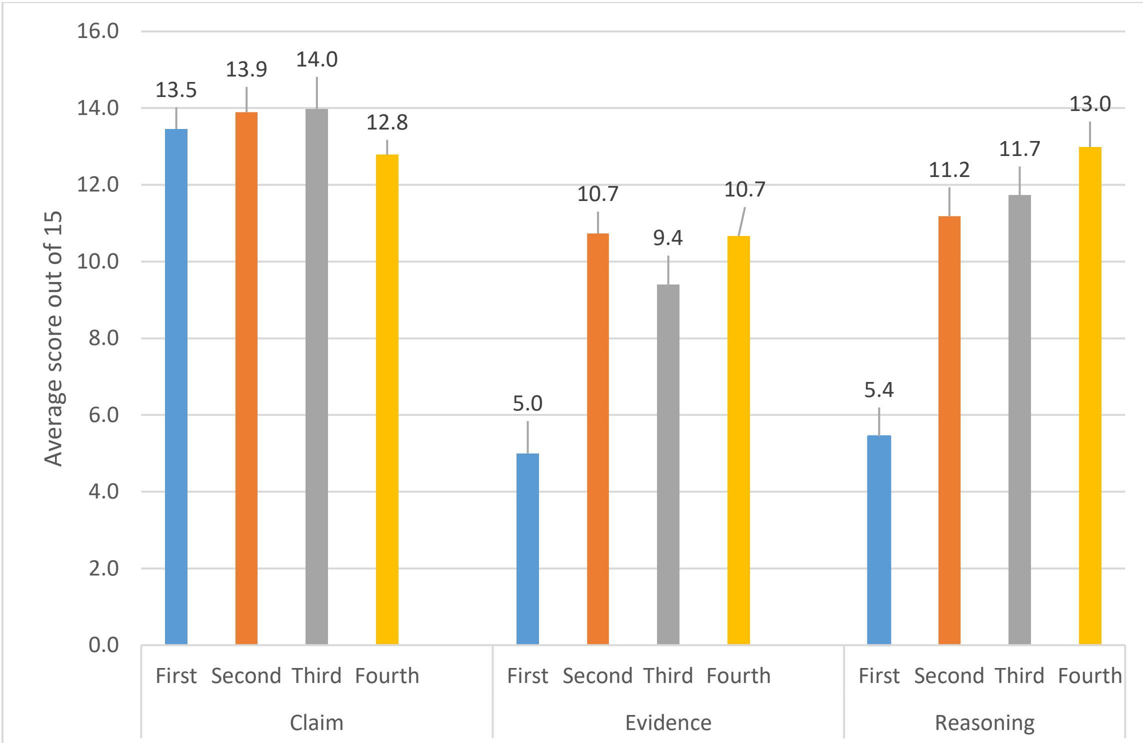

Figure 9. Claim evidence reasoning scores, (*N*=85).

The claim scores stayed relatively stable over the four assessments, showing that most students have mastered this skill. The drop to the lowest score of 12.8 out of 15 on the fourth Claim Evidence Reasoning prompt was due to the prompting question requiring application of specific content to a new situation to construct the claim, whereas previous claims only required students to propose an idea or possible solution.

Students' growth in their ability to use evidence is illustrated by the evidence they provided. In the first assessment, typical evidence, if it was given, is represented by the following quote, which attempts to provide evidence for why the orca J32 died, "She ate chinook salmon which had PCBs." This response uses only one piece of partially correct evidence. Additionally, the student doesn't reference the source of the evidence. By the final assessment students were much more skilled at providing evidence as shown by this evidence for why too much fertilizer can kill a plant, “Just like how the egg shriveled when it was put in sugar-water. The water left the inside of the egg in an attempt to create the equilibrium. Also, how the plant we put in sugar-water shriveled up because it was in a hypertonic solution which made the water leave the plant in an attempt at equilibrium.” This student used two pieces of correct evidence, which came from a common classroom experience. This growth in the amount and substance of evidence that students provided demonstrates the effectiveness of AST in increasing student ability in providing evidence to support a claim.

Additionally, data on student’s ability to use evidence and reasoning from the Peer-Observation Instrument show that there was a modest increase in the use of evidence and reasoning during classroom discussions (see Figure 10). During the first round of 10-15 minute discussions, students used evidence an average of 0.46 times per discussion and used reasoning an average of 0.62 per discussion. By the final discussion, several months later, students used evidence an average of 1.04 times per discussion and used reasoning an average of 1.08 times per discussion. This shows that their increased ability to use evidence was not limited to only paper responses, but that this skill was applied to verbal class discussions.

