ABSTRACT

ARGUMENTATION: EMBEDDING CLAIM, EVIDENCE, AND REASONING INTO YOUR CLASSROOM

By

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This is a thesis project aimed at creating an elementary science unit. The purpose for creating this unit was so that elementary teachers who are normally not comfortable with science content can carry out a unit that implements science processes, such as argumentation, without apprehension. The use of science notebooks is included to help students construct arguments through the collection of data. The unit starts off with process lessons for introducing the process of argumentation. It is my hope that teachers will be able to take the process lessons I have created and insert it into any science unit they teach. I have attached some content lessons adapted from the Full Option Science System (FOSS) in order to highlight how I would embed the elements of argumentation in an already established curriculum that might be used by a school district. The unit was reviewed by three teachers in the field and then revised to include their suggestions.

ARGUMENTATION: EMBEDDING CLAIM, EVIDENCE, AND REASONING INTO YOUR CLASSROOM

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CHAPTER 1

INTRODUCTION

Being an educator is not an easy career. Nothing can truly prepare an educator for the day-to-day interactions you have with the various personalities found in a classroom of 35, except for experience. Curriculum and how to implement it should be the easy part of your day. It has been brought to my attention that the changes being made in education with the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS) are making teachers feel as if it is their first year of teaching. They are expected to take a new approach to education that implements a higher level of rigor and focus on critical thinking through performance assessments. As it stands, most elementary teachers I have met are not comfortable teaching science, because they do not feel like they have a strong foundation in their content knowledge. I have witnessed teachers use science for vocabulary-building activities, as a workshop activity for language arts, or as homework. This in turn makes students feel just as uncomfortable with science as their teachers. Any time I talk to high school students about taking a science class, they tell me they just are not good at science. They say they do not get it, some tell me it is boring, and others say it is just too hard to learn. Their foundation in science may not be strong or it has been taught to them as the memorization of facts that can be overwhelming for most.

From my perspective, the NGSS are much more teacher and student friendly than previous standards through their approach of science as a process. They do this by introducing practices and assessing students on performance expectations instead of a litany of facts. It is actually a wonderful time for science. When you teach children that science is a process and that scientists did not just wake up one day and come to the conclusions that fill up their textbook, they begin to be able to appreciate and understand how scientists came up with those conclusions, not be afraid of them or try to memorize them. My focus for this project will be on how to implement argumentation within a science unit. Argumentation for the sake of this study will be defined as the process used for the defense of an idea or a set of ideas. Merriam-Webster (2015) defines argumentation as the act or process of giving reasons for or against something. McNeil's (2008) definition of argumentation includes an individual and social meaning, which begins with what the individual constructs in his or her mind and then what that individual tries to convey to others. It is my goal to create a frame for argumentation within a science unit on matter so that teachers can have an example of how to implement argumentation skills into any unit. Teachers need to be comfortable facilitating discussions so that students feel comfortable expressing their understanding within the content. When children construct their understanding they are more likely to remember it and continue to build on it throughout their lives.

The purpose for creating this unit was so that elementary teachers who are normally not comfortable with science content can carry out a unit that implements science processes, such as argumentation, without apprehension. It should be easy for teachers to use and students to follow. Not only should it help students take that leap from learning to understanding, it should help them express what they have learned. It is my hope that teachers will be able to take the unit I have created and insert those skills into any science unit they teach. For this project, I included a survey for teachers to fill out for feedback.

CHAPTER 2

LITERATURE REVIEW

The Next Generation Science Standards, which were developed in order to address preparation of students for college and career readiness in science, are what primarily drives this project thesis. It represents performance expectations that require all students to have a deeper understanding of a smaller number of disciplinary core ideas, are able to show evidence of that knowledge through scientific and engineering practices, and connect crosscutting concepts across disciplines (Pruitt, 2014)**.** The performance expectations focus on students applying ideas to explain phenomena, solve problems, and make decisions. In order to achieve this, there are specific science and engineering practices that must be taught. When students engage in any of the science and engineering practices, they must read, write, and visually represent their understanding of the concepts being taught. They must be able to listen to others ideas, present their own ideas, and refine their ideas to engage in reasoned argumentation with others' to reach shared conclusions. Building a good scientific argument means students must have the ability to assemble data into evidence to support a claim. Students must be able to read grade-appropriate texts and other media to summarize and obtain scientific and technical ideas, as well as compare the texts they read, and combine the information they obtain. In order to effectively communicate science understanding, students should be repeatedly exposed to reading, writing, and speaking.

Constructivism and Inquiry

Constructivist learning theory, which grew from Piaget's ideas, posits that when you tell students about an idea they will unconsciously compare what you say with all the rest of their knowledge and experiences (Colburn, 2007). Jerome Bruner's theoretical framework is based on the theme that learners construct new ideas or concepts based upon existing knowledge. These constructivist ideas about learning have been embraced by scholars in both literacy and science education. Some constructivist approaches have emphasized that the personal construction of knowledge with the individual's experience within the learning environment are important, whereas others have underlined the importance of social process in mediating cognition. Social constructivism was described by Lev Vygotsky, who thought that children learn with the help of teachers and other older children as facilitators that can help master concepts and ideas that they cannot master on their own. Children have a natural tendency to engage in inductive and deductive forms of argument when sound context is provided. According to research conducted by Deanna Kuhn (1999), children's intellectual development can be described on three cognitive dimensions: (1) metacognitive process, being an active constructor of knowledge, (2) metastrategic processes, knowing which strategies to use, and (3) epistemological framework, an understanding of how we know. When children engage in the process of reasoning and support each other in high-quality argument, the interaction between the personal and the social dimensions promotes reflexivity, appropriation, and the development of knowledge, beliefs and values (Erduran, Simon, & Osborne, 2004).

The construction of knowledge through personal experience and social interactions supports teaching science as a practice. It can improve the quality of student learning by helping them engage in the necessary peer discussions where they are invited to explain their understanding. Through this sharing process their ideas can be refined helping them develop a deeper and broader understanding of the disciplinary core ideas. The teacher's role in this aspect is as a facilitator moving discussions along, identifying any misconceptions, and providing that safe learning environment.

Inquiry-based instruction is the embodiment of science education adopting a constructivist approach. Some of the elements of inquiry-based teaching include first and foremost, science content, student responsibility for learning, student active thinking, and a balance of teacher guidance and student initiative. Hands-on activities must also be accompanied by class discussions so that students may be able to process for meaning what they observed in their independent design activities (Minner, Levy, & Century 2010). This is especially important for bringing about conceptual change. The National Research Council (NRC; 1996) describes inquiry as having the following features:

Learners are engaged by scientifically oriented questions

Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically-oriented questions

Learners formulate explanations from evidence

Learners communicate and justify their proposed explanation

Learners evaluate their explanations in light of alternative explanations

In a study done regarding inquiry-based science instruction by Minner et al. (2010), they found that 51% of the 138 studies in their synthesis showed positive impacts of some level of inquiry science instruction on students' content learning and retention.

The 5E instructional model represents an instructional model that is based on constructivist theories of learning that provide strong guidance and support for an approach to teachers that promotes student inquiry (Wilson and Kowalsi, 2009). The E's in this model stand for engage, explore, explain, evaluate, and extend. The 5E instructional model also mirrors the findings in the review on learning conducted by Bradford, Brown, and Cocking (1999) in their book, *How People Learn.* According to Wilson and Kowalsi (2009), both involve investigations that begin with what the student already knows, engage students in learning content as well as how to organize and reason about content, involve activities in which students control, reflect upon, and evaluate their learning, scaffold students working together and with the teacher to discuss evidence and connect their findings with scientific explanation.

Engagement in the practices introduced in the NGSS is also language intensive and these class and peer discussions become a place where all students can express themselves. All students must be provided equitable opportunities to engage with the scientific practices and construct meaning in science classrooms (Lee, Miller, & Januszyk, 2014). This forum can help all students express themselves inviting them to develop their communication skills over time. These language-learning opportunities will serve an integral part in developing those language skills. Inquiry-based instruction has also been shown to benefit English language learners (ELLs). It gives them time to build context, it is more concrete, and it is hands-on as opposed to text-based so that ELLs can build their thinking skills with the ability to access both languages (Amaral, 2002). In another study conducted by Lara-Alecio, Tong, Irby, Guerrero, Huerta, and Fan (2012), it was found that inquiry-based interventions have been found to promote the development of ELL's conceptual understanding of science.