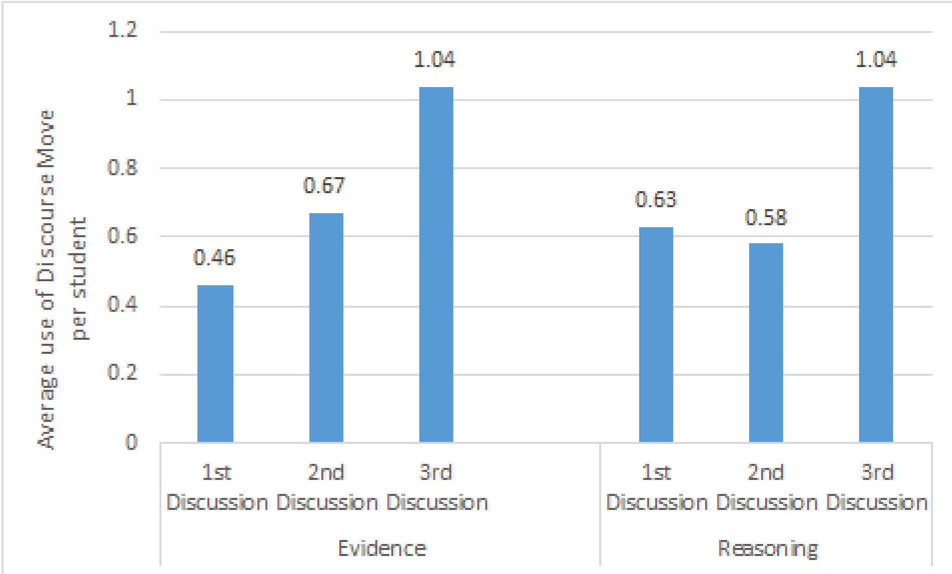

Figure 10. Student use of evidence and reasoning in discussion, (*N*=24).

<u>Teacher Perception</u>

Throughout the year, I took notes on my thoughts and perceptions of teaching with the AST framework (see Table 2). At the beginning of the year, I was excited by the potential that this framework had, "This has great potential!" Additionally, I was impressed by how typically low achieving students were now achieving success in biology. However, I was also aware of the amount of work this required in the first year. By the middle of the year, I was struggling to make headway in advancing student skills in modeling and discourse. Of note were my struggles with getting students to make sense of and scientifically explain an observation, "Sense making is tough - How did they learn anything before this??? They struggle to pull the meaning/significance out of labs and activities". Experiments that I had done in the past, I still did this year, but I tried to get the students to explain the significance and reasons for their results. This was very challenging, but it also revealed how previously I had thought students fully understood these examples when they actually had not.

At the end of the year, I finally started to see the payoff of the work I had put in throughout the year. Students were very much engaged by the new phenomenon, and were excited to try to model the understanding, “Great engagement the week after spring break, with a new phenomenon!” In addition, the discussion had improved and two classes held 15-minute discussions where I did not need to help move the discussion forward.

Table 2
Teacher Reflections on Ambitious Science Teaching

Beginning of the year reflections -This has great potential! -Low achieving students/strugglers perform better on assessments than in past years. -This is tough, first year of implementation, design units/curricula from scratch. Many aspects (7) that need to be incorporated simultaneously -A.W and P.P. struggle academically, but they have some of the best ideas in the class. -Discourse has been difficult to get all classes, students to proficiency. Needs to be constantly used and scaffolded.
Middle of the year reflections -Took a 5-6week break from structured discourse and it feels like we are back at the beginning with this skill. -It will take a few years to get good at this -Discourse and modeling are NEW for students, should be easier as they get an intro to it in Middle School -Sense making is tough - How did they learn anything before this??? They struggle to pull the meaning/significance out of labs and activities. -Maybe they should call this “Overly Ambitious Science Teaching”

Table 2 Continued
Teacher Reflections on Ambitious Science Teaching

End of the year reflections -Great engagement the week after spring break, with a new phenomenon! -Students did a good job of modeling their understanding, gave them a model template and they started writing and drawing what they were thinking. A further analysis of their models show that they are doing a better job of communicating their current understanding. -Students finally started using sentence starters in discussion, and the quality of discussion dramatically improved. 2 classes where the discussion ran itself without my help. -Had some other science teachers review the latest tests that my students took. They were very impressed by the depth of knowledge the students showed and the connections they made.

I believe my data shows that implementation of AST increased student skills in constructing a claim with evidence and reasoning, and in participating in the talk of science. Most importantly, AST style lessons increased student engagement in the lesson, and continued implementation of AST led to increased participation and engagement in class discussions.

INTERPRETATION AND CONCLUSION

Major Findings

My main research question is, "How will the Ambitious Science Teaching (AST) framework of using a puzzling scientific phenomena and evidence based explanations to frame a unit of study increase student motivation and engagement in biology?" Student perception of their motivation and engagement did not change with continued implementation of the AST framework, however other measures such as the engagement scores from the Peer Observation of Discourse instrument (see Figure 5), and the At-Task Observation instrument (see Figure 6) indicate that student engagement in the classroom did show growth. In addition, their responses to the open-ended questions on the survey indicate that key elements of the AST framework are the most helpful for student learning, and their favorite aspects of the class.

A possible explanation for these mixed findings is that student motivation and engagement in the class may have been fixed within the first 8 weeks of school and the first two AST units. At the time of the initial survey, students had sufficient exposure to Model-Based Inquiry teaching by which they may have reached a conclusion of how motivated and engaged they were going to be in the class, and this conclusion stuck with them for the rest of the year.

A second major finding is that student skills in discourse and supporting a claim with evidence and reasoning increased with continued implementation of the AST framework (see Figures 7, 9). The year-long focus on these two skills, and their integration into the fabric of the classroom positively impacted students in these areas. As one of the goals of this project was to increase students' skills with the NGSS science practices, and these findings affirm that the AST framework was successful in this area.

This has manifested itself in students being more eager to explain their thinking, and wanting to know if their explanation/understanding is correct. As I have focused on how I led classroom discourse this year, emphasizing dialogic discourse as described by Scott, (1998) and utilizing talk moves such as the reflective toss (Van Zee & Minstrell, 1997b), I have noticed that students have improved their ability to explain an observation over previous years. An example of this is a demonstration we did of osmosis in eggs that had their shells removed. In previous years, I would show students an egg that had lost mass while in a corn-syrup solution, and an egg that had gained mass while in distilled water. I would then explain to the students what had happened, with limited success in improving student understanding and limited student engagement. This year we did the same demonstration, but I had prepared students with the essential background knowledge, and then had them explain in their own words, what had happened. As the class discussed this, I pressed students for deeper explanations and involved their classmates in the process of questioning explanations. This approach, based on the AST framework, led to increased engagement from previous years, better student explanations and models of the demonstration, and gave me a better picture of student misunderstandings so I could target my instruction to address these misconceptions.

Implications on Teaching Practice

A final finding of this project is that implementing a Model-Based Inquiry teaching framework that focuses on discourse and sense-making is a difficult, multi-year project (see Table 2). This was my first year of implementing the AST framework, and I initially thought that my students and I would have mastered this style of teaching and learning in two to three months. The reality was that it takes significant scaffolding from the teacher to help students share and communicate their current understandings through discourse and models. Once students have shared their ideas, the teacher needs to craft instruction and experiences to move the students forward on their journey of conceptual change. This has been a significant change for me in how I approach and plan a unit of instruction. Additionally, these students have 9 years of education where the primary mode of instruction is to "sit and get", and they are comfortable with this model. The AST framework pushes them out of this comfort zone, to daily communicate their current understanding, even if it is wrong. In this first year of implementing this model, a number of students have struggled because they aren't used to explaining their thinking. When pressed for an explanation of why they gave a particular answer they shrug their shoulders and say, "I don't know." Additionally, some students don't want to give an answer until they know it is correct. Whereas with the AST framework, student ideas, even if they are incorrect, are foundational to building a correct and thorough understanding of biology.

On a positive note, a number of typically low-achieving students excelled with this framework because they could talk out their understanding, and not always have to write what they were thinking. A particularly poignant moment came when I handed back the first test which was based on students using evidence to explain the phenomenon of the southern resident killer whales. An 'A' student who I had taught the previous year got her test back and said, "Mr. Van Loo, I got a 60%, I am not happy with how I did.". Alternately, a typically low-achieving student responded, "I got a B, wait, did I do better than a smart kid?". This illustrates that this framework has significant value for students who have historic academic struggles as it moves science beyond the rote memorization that they struggle with, to explaining what is happening based on experimental evidence and personal experience.

VALUE

This research project shows that the AST framework is successful in developing student skills in the NGSS Science Practices of; developing and using models, constructing explanations, and engaging in argument from evidence. As students build these skills, they will begin to experience the depth and nature of scientific knowledge, bringing us one step closer to realizing the vision of the next generation of science education.