Argumentation

In order to become critical consumers of science, it is important that teachers provide students with opportunities to use critique and evaluation to judge the merits of any scientifically based argument. According to Stephen Toulmin, a philosopher, an argument is an assertion and its accompanying justification (Duschl & Osborne, 2014). Toulmin's model has made a significant impact on how science educators have defined argument (Erduran et al., 2004). Toulmin's model of analysis proposes a structure of argument according to five elements: claims, data, warrants, backings, qualifiers and rebuttals (Erduran et al., 2004). In order to make use of Toulmin's model in an elementary school setting, McNeil (2008) simplified this model into three key components: claim, evidence and reasoning. The claim is an assertion or conclusion that answers the original question. The evidence is scientific data that supports the claim. The reasoning is a justification that shows why the data counts as evidence to support the claim. The use of rebuttals in an argument is a good indicator of argument quality in scientific reasoning and should be included as discussions advance. A rebuttal is a claim that responds to an opponent's counterargument by countering this counterargument. When students make a rebuttal they not only need to justify their claim, but also look for its limitations (Garcia-Mila, Gilabert, & Felton, 2013). Some of the goals included in the NGSS are to construct a scientific argument using data to support a claim, identify possible weaknesses in an argument, modify and improve an argument in response to criticism and present counterarguments. For students to achieve these goals, they will need instructional support. Taking from separate studies done by Ronald Giere and David Klahr, regarding scientific processes, Osborne (2014) compiled science practices into three distinct phases of activity: experimenting, hypothesis generation, and evidence evaluation. This model pertains to science education in that it supports the key practices of scientists, such as data analysis and establishing the validity of claims as being important to teach students (Osborne, 2014).

Instruction to Support Argumentation

Argumentation needs to be taught explicitly. An important part of science teaching is managing the classroom to position students for learning (Harris & Rooks, 2010). Building a community of learners where everyone feels comfortable sharing is the first step to facilitating argumentation in the classroom. Curriculum interventions that facilitate argumentative discourse among young adolescents must be situated in contexts where students value other perspective as a means of refining and elaborating their understanding in science (Garcia-Mila et al., 2013). Then teachers can define argument, provide examples of arguments, prompt students to justify their ideas with evidence, encourage debate and counterargument, and promote student reflection to facilitate argumentation. Students need to be able to distinguish evidence from opinion. Teaching students how to apply data to an argument as well as considering moral, ethical, and social concerns can help build stronger arguments. When using data as evidence, students also need to be able to interpret explain the data and why it pertains to their claim (Sandoval & Millwood, 2005), Zohar and Nemet (2002) found that when students are given explicit instruction in argumentation coupled with the opportunity to practice with science content, they are more likely to cite specific scientific knowledge as evidence in their arguments and perform better on tests of content knowledge than peers in a control group.

Osborne (2014) synthesized the main point of two separate studies done by Ronald Giere and David Klahr regarding scientific processes in order to distinguish between three distinct phases of activity: experimenting, hypothesis generation, and evidence evaluation. Osborne's model pertains to science education in that it supports the key practices of scientists, such as data analysis and establishing the validity of claims, as being important to teach students so that they may understand that science is about ideas not facts or experiments alone.

Arguments need to be defined, structure should be explained, and criteria for distinguishing between good and bad arguments should be acknowledged. Teachers should pose questions that can help students determine why their evidence is relevant to their claim. There appears to be a relationship between teachers' open-ended questions and the prevalence of student talk and argumentation in classroom discussions (McNeil, 2008). The traditional classroom discussion follows the IRE pattern where the teacher initiates a question, a student responds, and the teacher evaluates (McNeil & Pimetel, 2010). This type of discourse promotes a classroom environment where the teacher looks for a correct response and the students only address the teacher prompts. Students can be encouraged to draw from their everyday experiences, so that they may connect their ideas and build upon what they already know or understand. The evidence that exists suggests that argumentation is fostered by a context in which student-student interaction is permitted and encouraged (Duschl & Osborne, 2002). A teacher can promote student-to-student interaction by asking the students to respond to their peers as well as asking open-ended questions that can generate various responses. Categorizing students' reasoning by using a rubric can help guide teaching practice (Dolan & Grady, 2003). Students should also be aware of what is expected of them. Creating a rubric can help students identify the parts of an argument that are beneficial, such as providing evidence.

Argument research also emphasizes the link between dialogic and rhetorical argument pointing to dialogic (social) argument as a powerful vehicle for developing the kinds of thinking needed (Kuhn, 1993). Encouraging students to draw from their everyday knowledge and experiences is important to help them connect their different ideas to develop more robust and usable scientific knowledge. An individual's prior content knowledge will impact the quality and complexity of scientific arguments she or he produces (Garcia-Mila et al., 2013). Critically important to argument is also allowing the learner to have sufficient time to understand the central concepts and underlying principles that they are attempting to reason about. Letting them construct their knowledge through reasoning over time will help solidify the concepts. Science classrooms should include opportunities for students to engage in classroom discussions in which students practice talking science, challenge each other's ideas and influence the direction of the discourse. Student success at writing scientific arguments to explain phenomena in which they justify the claims they make with appropriate evidence and reasoning requires more than an understanding of just science content. Students' ability to write scientific explanations improved the greatest when teachers provided a rationale for engaging in scientific explanation and explicitly and appropriately defined the different components of the scientific explanation framework: claim, evidence, and reasoning. When engaged in a class discussion, students actively listen and respond to each other playing an important role in the direction of the conversation. Students must understand that evidence-based claims are persuasive. It is important to consider the interplay between students, understanding the kind of explanations they ought to produce and their understanding of available data and its significance in relation to their problem. An exploration of historical episodes in science can provide opportunities for students to identify the ideas, evidence, and arguments of professional scientists.

Argument and Language

The use of writing as an instrument for learning underlines the personal construction of knowledge, whereas the use of talk for learning is consistent with social constructivist thought. Oral discourse is divergent, highly flexible, and requires little effort whereas written discourse is convergent, more focused, and places greater cognitive demands on the writer. In a study conducted by Rivard and Straw (2000), they identified talk and writing as complimentary modalities. Peer discussions generates questions, helps students formulate ideas together, and require them to explain their ideas. Writing enables students to organize their thoughts, so that they can express their thoughts. An instructional strategy encompassing both should enhance learning more than another using either of these two language modalities alone. Their findings suggested that science teachers should endeavor to include more writing tasks in the classroom, but only after students have had sufficient opportunities for collaborative exploratory talk while being guided by cognitively engaging problem-solving tasks. The use of learning strategies such as sharing ideas, classroom dialogue, peer discussions, concrete experiences, and journal activities can help construct knowledge. Peer discussion combined with analytical writing enhances the retention of science knowledge by students over time.

Using science notebooks to record a collection of evidence can help students write science explanations, giving them a place to record sources of evidence for their claims. A student notebook is a set of student writings and/or drawings that help construct and represent their understandings. It can be a central place where language, data, and experience work together to form meaning to the student. Students can make use of their notebooks in three different instructional contexts: to explore their prior knowledge, to make predictions based on a teacher demonstration, and to document small-group investigations. Students can learn through writing when the teacher provides a clear focus for the student to understand what they should be learning. Written text allows for inspection and revision, which enables knowledge transformation and possible conceptual change for the writer. Science notebooks should be structures so that students have multiple opportunities to write daily (Lara-Alecio et al., 2012)

Science notebooks are also a venue for teachers to work with students to clarify gaps in understanding and to move their students forward. The notebook provides teachers with opportunities to access the ideas and understandings that children have of science phenomena and concepts as well as the literacy forms that are familiar to them as tools for expressing meaning. Notebook entries reflect learning in real time and provide a window on students emerging conceptions. They can use notebooks to help decide who needs extra help and when to revisit concepts or ideas in later lessons. A fundamental challenge to a teachers' use of science notebooks to monitor students' development of conceptual understanding can include the lack of knowledge of the science content and learning goals of each lesson (Aschbacher & Alonzo, 2006). This can affect the nature of guidance that is provided by the teacher, which will in turn affect what students write in the notebooks and how informative these entries can be with respect to their understanding. To enable effective student learning through writing, teachers need both a clear sense of the rationale and demands of the writing task they seat as well as appropriate (Hand & Prain, 2004). Students' success at writing scientific explanations to explain phenomena include curricular scaffolds as well as multiple opportunities to write scientific explanations. Teachers need to be able to develop a solid conceptual understanding of the big ideas and awareness of key learning goals in order to provide the scaffolds needed for students to succeed. In a study conducted in Southern California known as The Valle Imperial Project, science notebooks was an integral component in which researchers examined the relationship between writing and achievement (Amaral, 2002).