This classroom research project was incredibly enlightening for me in how I collect and use data to inform my instruction. Previously, I had collected data in my classroom, but the limited nature of the data led to an analysis that was superficial, looking for a trend to confirm what I wanted to see in the data. The systematic nature of this research, and the abundant data it produced, allowed me to comprehensively analyze the data to see what stories it produced instead of looking for the story I wanted it to tell.

As this project showed modest gains in student skills, and as faithful implementation of the AST framework is a multi-year process, the next steps of this project are very clear to me. With our district's dedication to student success and meeting the NGSS standards, I and the other science teachers in the district will continue to work at implementing the AST framework. During this process, I will continue to collect data on how the AST framework impacts student achievement. I will focus on how their skills in using evidence and reasoning change within a year, and from year to year. It is my hope that this district-wide initiative will lead to students arriving in my biology class with a stronger foundation of science skills, particularly the ability to use evidence and reasoning. Secondly, I will continue to assess motivation and engagement with the same survey two times per year. The initial survey I will give earlier in the year before attitudes about motivation and engagement are set. It is my hope that in time the AST framework will be a way to motivate and engage the lowest achieving students.

This research has raised a number of questions for me. First, does student motivation and engagement change over the course of a year? As the survey results showed startling consistency from the initial to the final survey I would like to see at what point in the year student motivation and engagement becomes fixed, and what can be done to improve it. Secondly, I would like to investigate which strategies can be used to target the students who begin the year with low motivation and engagement. Glyn et al. describe how the purpose of their Science Motivation Questionnaire is for teachers to identify students with low motivation at the beginning of the year so that the teacher can focus early interventions on these students to increase their motivation in the class (2011). I would like to use the data from the initial survey to identify and target the 10 - 15 students with the lowest motivation at the beginning of the year, and measure if this targeted intervention had an impact on the student's motivation and success in the class. Finally, I would like to investigate what strategies are most successful in helping students make sense of classroom observations and experiments. Through the first three AST units I tried to help students make sense of what we did in class, by recording each activity into a summary table that had a brief description of the activity, what the students learned, and how this connected to the unit's phenomenon. Unfortunately, we never got in a rhythm of regularly filling in the summary table, which meant that completing this synthesis activity was very difficult and time consuming every time we tried it. By the end of the third unit I abandoned this strategy for the year. My further investigation would look for ways to teach and scaffold sense-making activities like the summary table at the beginning of the year, so that this synthesis and reflection becomes a classroom routine. It is my belief that this is the final piece of successfully implementing AST as it gives students a way to process what they learn, anchor it to the unit phenomenon, and see how their understanding changes over time.

REFERENCES CITED

Ambitious Science Teaching - AST. (2016). *AST*. Retrieved 22 November 2016, from http://ambitiousscienceteaching.org/

Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.). (2012). The handbook of research on student engagement. New York, NY: SpringerScience.

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation with science majors and nonscience majors. Journal of Research in Science Teaching, 48, 1159-1176.

Khan, S. (2007). Model-based inquiries in chemistry. *Science Education*, *91*(6), 877-905.

Morgan, G. (2008) Improving Student Engagement: Use of the interactive whiteboard as an instructional tool to Improve engagement and behavior in the junior high school classroom. (Unpublished doctoral dissertation). Liberty University, Lynchburg, VA.

Jones, R. A. (2012). What Were They Thinking? *The Science Teacher*, *079*(03), 66-70.

McNeill, K. L. (2009). Teachers' use of curriculum to support students in writing scientific arguments to explain phenomena. Science Education, 93(2), 233-268.

Office of Superintendent of Public Instruction (OSPI). (2016). Washington State Report Card, Sedro-Woolley Senior High School 2015-2016. Retrieved from http://reportcard.ospi.k12.wa.us/summary.aspx?schoolId=2358&reportLevel=School&orgLinkId=207&yrs=2015-16&year=2015-16

Passmore, C., Stewart, J. and Cartier, J. (2009), Model-Based Inquiry and School Science: Creating Connections. School Science and Mathematics, 109: 394–402.

Reeve, J. (2013), How Students Create Motivationally Supportive Learning Environments for Themselves: The Concept of Agentic Engagement. Journal of Educational Psychology 2013, Vol. 105, No. 3, 579–595

Rewitz, W. (n.d.) Make your Probe Explanations Cl-Ev-R. Uncovering Student Ideas. Retrieved 23 November 2016, from http://uncoveringstudentideas.org/resources/tips-and-strategies

Schweingruber, H., Keller, T., & Quinn, H. (Eds.). (2012), *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Academies Press.