NGSS and Argumentation

Due to the fact that we live in a society where the world is easily connected, the NGSS has taken all learners into consideration. The writers of the NGSS have taken the extra step by connecting to the science standards to the CCSS for Language Arts, as well as Math, in order to support students (Krajcik et al., 2014) so that they can experience success and be college ready. The connections to CCSS for math and language can be found in the connection boxes just below the foundation dimension boxes in The Standards, Volume 1 (NGSS Lead States, 2013). When one reads the CCSS for Language they can immediately make the connections that can help support the student's success in science. For example, by the end of fifth grade students should be able to support a point of view with sufficient reasons and information that draws evidence from informational texts as well as build on other's ideas and clearly express their own (CTA, 2010). This set of grade level expectations can easily be connected to practices 6 through 8, which respectfully are: constructing explanations and designing solutions, engaging in argument from evidence, and obtaining evaluating and communicating information. The goal is to develop lesson level expectations and performance tasks, select resources that scaffold learning to meet the performance expectations, while applying and reinforcing literacy and mathematics standards (Krajcik et al., 2014). Thus, it is imperative for teachers to build classroom environments that provide students with multiple opportunities to think about what they know, how they know it, and how to express what they know through argumentation.

CHAPTER 3

METHODOLOGY

I assembled a 2-week unit for fifth grade teachers in California. The performance expectations are a blend of the three dimensions of NGSS: disciplinary core ideas, science and engineering practices, and crosscutting concepts. The dimensions are meant to serve as tools to build understanding. Since instruction needs to build towards a student's ability to demonstrate understanding of the performance expectations, I needed to take a look at the performance expectations for the selected grade level. Fifth grade was selected because it was the grade level that I taught for the most amount of time. I chose Matter and Its Interactions because it lends itself well to argumentation. Pruitt (2014) states that in order to build a good scientific argument students must know how to assemble data into evidence, which led me to bundle the performance expectations found in TABLE 1.

TABLE 1. Performance Expectations

5-PS1-2	Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
5-PS1-3	Make observations and measurements to identify materials based on their properties
5-PS1-4	Conduct an investigation to determine whether the mixing of two or more substances results in new substances

These performance expectations can be found under Matter and Its Interactions for fifth grade. They lend themselves extremely well to practices six through eight.

Practices

The curriculum addresses the three performance expectations as well as the following practices: (6) constructing explanations, (7) engaging in argument from evidence and (8) obtaining, evaluating and communicating information. The practices build upon each other and need to be explicitly taught so that students effectively engage in argumentation to build upon their understanding of core concepts. According to the Framework (NRC, 2012), the practices are defined as follows:

Practice 6: An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. For grades 3-5, students should be able to construct an explanation of observed relationships, use evidence to construct or support an explanation or design a solution to a problem, identify the evidence that supports particular points in an explanation, apply scientific ideas to solve design problems, and generate and compare multiple solutions to a problem base on how well they meet the criteria and constraints of the design solution.

Practice 7: Argumentation is a process for reaching agreements about explanations and design solutions. Students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits. For grades 3-5, students should be able to (1) compare and refine arguments based on an evaluation of the evidence presented, (2) distinguish among facts, reasoned judgment based on research findings, and speculation, (3) respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions, (4) construct and/or support an argument with evidence, data, and/or a model, use data to evaluate claims about cause and effect, and (5) make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Practice 8: Being able to read, interpret, and produce scientific and technical text is a fundamental practice of science and engineering, as is the ability to communicate clearly and persuasively. In grades 3-5, students should be able to (1) read and comprehend grade-appropriate complex texts and/ or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence, (2) compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices, (3) combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices, (4) obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem, and (5) communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams and charts.

Crosscutting Concepts

I also address the crosscutting concepts patterns and cause and effect. The crosscutting concepts are fundamental to an understanding of science and engineering since they bridge disciplinary boundaries and have explanatory value (NRC, 2012). As students are engaged in collecting evidence, they will begin to see patterns emerge. For example, while mixing substances, they might identify that when an acid is mixed with a base, gas is released. Patterns emerging can be used as evidence from a lab that a new substance is forming. Patterns can also lead to questions that can further an investigation. These repeating patterns are clues that a cause-and-effect relationship exits. For example, a student can further investigate the cause of a specific chemical reaction. When students engage in scientific argumentation, it is often centered about identifying the causes of an effect. The crosscutting concepts are valuable to tie concepts together.

Disciplinary Core Ideas

As stated before, the disciplinary core idea (DCI) that will be addressed is Matter and Its Interactions, specifically, Chemical Reactions. The DCI for chemical reactions are:

1. When two or more different substances are mixed, a new substance with different properties may be formed.

2. No mater what reaction or change in properties occurs, the total weight of the substances does not change (Boundary: Mass and weight are not distinguished at this grade level).

The previous state standards, found in the Science Framework for California Public Schools (CDSM, 2004), required that students identify which atoms in a reactant rearrange during chemical reactions to form products with different properties. With NGSS, students don’t need to understand the atomic scale or differentiate between weight and mass in order to talk about reactants and products being rearranged. Their investigations will include substances with different properties, but it is not necessary to familiarize them with chemical equations that have to balance out.

The following chart is a useful tool to organizing the elements of the NGSS so that teachers maximize their instruction and students are consistently being exposed to all three dimensions in order to build understanding.

TABLE 2. NGSS Dimensions

Dimension 1: Practice	Dimension 2: DCI	Dimension 3: Crosscutting concept	Lesson Level Expectation
Argument from evidence	When two or more substances are mixed a new substance with different properties may be formed	Patterns	Construct an argument that a new substance has been formed

Unit Elements

The unit includes a series of inquiry lessons related to the three performance expectations. The unit starts off with a conceptual flow that illustrates the important concepts that should be covered when teaching the process of argumentation. It is then followed by process lessons to introduce and review the concept of claims, evidence and argument, as well as philosophical chairs, and the use of a class rubric to assess scientific explanations. Finally, I chose existing science curriculum to embed argumentation into.

Unit Lessons

Lessons were chosen to include skills that address practices six through eight. This unit consisted of eight lessons. The lessons were adapted from existing inquiry-based curriculum from the Full Option Science System (FOSS) kits, developed by Delta Education and the Lawrence Hall of Science. The content lessons focus on data collection and making sense of the data to understand what it means and how it can be used to create an evidence-based argument. The practices will help scaffold the process of argumentation. For example, practice six, constructing an explanation, will be repeatedly used to tie the data into their reasoning. The repeated exposure following the lessons will build student ability to use these explanations to engage in argument from evidence, which is practice seven.

Supporting Text Materials

The lessons include text materials and other digital materials as another way of gathering evidence to support their arguments. This would connect to CCSS ELA standards related to writing, which include drawing evidence from literary or informational texts to support analysis, reflection, and research. Students are expected to explain by using that evidence to support particular points in a text, identifying which reasons and evidence support which points.

Philosophical Chairs

An introduction to Philosophical Chairs includes the use of a short article to be read by the students. An article was chosen so that the teacher could facilitate a discussion. The teacher will pose an open-ended question so that as the students reread the article they can make notes in the margin that address the question. This process supports the CCSS ELA Speaking and Listening standard 1: Engage effectively in a range of collaborative discussions with diverse partners building on others' ideas and expressing their own clearly. Philosophical Chairs has a set of agreed upon rules where all students must take an active role in the discussion.

Assessments

Formative assessments will be built into the lessons as checkpoints as to whether students understand what an argument is, how they perform during Philosophical Chairs, and their understanding of the content. It is critical for teachers to assess student's level of understanding in order to support those who might need to develop the ideas being taught before moving forward.

A summative assessment was included to evaluate students' content knowledge as well as their ability to create a written evidence-based argument. Although the identified performance expectations do not specifically address practice 6-8, the practices are intertwined. The lessons are building upon each other helping the learner construct multiple explanations that include mounting evidence to support their claim. The cross-cutting concept, pattern, has been included due to the fact that through conducting investigations evidence can help to either support one's claim or change their original claim.

Data Collection

This study generated qualitative data aimed at improving the unit. The survey included five open-ended questions (See Appendix A). The questions were designed to assess whether the unit could be easily implemented in a classroom where diverse abilities needed to be targeted. The evaluators were asked to provide feedback by returning a survey. The use of open-ended questions was to obtain as much feedback as possible to leave it open to helpful suggestions. Two of the three teachers returned the survey, while one chose to provide feedback over the phone.

The 2-week unit was sent out to three current classroom teachers. One teacher currently teaches fifth grade in Manhattan Beach, the other is an International Baccalaureate (IB) facilitator for a school in Long Beach, who taught fifth grade before taking on the facilitator position, and was a coach for new teachers. The last teaches fifth grade in Los Alamitos. Only one of the teachers is at a Title I school with a high population of ELLs. None of the teachers have a specialization in science, which was helpful since I wanted to target teachers who are not heavily exposed to science education. The teacher from Los Alamitos, although she has no formal science education training, is the school lead for science and enthusiastic about science teaching. The teacher in Manhattan Beach typically focuses on ELA instruction and is uncomfortable with science teaching, but has partnered with other teachers to support science curriculum. Lastly, the teacher from Long Beach supports science instruction and is a new teacher coach with a very traditional view of science. It was also helpful that all the teachers reviewing the unit were from different school districts, so that it is pertinent to all teachers not just specific to one district.

An e-mail invitation was sent out to four teachers, all of who had experience teaching fifth grade. They were either recommended by science education or had previously worked with the researcher. The unit was sent out with the survey once the teachers agreed to review the unit. One copy was hand delivered in hopes that other teachers on her team might contribute to the evaluation. The teachers were requested to turn in their comments by e-mail once they had ample time review it. Reading and reviewing the unit should take no more than 2 hours. All evaluators took approximately a month to send back the feedback. It was sent out in March in hopes that it would be read over Spring Break when teacher's schedules were hopefully less hectic. The evaluation of this unit was voluntary and the use of the unit was offered. One teacher never responded to any e-mails to evaluate the unit.

CHAPTER 4

DATA AND RESULTS

Introduction

The purpose for writing this unit was to showcase how NGSS, along with Common Core State Standards could be easily implemented into currently used curriculum by classroom teachers. Specifically, this project sought to clarify what the process of argumentation included and how it is a process that can be included into many instructional units. A conceptual flow was created in order for teacher's to follow the process that students need to be familiar with in order to construct arguments that successfully include claim, evidence, and reasoning. The conceptual flow details what we should teach students to help them construct strong arguments.

Feedback Analysis

Once the feedback was received it was analyzed to address multiple concerns that came up within the responses. I was looking for two types of responses: what was needed to support the teachers and what was needed to support the students. If a concern was brought up two or more times across the surveys as well as within the survey questions, it was noted. The feedback was given to the researcher through conversations as well as written feedback.

Overall Trends

Across the three teachers, there was consistent feedback that there was a need for a graphic organizer and scaffolding in order to support English Language Learners and students with special needs. A summary of the answers is provided in Table 3.

TABLE 3. Shortened Answers From Surveys

Question	Evaluator 1	Evaluator 2	Evaluator 3
Is this appropriate for a 5th grade classroom? Would it work? What parts might not work?	• It is appropriate • Each lesson needs a time frame • It might not work if science is not taught often	• It is appropriate • Create a lesson to bridge the process and content lessons	• It is appropriate • Include a lesson on misconceptions • Include a lesson on what physical properties are
Could this be easily implemented? Would any teacher be able to pick this up and use it, not matter their experience.	• Science content is often shortened due to a lack of time, need a time frame • Bold vocabulary or list	• Approximate time • Materials Needed • Include standards • Learning target or purpose	• Include a lesson in regards to the scientific method • Include a note on how to teach vocabulary without giving the definition
Is the unit rigorous? Too, rigorous? Please explain.	• Yes • Tie lessons in to Depth of Knowledge • Add standards to each lesson	• Yes • Add a skills lesson for proper citation of evidence in writing	• Yes • Help students identify when their claims have evolved
Can you see how formative and summative assessments are built within the unit?	• Include a list of assessment with prompts • Include sample rubrics to grade and judge student assessments	• Label the assessments	• The last lesson regarding the mystery powder is an excellent assessment to test what students have learned
Is there enough support for students with special needs such as English Language Learners?	• Include a section to address ELL or Special Needs • Add possible thinking maps or graphic organizers	• Use a consistent graphic organizer • Provide scaffolding for ELL's or Special Needs	• Include vocabulary support for EL's

All teachers felt that the unit was appropriately rigorous for fifth grade. One teacher stated that it included depth of knowledge, which is required by the Common Core State Standards for English Language Arts. Most teachers also felt that the state standards should be included in the lessons, especially for new teachers. Two of the three teachers mentioned vocabulary as a support for teachers to implement instruction. All of the teachers had suggestions for lessons to include in the unit.

Specific Feedback by Individual Teacher

The teacher from Manhattan Beach highlighted that the unit was rigorous enough. They are currently using Norman Webb's Depth of Knowledge (DOK) for ELA and that including these levels into the lessons can help attach it to ELA standards as well as science. "Currently, teachers are using DOK so maybe including that within the unit." The DOK levels are: Recall and Reproduction, Skills and Concepts, Strategic Reasoning, and Extended Reasoning. She also suggested that adding the NGSS Standards to each lesson or the entire unit would be beneficial. Her concern was based on their limited time frame for teaching science. Her school has a heavy focus on ELA and math, so her concern was being able to squeeze in as much as possible to justify teaching science beyond 45 minutes. "Due to a lack of time and a heavy focus on ELA and math, sometimes science content is shortened."

The IB facilitator's concerns fell in line with supporting a new teacher as well as ELLs and special needs students. This makes sense given her previous experience as a coach for new teachers at her school. For teachers, her suggestions included labeling what the assessments were, including standards and learning targets, approximating time frames, and a list of materials needed. "However, a brand new teacher with less knowledge of assessment may not see them (the formative and summative assessments)." For students, her suggestions were to provide a consistent graphic organizer for writing claims with supporting evidence, including a skills lesson for proper citation of evidence, and making sure to connect labs with what was taught in the process lessons.

The teacher from Los Alamitos generally appreciated the flow of the lessons. Her concerns were focused on students' prior knowledge. She felt that making sure they were supported with the vocabulary, knew what physical properties were, and clearing up misconceptions should be included in the content lessons. "The lessons are good at this level. It is rigorous, but not unattainable." She felt that the unit was rigorous enough for the population she taught and that highlighting how claims can evolve with the addition of new evidence was pertinent for students to produce strong arguments. She also appreciated the links to argumentation included in each lesson. She felt that this was good support for a teacher unfamiliar with the process of argumentation.

Revisions

In order to capitalize on the suggestions provided by the teachers, I went back and looked at the lessons to match them up with what was consistently mentioned in the feedback. The changes I made were based on the following criteria:

1. Ease of use for teachers
2. Support to include all learners
3. Pertinence to all teachers, not specific school districts

The third category was added to address their various suggestions in how to help implement the unit. I did not feel I should just address the concerns of a specific district, but I should highlight the implementation of what might benefit all teachers. A summary of the revisions made with a connection to the evaluation feedback can be found on Table 4.

TABLE 4. Summary of Revisions From Feedback

Area of Focus	Evaluation Feedback	Revisions
Ease of use for teachers	• Include standards • Timeframe	• NGSS included in each of the content lessons, but not in the process lessons • Created a graphic organizer • Included details to help facilitate discussions to move them along
Support to include all learners	• Provide a consistent graphic organizer, sample rubric • Scaffolds for ELL or Special Needs	• Included a graphic organizer to Process Lesson One: Introduction to Argumentation • Included a basic rubric • Introduction to the use of science notebooks for supporting ELLs • Detailed check points for student understanding
Pertinence to all teachers, not specific school districts	• Create a lesson to bridge process and content lessons • Create a lesson on citing evidence • Create a lesson on the scientific method • Tie lessons in to DOK	• Introduction to the use of science notebooks and how it can help students organize all their information so that they may go back to it as a reference

Ease of Use for Teachers

One of the trends within the surveys was including state standards into the lessons. I did not feel it was prudent to add any standards to the specific argumentation process lessons. I feel that these lessons can address many standards and should be chosen by the teacher. For example, the process lesson for philosophical chairs targets speaking standard 1 for English Language Arts: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. Yet it can also address reading standard 1: Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text (NGA Center, 2010). However, NGSS standards were added to the science content lessons that do have specific performance expectations. Since this unit was designed for teachers to easily embed argumentation into their content lessons, I began there. I added details in each lesson that would help support a teacher to facilitate discussions so that students feel more comfortable with the process of argumentation. I gave examples of the types of questions that should be asked to help move those discussions along. I also included support for how to use the graphic organizer I created when needed. I included additional details about when teachers could use an item as a formative assessment to help support their teaching, as well as give the students feedback on their progress. Introducing the science notebook can also be helpful to any teacher as anecdotal evidence as to how students are responding to the focus questions. The teacher can pick up on trends within answers to determine what needs to be reviewed and can easily assess students.