Scott, P. (1998), Teacher Talk and Meaning Making in Science Classrooms: a Vygotskian Analysis and Review, Studies in Science Education, 32:1, 45-80.

van Zee, E., & Minstrell, J. (1997a), Reflective discourse: developing shared understandings in a physics classroom, International Journal of Science Education, 19:2, 209-228.

van Zee, E., & Minstrell, J. (1997b), Using Questioning to Guide Student Thinking. *The Journal of the Learning Sciences*, *6*(2), 227–269.

White, B., & Frederiksen, J. (1998) Inquiry, Modeling, and Metacognition: Making Science Accessible to All Students, Cognition and Instruction, 16:1, 3-118.

Windschitl, M., Thompson, J. and Braaten, M. (2008), Beyond the scientific method: Model-based inquiry as a new paradigm of preference for school science investigations. Sci. Ed., 92: 941–967.

Windschitl, M., Thompson, J., Braaten, M. and Stroupe, D. (2012), Proposing a core set of instructional practices and tools for teachers of science. Sci. Ed., 96: 878–903.

APPENDICES

APPENDIX A

STUDENT ENGAGEMENT SURVEY QUESTIONS

Student Survey Questions

(Reeve, 2013)

Note: Participation in this research is voluntary. Participation or non-participation will not affect your grades or eligibility to participate in any other class activities.

Behavioral Engagement items

When I am in class, I listen very carefully.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I pay attention in this class.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I try hard to do well in this class.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

In this class, I work as hard as I can.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

When I'm in this class, I participate in class discussions.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

Agentic Engagement (candidate items)

I let my teacher know what I need and want.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I let my teacher know what I am interested in.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

During this class, I express my preferences and opinions

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

During class, I ask questions to help me learn.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

When I need something in this class, I’ll ask the teacher for it.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I adjust whatever we are learning so I can learn as much as possible.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I try to make whatever we are learning as interesting as possible.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

Cognitive Engagement items

When I study for this class, I try to connect what I am learning with my own experiences.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I try to make all the different ideas fit together and make sense when I study for this class.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

When doing work for this class, I try to relate what I'm learning to what I already know.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I make up my own examples to help me understand the important concept I study for this class.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

<u>Emotional Engagement items</u>

When we work on something in class, I feel interested

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

This class is fun.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

I enjoy learning new things in this class.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

When I'm in this class, I feel good.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

When we work on something in this class, I get involved.

Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	agree	Strongly agree
1	2	3	4	5	6	7

APPENDIX B

SCIENCE MOTIVATION QUESTIONNAIRE

Science Motivation Questionnaire II (SMQ-II): Components

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

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

Note. The SMQ-II is copyrighted and registered. Go to **http://www.coe.uga.edu/smq/** for permission and directions to use it and its discipline-specific versions such as the Biology Motivation Questionnaire II (BMQ-II), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II) in which the words *biology*, *chemistry*, and *physics* are respectively substituted for the word *science*. Versions in other languages are also available.

APPENDIX C

CLAIM EVIDENCE REASONING RUBRIC

Claim Evidence Reasoning Grading Rubric

Criteria for successful argument	**Yes 5**	**Maybe 3**	**No 0**
Did they state a **claim?**			
Does there **claim** answer the question?			
Does their **claim** stand alone -Would someone who didn't read the question understand the claim?			
Total points for your CLAIM=_____/15			
Did the use **appropriate evidence?** -Does the evidence support their claim			
Did they use **correct/accurate evidence**? -Does the evidence come from what we learned in class, or from scientific observations?			
Did they use **enough evidence** to support their ideas? -Used more than one piece of evidence and all their ideas are supported by evidence?			
Total points for your EVIDENCE=_____/15			
Does there **reasoning add something new** - not just restating the claim or evidence?			
Does there **reasoning fit** with other theories and laws that are used in science to explain how the world works?			
Does their **reasoning explain how** the evidence supports their claim?			
Total points for your REASONING_____/15			

Adapted from Rewitz (n.d.)