Support to Include All Learners

Including a graphic organizer in the first process lesson alleviated the issue in regards to having strategies to support all learners. This place was a natural fit because the teacher can then use the same graphic organizer each time they ask the students to state a claim and support it with evidence. I also went back to the lessons and highlighted where the graphic organizer could be used to help students organize their information to create an argument. This not only supports the teacher, but it supports the students. The teacher can make multiple copies of the organizer and have the students fill it out and place it in their notebook any time they need to construct an argument. The students in turn have a consistent format to organize their information so that they may become successful at constructing arguments by being reminded of what should be included. I grappled a bit with how I wanted to create it so that it did not plagiarize what someone else had already created. Being trained as a teacher in LBUSD, I wanted to use a thinking map or a frame that is often used in G.A.T.E. classrooms. It also took me some time going over some samples of claims to create what would be most effective. Once again, I also feel that the use of notebooks supports all learners in that it contains notes, vocabulary, investigations, graphic organizers and the students' thoughts as it evolves through discussions. A successfully carried out structure in a notebook can become a useful study tool for students. They can be helped along by going back and re-reading what was done in previous investigations and to go back and review what data has already been collected when looking for evidence to support their writing.

Pertinence to All Teachers, Not Specific Districts

Upon re-reading the unit after I categorized the responses, I decided to include a short introduction on the usefulness of science notebooks. I understood their concern in regards to scaffolding instruction for ELLs, especially when it includes content-related vocabulary. Research shows that the use of notebooks can be beneficial to English Language Learners, exposing them to daily writing and speaking experiences (Amaral, 2002). The use of notebooks addresses the need to include lessons on vocabulary or the creation of lessons to bridge from process to content. Students can go back and refer to the vocabulary used in each lesson to include in their argumentation. Teachers can embed a variety of thinking maps, graphic organizers, and diagrams within the notebook to support students understanding of content as well as the use of new vocabulary. The notebook can be used to address all levels of learners and can be used as a tool for guiding teaching as well as for assessment. It is a tool that all teachers should implement when teaching science content so that it can enhance students' construction of knowledge.

I then included a sample of a rubric that can be used. This rubric can be modified to fit different assessments so that a teacher can include specific information to fit the content being taught. Although I wanted to originally include a sample rubric in the unit, it took me some time to construct it so that it could be modified to include the content. I also wanted to make sure that the rubric helped the teacher assess the child not by a number, but by an ability level. Identifying a student as a novice in constructing arguments is more helpful than assigning them a number such as 1 or 0, which can negatively affect a child's further attempt at constructing an argument. It can also help the teacher target what area that child needs help in.

Conclusion

The results suggest that teachers are still very dependent on centering their teaching on a specific standard, front-loading vocabulary, and are still tied to a time frame. When writing curriculum, one should keep this in mind. Although all teachers suggested that the unit was at an appropriate level of rigor for students in fifth grade, they did express a valid concern for making sure that specific rubrics and graphic organizers specific to argumentation were included so that all levels of learners were addressed. Upon going through this unit, I felt that I should have included a question in regards to the conceptual flow for argumentation. The teacher feedback focused on the content lessons without any opportunity to comment on how those lessons fit onto the conceptual flow. My goal was to create lessons that would help a teacher embed argument into any content unit, yet I failed to ask them to evaluate that portion. My next steps would be to actually use this conceptual flow in the classroom with the curriculum that is in current use at schools in order to evaluate whether the students are able to evolve in their understanding in successfully writing an argument at the expert level.

APPENDICES

APPENDIX A

SURVEY QUESTIONS

1. Is this appropriate for a 5th grade classroom? Would it work? What parts might not work?

2. Could this be easily implemented? Would any teacher be able to pick this up and use it, no matter their experience?

3. Is the unit rigorous? Too, Rigorous? Please explain.

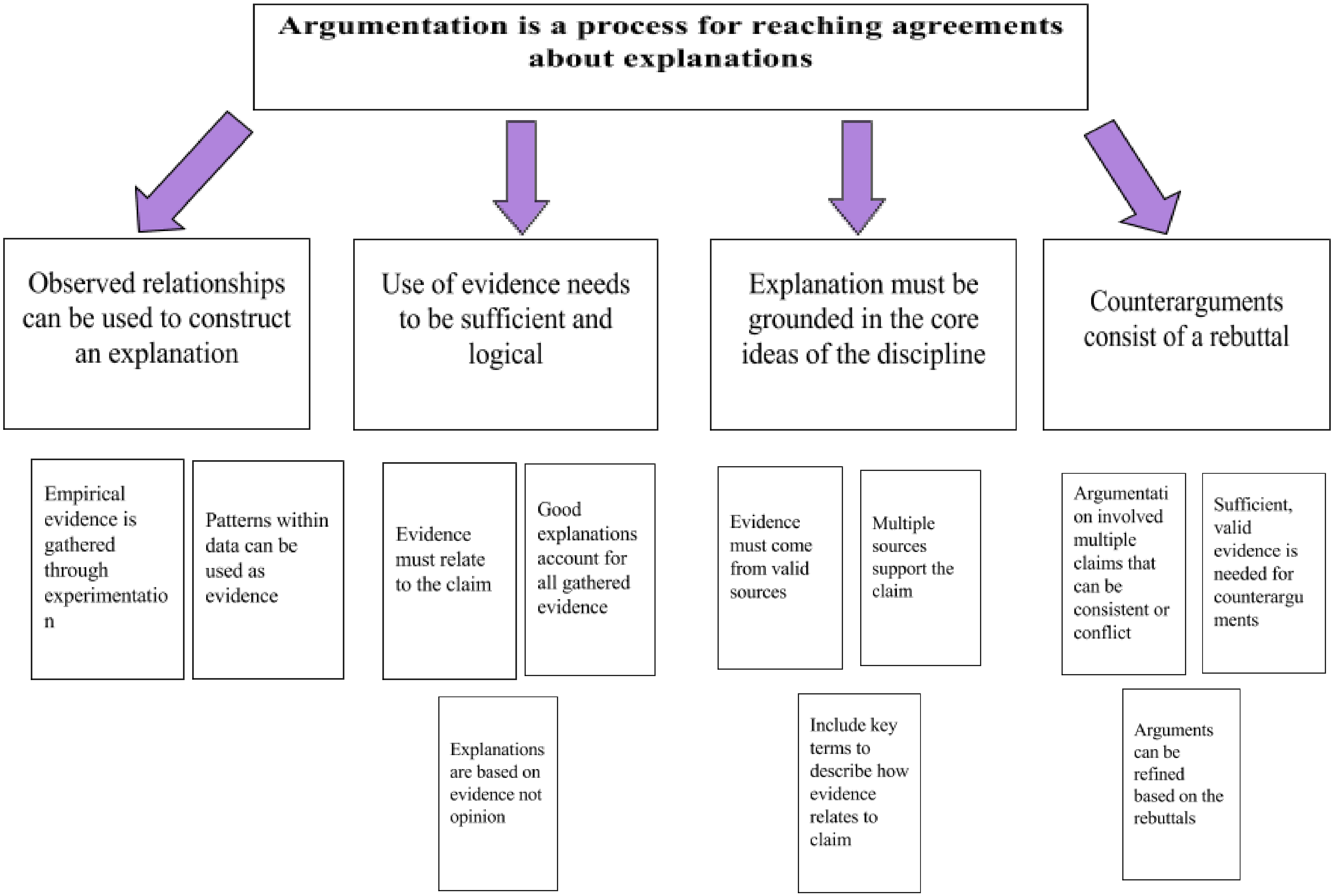
4. Can you see how formative and summative assessments are built within the unit?

5. Is there enough support for students with special needs such as ELL's?

APPENDIX B

EMBEDDING CLAIM, EVIDENCE, AND REASONING INTO YOUR CLASSROOM

Table of Contents


Argumentation is a process for reaching agreements about explanations
Observed relationships can be used to construct an explanation
Use of evidence needs to be sufficient and logical
Explanation must be grounded in the core ideas of the discipline
Counterarguments consist of a rebuttal
Empirical evidence is gathered through experimentation
Patterns within data can be used as evidence
Evidence must relate to the claim
Good explanations account for all gathered evidence
Explanations are based on evidence not opinion
Evidence must come from valid sources
Multiple sources support the claim
Include key terms to describe how evidence relates to claim
Argumentation involved multiple claims that can be consistent or conflict
Sufficient, valid evidence is needed for counterarguments
Arguments can be refined based on the rebuttals

Utilization of the Conceptual Flow

Teaching students how to create scientific explanations during a unit of instruction can get quite tricky. I created the conceptual flow on the previous page to help guide teachers through the process. Any set of content lessons that are used throughout the year should be able to be placed on this conceptual flow. For example, all of the content lessons I chose for this unit are gathering empirical evidence, but the teacher can start to pick and choose which lesson is best related for what part of the process of creating an argument. I could choose Investigation 2: Part 1 as the lesson where I discuss patterns. I can go in depth about the grams of salt it took each group to saturate 50 ml of water. This piece of evidence can then be used as a property of salt that can be used in a formative or summative assessment. This conceptual flow and the process lessons should be used to strengthen your comfort level when implementing argumentation in science.

Rubric for Assessment

Component	Level		
	Beginner	**Novice**	**Expert**
Claim-a conclusion that is written as a statement that answers a question, problem,or explains a phenomena	Does not make a claim or makes a claim that is unrelated to the topic/concept	Makes a vague statement or attempts to state a conclusion that is related to the topic/concept	Makes an accurate and complete claim
Evidence- Scientific data that supports a claim. The data needs to be appropriate and sufficient to support the claim	Evidence not provided or provides inappropriate evidence	Provides one or two pieces of evidence that supports the claim.	Provides multiple pieces of evidence that supports the claim
Reasoning- a justification that connects the evidence to the claim.	Does not provide reasons that connect the evidence to the claim or provides reasoning that does not connect the evidence to the claim	Makes a connection between the evidence and the claim, but does not detail how the evidence supports the claim.	Makes strong connections between the multiple pieces of evidence and the claim

This rubric should be modified to fit your assessment. Specific types of information should be included in a rubric, such as "Gravel and water create a mixture, but not a solution since the gravel did not dissolve in the water." This could be placed as an example of a novice level of reasoning.

Science Notebooks

The science notebook is an integral component in teaching the process of argumentation. Students should be able to go back and look up data from previous experiments as well as document their process of thinking. Notebooks can be used to explore prior knowledge, document small group investigations, and frame their understanding of scientific concepts. Science notebooks also provide a support for English Language Learners to have multiple opportunities to write, develop their conceptual understanding, and increase their vocabulary.

You the teacher can then in turn use the notebooks to assess student understanding. These can be used for formative as well as summative assessments. It can provide a review for students for exams as well as document how their writing and thinking changes. As you review notebooks, you can also provide the students with feedback and it can help inform your instruction.

It is ultimately up to you on how you set up your notebook, but I have found that if you do the following, you can help students stay organized and absences won't incur a problem:

- Reserve two pages for a table of contents
- Number your pages in advance, if they run out of room use post-it notes or staple additional paper
- Use the right side for teacher notes, procedures, or handouts
- Use the left side for student observations, data tables, diagrams, scientific explanations, graphic organizers

Numbering the pages and constantly filling out the table of contents gives you and the students the ability to look back at previous work. For example, we took notes on cell functions on page 52 and drew a diagram of a cell on page 51. Let's go back and see which cell structure provides energy.

Process Lesson One: Introduction to Argumentation

Synopsis: This lesson gives some general direction on an effective way to introduce the process of argumentation to your class. It can be used during an ELA block if need be since they are reading expository text. It is a 5E lesson plan, but it can be adapted whatever format your school uses.

Engage

Find a science article that introduces a new discovery and read it out loud to your students. You want to choose and article that can identify how they:

- Collected evidence
- Found patterns
- Formed a conclusion

Sample Article: Scientists Discover Spectacular Ruby-Red Seadragon

DOGOnews.com

Explore

Discuss the article and identify the above points with your students. Your goal is to assess their prior knowledge of the scientific process. Do they know how to identify evidence? Ask them to pick out parts of the article that address these important points. Make a class chart that identifies what evidence was collected, any patterns, and the final conclusion in the article.

What was the claim the article is making?
What evidence did the article use to make that claim?
Are there any patterns in the evidence or how the evidence was used?

Explain

In their science notebooks, ask the students to write down the following vocabulary:
Argumentation: the process used for the defense of an idea or a set of ideas
Argument: a statement that coordinates evidence and theory to support or refute a claim
Parts of an argument

1. **Claim:** a conclusion that answers the original question
2. **Evidence:** scientific data that supports the student's claim that must be appropriate and sufficient
3. **Reasoning:** why/how the evidence supports the claim

<u>Explore</u>

Ask the students to go back to the article and highlight the claim, the evidence to support that claim, and the reasoning.

After about 5 minutes ask them to discuss what they found with someone else.

<u>Explain</u>

Introduce the graphic organizer you will be using to help them organize the parts of an argument that they found within the article. Let them know they will be organizing the information they found with you.

<table>
<tr><td colspan="3">Claim: (What was discovered?)</td></tr>
<tr><td>Evidence: (How do they know?)</td><td>Evidence</td><td>Evidence</td></tr>
<tr><td colspan="3">Reasoning: (How does the evidence relate to the claim?)</td></tr>
</table>

Evaluate

Once you finish completing the chart, ask the students to attempt to write the **argument** for that discovery in their notebooks. This must include the claim, evidence and reasoning that is included in the article. Let them do this together. It helps to collaborate.

Extend *(This can be done another day if limited on time)*

Hand out short science-based arguments to groups of students so that they may discuss whether the arguments are complete or not. They must identify the claim, evidence, and reasoning. Make copies of the graphic organizer so that they can tape or glue them into their notebook and ask them to fill it out with the information they find.

Teacher Note: *Be sure to walk around and listen to discussions. Help students with this process by asking them open-ended questions that can guide them. For example, "That is an interesting claim. Where in the article does it say that?"*

Process Lesson 2- Constructing an argument
Day 1: Introduction to Philosophical Chairs

Synopsis: This lesson introduces philosophical chairs, which is a format used to help students have a discussion where they are all given a chance to participate. It is structured so that they are encouraged to be respectful of everyone's thoughts and opinions, as well as encouraging them to use academic language.

Philosophical Chairs Procedure:

1. Teacher assigns a reading
2. Teacher poses a statement and asks students whether they agree or disagree with the statement. They can also be undecided
3. Teacher asks students to sit on different sides of the room based on what they chose. Undecided students need to be able to face both groups
4. Teacher goes over rebuttals and how to respectfully disagree with their peers. They don't have to raise their hand to talk, but must use academic language.
5. Ask all sides to prepare for the discussion by going over the evidence from the article. Everyone in the group must talk at least once. Statements must address the previous speaker. The undecided folks will prepare by creating a t-chart where they will keep track of the evidence presented by both groups that they will use to choose a side by the end.
6. Teacher's role is to facilitate the discussion. Make sure everyone is being respectful and no one is interrupting. Move the discussion along by referring to what a student said or going back to the statement and asking what in the text made them choose their position. You want to keep the group focused on the article and the evidence, encouraging students who haven't spoken to speak. The teacher determines when the discussion is over.
7. **Exit slip:** Every student must write down their position and hand it in to the teacher. They must state their claim (whether they agreed or not), evidence, and reasoning.

Suggested Resources: Tweentribune.com, timeforkids.com, DOGOnews.com, any local newspaper

Article: A Humanoid Robot To Debut At Japan's Mitsubishi Bank
By: Meera Dolasia
DOGOnews.com
Statement: Companies should not employ robots because it would take jobs away from humans who need the money.

Teacher Note*: If there are too many students in one category, you can assign them a side and be able to defend it. Be sure to choose at least 3 students to be neutral, so that they can judge based on the evidence presented by both sides.*

Engage
Read the article together and then project the statement

Explore
Ask the students to discuss the statement in small groups, walk around and help discussions along.
Why do you agree with the statement?
Did the information from the article change what you first thought?
What information from the article convinced/strengthened your opinion?