APPENDIX D

AT-TASK OBSERVATION INSTRUMENT

At-Task Observation Instrument

This technique provides data on individual student's engagement levels. Each square is a student. Scan the classroom every 3 to 5 minutes ("sweep:). Record the time of the sweep and a brief notation as to the activity taking place. Focus once on each student briefly during each sweep. For each student, record an at-task (+) or off-task notation. The following questions could be asked in reviewing the data: What was the predominant off-task behavior? During which activity did most off-task behaviors occur? During which sweeps were most students off-task? Which students were off-task most often? Possible reasons/recommendations?

Teacher ______________________________ **School** ______________________
Start Time _______________ **End Time** _____________ **Date** ______________

+ = At- Task

Off-Task Codes

A – Turned around
C – Schoolwork other than assignment
O – Out of seat
H – Head down
N – making noises/faces
S – Stalling
T – Talking

Students

1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8
1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8
1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8
1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8
1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8	1 5 2 6 3 7 4 8

Sweeps: Every 3-5 minutes record the time of the sweep and a brief notation of activity taking place at that time:

sweep 1.	sweep 2.	sweep 3.	sweep4.
sweep 5.	sweep 6.	sweep 7.	sweep 8.

APPENDIX E

PEER OBSERVATION OF DISCOURSE INSTRUMENT

Participant Name____________________ Period _____Date______

Topic/Article Name _________________________________

At the end of the seminar, reflect and circle the level of participation that best fits your performance.

4 The Effective Participant

- **Always paraphrases prior student's comments before adding one's own information.**
- **Poses multiple new insights, comments, or questions for the discussion.**
- **Remains respectful of whose turn it is to speak.**
- **Stays focused on the discussion at hand (no distracted talking, working on other assignments, etc…)**

3 The Satisfactory Participant

- **Most of the time paraphrases prior student's comments before adding one's own information.**
- **Poses two new insights, comments, or questions for the discussion.**
- **Remains respectful of whose turn it is to speak.**
- **Stays focused on the discussion at hand (no distracted talking, working on other assignments, etc…)**

2 The Emerging Participant

- **Occasionally paraphrases prior student's comments before adding one's own information.**
- **Poses one new insights, comments, or questions for the discussion.**
- **Remains mostly respectful of whose turn it is to speak.**
- **Stays mostly focused on the discussion at hand (no distracted talking, working on other assignments, etc…)**

1 The Beginning Participant

- **Does not paraphrases prior student's comments before adding one's own information.**
- **Poses no new insights, comments, or questions for the discussion.**
- **Remains mostly respectful of whose turn it is to speak.**
- **Stays mostly focused on the discussion at hand (no distracted talking, working on other assignments, etc…)**

0 The Non-Participant

- **Does not paraphrases prior student's comments before adding one's own information.**
- **Is not focused on the discussion at hand (talking, working on other assignments, etc…)**

Inner-Outer Discussion Circle
Observation Form

Participant Score:__________
Directions: Each time your partner does one of the following, record a check on the line.

Observer name: ______________________

Speaks in the discussion
____ ____ ____ ____ ____ ____ ____ Total ____

Uses a Sentence Starter
____ ____ ____ ____ ____ ____ ____ Total ____

Refers to the text/activity
____ ____ ____ ____ ____ ____ ____ Total ____

Asks a question
____ ____ ____ ____ ____ ____ ____ Total ____

Provides Evidence
____ ____ ____ ____ ____ ____ ____ Total ____

Provides Reasoning
____ ____ ____ ____ ____ ____ ____ Total ____

Adds to someone's idea
____ ____ ____ ____ ____ ____ ____ Total ____

How would you rate your Partner's engagement? (circle one)
5) Always engaged 95-100 % of the time looked at speaker, followed the conversation, and was thinking about what was being said.
4) Mostly engaged 80-95% of the time looked at speaker, followed the conversation, and was thinking about what was being said.
3) Occasionally engaged 60-80%) of the time looked at speaker, followed the conversation, and was thinking about what was being said
2) Somewhat engaged 40-60% of the time looked at speaker, followed the conversation, and was thinking about what was being said
1) Rarely engaged 20-40% of the time looked at speaker, followed the conversation, and was thinking about what was being said
0) Never engaged 0-20% of the time looked at speaker, followed the conversation, and was thinking about what was being said

APPENDIX F

INSTITUTIONAL REVIEW BOARD APPROVAL

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Brennan Van Loo and Walt Woolbaugh

FROM: Mark Quinn *Mark Quinn cj*

DATE: November 17, 2016

SUBJECT: "*The Effects of Model Based Inquiry Teaching on Student Engagement and Motivation in a High School Biology Classroom"* [BVL111716-EX]

The above research, described in your submission of November 17, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

__X__ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

__X__ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement}, survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.