Explain
Tell your students they need to decide whether they agree or disagree with the statement. Discuss what was talked about in the small groups. Create a graphic organizer such as a t-chart for the pros and cons of employing robots. Ask them to go back to the article and look for evidence that supports either the pro or the con and make a decision.
Give them about 10 minutes to completely go through the article and decide.

Engage
Divide up the class by agree, disagree, and neutral. Ask them to talk to each other and make a chart of evidence that supports their position. Ask them to do a bit of research to support their position. They must add at least two more resources. They can include interviewing working adults what they think about robots being employed. Hand out the graphic organizer from the previous lesson and ask them to come to the discussion with this filled out so that they can refer back to it.

Teacher Note: Try to have on hand supplemental resources and websites for them to utilize

https://hbr.org/2014/12/what-happens-to-society-when-robots-replace-workershttps://hbr.org/2014/12/what-happens-to-society-when-robots-replace-workers
https://hbr.org/2014/12/what-happens-to-society-when-robots-replace-workers

Process Lesson Two- Constructing an Argument
Day 2: Philosophical Chairs

Evaluate

Go through steps 4-7 Philosophical Chairs. Ensure all students write down their thoughts on at least two points they heard any of the other students state before ending the session. End the session after no more than 20 minutes. Make sure that everyone turns in an exit slip.

Extend

Once you have read what they wrote, ask them to go back and revise. Remember to question the student's logic so that they further develop their explanation. Any claims you feel need more support should be discussed with that student. You can also direct them to other students for peer support.

Teacher Note: The first three times you do this, spread it out between two days: one day for reading the article and researching, the next day for the discussion. This should be done monthly so that students can have an opportunity to practice connecting the evidence to the claim, which is reasoning. **This is the most difficult for students to understand.**

Process Lesson 3- Counterargument

Synopsis: In order for students to become experts at writing an argument that includes evidence to support their claim, they need to be able to discuss why other alternatives are not an option. This lesson helps them practice forming a rebuttal to also help support their claims.

Engage

Construct an illogical argument that your students will feel strongly about. For example, "I am canceling recess because it is not educational. You can play at home and you need every minute in school to concentrate on academics." You want to pull your students attention in so that they want to deconstruct your argument.

Explore

Ask your students to work in groups and find the holes in your argument. In other words, pick apart your argument and find a way to change your mind.
Can you think of ways that recess can be educational?
Does the cancellation of recess also include the cancellation of P.E.? Why? Why not?
Is every minute necessary for academics?

Explain

Once you have given your students an opportunity to come together to change your mind, explain that in the scientific community, scientists go through this process when they need to defend what they have discovered. They must be able to support their findings against what the scientific community already holds as true.

Rebuttal: recognizes and describes alternative explanations, and provides counter evidence and reasoning fro why the alternative explanation is not appropriate

Evaluate

Hand out short concepts that have historically been argued in science to each group and ask them to construct the argument that went against popular belief at the time. Some of the questions they should consider are as follows:

- What was the new idea?
- What was the rebuttal from the well-established idea?
- What evidence did the person with the new idea present to counter the well-established idea?

Some examples of famous arguments:

- Galileo's heliocentric universe
- Theory of Plate Tectonics
- Extinction of the Dinosaurs
- Evolution
- What makes a planet (Pluto)

Extend

Never underestimate the power of reading out loud to your students. Many biographies of scientists give students food for thought in regards of how their discoveries came about. Robert Hooke and his conflict with Sir Isaac Newton also provide an interesting discussion of who should get credit when sharing ideas. This could strike a nice debate.

Investigation 1: *Separating Mixtures*
Part 1: Making and Separating Mixtures

NGSS 5-PS1-3 Make observations and measurements to identify materials based on their properties

<u>Engage</u>
Introduce the three solids that the students will be exploring- gravel, powder, and salt. Ask the students what they know about the three. Let them know that they will be exploring the physical properties of the three materials. Encourage them to touch, but not taste the materials and remind them that we describe objects with the use of our senses.

<u>Explore</u>
Have the material people pick up their materials: three cups, three sticky notes, and one spoonful of each solid. Have the recorder label the cups G (gravel), P (powder), and S (salt). Allow four minutes for the groups to observe the materials with hand lenses and discuss the properties of each.

What is similar about the materials? Different?
What do the materials look like? feel like?
Do the materials look different under the hand lens than without it?

<u>Explain</u>
Ask students to describe their observations. During this time you can provide additional information about the solid materials. Ask students to write down some of the physical properties (use of the 5 senses) of the material in their science notebook.

***Ask*:** What do you think might happen if you add water to each cup containing the dry materials?

<u>Explore</u>
Let the students share their ideas. After about 2 minutes, ask a different material person to pick up a syringe, three stir sticks, a container of water and a paper towel. They should then hand out the materials so that three different group members have the supplies needed to make a mixture out of the previous solids.

Use the syringe to add 50ml of water into each cup, stir the contents with a stick, observe what happens, and record it in their notebook. Remind students to share their observations with their group and record what happens in each cup. Give the students about 5 minutes to share their information.

What is now happening in each cup?

Explain

When you put two or more materials together, you make a mixture. Create a class chart with the heading “mixture” and sub headings: G, P, and S. Ask the students to describe what happened in each cup and write it down on the class chart. Help the students use their observations to define what a mixture is and add it to the chart.

Focus Question: **How can a mixture be separated?**
Give the students about 3 minutes to share their ideas with each other and then discuss with them.

Explore

Introduce the screen and go over the procedure for using it. Have a different materials person pick up and label a second set of three cups. Ask the students to stir the mixtures thoroughly, then using the second cup with the corresponding label, pour the mixture through the screen. They must do this for each cup. Ask them to record what happens.

Ask: **Which mixtures were you able to separate?**

Introduce the filter paper and how to use it. Have a different materials person get one funnel and two filter papers to hand out. They should try to filter the powder and water and salt and water mixture. Ask them to carefully open up the two filter papers and spread them flat on a paper towel and the table and find out which of the two they were able to filter. Make sure they are recording what happened.

Explain

Introduce the words solution, dissolves, and transparent. Ask the students to tell you what they think these words mean or give you examples of what they think they mean. Then explain that the salt dissolved in water to make a saltwater solution and that the solution is transparent or clear.

Introduce solute and solvent to describe the parts of a solution. Ask the students to include the parts of the experiment as examples of the vocabulary words. Go back to the focus question, discuss, and ask the students to write down an answer to the focus question in their notebook: Which mixtures were you able to separate?

Link to argumentation

Explain to the students that by making observations, recording the physical properties of different materials, and observing how they react when mixed with other substances they gathered empirical data that they used to create an explanation in order to answer the focus question.

Evaluate

Collect student notebooks and read their answers to the focus question. Respond to their answers letting them know whether they are correct or if they need to add to their answer. Try using open-ended questions to help lead them to their answers. For example, "When you used the filter paper, which substances were you able to filter? Why?" This prompts them to look back at their data and add to their explanation by answering the question you asked.

Investigation 1: *Separating Mixtures*
Part 2: Separating a Salt Solution

NGSS 5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Engage

Ask students to recall what mixtures they made in part 1. Ask:

- What is a mixture?
- How can it be separated?

Explore

Focus Question: **Where does the solid material go when a solution is made?**
Which was the solute? solvent?
Can you give me more detail about where the solute went?
Does it go somewhere?

Allow the students some time to talk with their group members and ask them to share out.

Explain

Tell the students:
Today you will be investigating salt solutions from a scientific perspective. Everything will be measured precisely in order to collect evidence. First, we need to determine the mass of 50ml of water.

Demonstrate weighing 50ml of water on a balance.
a. Put two cups on the balance and zero the system
b. Use a syringe to put 50 ml of water in one cup
c. Using the 1-gram pieces, have students ad pieces (5 at a time) until balance is achieved

Explore

Ask the materials person gather a cup of 50ml of water and one spoon of salt. The students will repeat the same procedure to find the mass of the salt water. Make sure to tell them to mix the salt and water until the salt is completely dissolved.

After about 3 minutes, ask the students to write down the mass of the saltwater solution and discuss what they found out.
Is the mass the same, more, or less

Explain

Ask the students to go back to the focus question. Explain that they have gathered some important data that they can use to make a comparison between how much water weighs and how much salt water weighs.

Link to argumentation

Ask the students to make a claim that answers the focus question. Where did the salt go? How do they know it is still present in the solution and it didn't just disappear? Review claim, evidence, and reasoning from Lesson 2-Constructing an Argument. Feel free to include the graphic organizer to glue into their notebook to help them organize their information.

Explore

Let the students share their ideas. After about 2 minutes, remind the students that mixtures can be separated. Ask them how they think they can separate the saltwater solution.

If students don't offer evaporation, suggest using it to and have the groups set up evaporation trays. Groups should label a piece of paper to place in the dish and pour about 25ml of the saltwater solution into it.

When the saltwater solutions have evaporated, let the students observe the salt in the dishes. Provide a hand lenses for observing and introduce crystals. Ask them to write down those observations.

Explain

Let them know that what was left behind is another piece of evidence that they can add to answer the focus question from part one: **How can mixtures be separated.**

Evaluate

Ask volunteers to share their claims. This is a good opportunity to model how to use a rubric so that students can also evaluate whether they have come up with a strong explanation. Go back and read the two focus questions. Tell the students that they will use the discussion as well as the rubric to evaluate each others claims. Ask them to make sure the claims they evaluate includes vocabulary words to describe, as well as use the data from the labs as the evidence. Remind the students that a solid claim links the answer to the focus question and the evidence used. Ask the them to offer their classmate a suggestion.

Collect the notebooks and evaluate the feedback received from classmates, offer your own if needed, look for trends in the answers. Do you need to reteach a concept?

Investigation 2: *Reaching Saturation*
Part 1: Salt Saturation

NGSS 5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Engage

Ask students:

- Where the solid material goes when a solution is made?
- What would happen if we added more salt to the solutions we made? Will he salt keep dissolving forever?

Explore

Focus Question: **How much salt can you dissolve in 50ml of water?**

Allow the students some time to talk with their group members and ask them to share out.
How much salt was dissolved in the previous investigation?
Can you pour the entire contents of a salt shaker into 50ml of water and expect it all to dissolve?

Explain
Tell the students:
Today you will be adding to our knowledge of salt solutions using precise measurements. We know the mass of 50 ml of water as well as 50ml of water with one spoon of salt.

Review the procedure
a. Each pair will get two bottles, but only one supply of salt, syringe, and funnel
b. Put 50 ml of water into each of the bottles
c. Use a small sticky note and place the bottom of the note right at water level
d. Add one spoon of salt in both bottles, and shake until the salt is dissolved, repeat, and tally spoonfuls

e. When no more salt will dissolve in the solutions, return the materials

Explore
Ask the materials person gather the materials needed and ask them to start their investigation.

Once you start seeing groups return materials, have them write their number of spoonfuls on a class poster.

Discuss as a class:
- *What happened to the salt?*
- *What happened to the level of the liquid?*
- *Why did the level go up?*
- *Are there any discrepancies in the number of spoonfuls of salt?* (this might include what teams viewed as a spoonful)

Explain
Tell the students:
You made a solution by dissolving solid material in a liquid. In this case the solution was salt dissolved in water. When solid material is added to a solution until no more will dissolve, the solution is a saturated solution. You all made saturated salt solutions.

Explore
How can we make this investigation more scientific?
What can we measure?

Guide the students to determine that they need to find out how many grams of salt were actually dissolved. They can do this by going back to investigation one and taking what they know about the mass of 50 ml of water as well as 50 ml of water with a spoonful of salt and how they figured that out.

Procedure:
a. Place a labeled cup under the funnel
b. Filter the solution using a wet filter paper. The saturated solution will pass through the filter; the undissolved salt won't.
c. Place the saturated salt solution on one side of a balance and 50ml of plain water on the other side
d. Add gram weights to the plain water to achieve balance. The mass added to the 50 ml of water is equal to the mass of salt dissolved in the 50ml of water used to make the saturated solution.
e. Record the number of grams of salt it took to saturate 50 ml of water

Evaluate

Ask the students to record the number of grams on the class poster and compare. It takes 10-15 grams of salt to saturate 50 ml of water. Discuss reasons for the variation in the results of different teams. Ask the students to write down their observation on the properties of saltwater solutions based on this lesson.

Link to argumentation

Remind them that they are continuing to add empirical evidence to what they know about saltwater solutions and this can be used to help support a claim.

Be sure to discuss with them that collecting evidence can help them create a convincing argument by using all appropriate evidence.

Let's list some properties of salt that we have learned through these investigations.

Investigation 2: *Reaching Saturation*
Part 2: Epsom Salt

NGSS 5-PS1-3 Make observations and measurements to identify materials based on their properties

Engage

Review vocabulary: solute, solvent, solution, and saturation

Explore

Tell the class you have a new substance for them to investigate. You can provide information for them to read as well as small cups for them to explore its properties.

Epsom salts is not used in food. It is used to make a soothing salt bath to soak sore feet.

Focus Question: **How can we find out how many grams of Epsom salts can you dissolve in 50ml of water?**

Let the students discuss what they should do. Many should suggest going back to the procedure they used for the saltwater solutions. If not, you can ask:
How did we find out how much salt could be dissolved in 50 ml of water?

Explain

Tell the students:
We want to investigate the properties of Epsom salts so before you get started create a chart that compares table salt to Epsom Salt. Use the same procedure as in the previous investigation in order to:
1. Find out how many spoonfuls will dissolve in 50 ml of water
2. How many grams that is

Explore
Ask the materials person to gather the materials needed and ask them to start their investigation.

Once you start seeing groups return materials, have them write their number of spoonfuls on a class poster.

Discuss as a class:

- What was the difference between spoonfuls of Epsom Salt compared to table salt?
- Discuss the reasons for the variation in the group's results. Was it closer in number than the previous investigation?
- What conclusions can be made from the results?

Explain

Introduce the concept of **solubility**:
An important property of a substance is how it dissolves in a liquid, such as water. The property of "dissolvability" is called solubility. Different salts have different solubilities. This is an identifiable property that can help you identify a substance.

Evaluate

Ask the students to write down:
Which substance was more soluble: table salts or Epsom salts?

They must include their new vocabulary words: solvent, solute, solution, saturation, and solubility. They must also use data to back up their claim. For example, grams or spoonfuls that dissolved in 50 ml of water.

Link to argumentation
Students are stating a claim, using their data as evidence to support their claim, while including key terms to construct their explanation. Use the graphic organizer to help them organize their data. Linking the data and explaining how it relates to their claim is their reasoning. Make sure they are making a connection between the data and their claim. Walk around and ask them to explain what they are thinking. Also let them discuss as a group what they will be writing.

Investigation 2: *Reaching Saturation*
Part 3: The Saturation Puzzle

NGSS Disciplinary Core Idea PS1.A: Measurements of a variety of properties can be used to identify materials
NGSS 5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances

Engage

Show students a cup of the mystery powder (citric acid). Tell them:
This white material was in the kit with the Epsom salts. I'd like you to figure out what it is. Since we are working with a mystery substance we need to wear protective eye wear.

Explain

Hand out Substance Data Sheet and explain that this sheet has some information about the properties of five substances, including salt and Epsom salt. Explain that each group will be responsible for creating a plan for investigating the mystery powder. They will have five minutes to formulate a plan, which needs to be approved before they get started. Once the plan is approved, they will have 25 minutes to gather the data needed to identify they mystery substance.

Explore

Let the students begin the investigation and only facilitate and assess progress:
How are you setting up your investigation?
What types of information can you use to solve this mystery?
Explain this to me a little more in detail.
Would looking back at the other investigations we have done help you?

Evaluate

When students have determined the amount of mystery chemical needed to saturate 50 ml of water ask them to write down what the mystery substance was in a complete explanation. Review that this includes stating their claim (what they mystery substance is), using their data as evidence to support their claim (grams it took to saturate 50 ml), describing using key terms, such as solubility and saturation, and using multiple sources to support their claim.

<u>Link to argumentation</u>

At this point students have collected enough data to use as evidence from multiple investigations. If there happens to be a student who disagrees on what the mystery substance is, let the students discuss it amongst themselves and to include this information as a counterargument within their argument. Ask them to include their rebuttal. This is a great summative assessment that not only assesses argumentation, but assesses what the students know about mixtures, solutions, setting up an investigation, and identifying substances by using their physical properties.

Teacher Note:

This lesson is going to become an anchor for when you introduce chemical reactions. They will be able to look back at their notes or recall that each powder has specific physical properties. This will help them determine later whether a new substance has been made.

Material	**Appearance**	**Amount needed to saturate in 50 ml of water**
Barium Bromide	Small white grain	52
Citric Acid	Small white grain	67
Epsom Salt	Small white grain	40
Salt	Small white grain	17
Sodium Acetate	Small white grain	26

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