An Examination of Oral Argumentation Using Socioscientific Issues Among Secondary Students with Disabilities

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AN EXAMINATION OF ORAL ARGUMENTATION USING SOCIOSCIENTIFIC
ISSUES AMONG SECONDARY STUDENTS WITH DISABILITIES

by

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ABSTRACT

AN EXAMINATION OF ORAL ARGUMENTATION USING SOCIOScientIFIC
ISSUES AMONG SECONDARY STUDENTS WITH DISABILITIES

Mindy A. Gumpert
Old Dominion University, 2019
Committee Chair: Dr. Robert Gable

The recent science education reforms mandate that all students must receive adequate opportunities to access the science curriculum in order to gain a better understanding of how science and the world works (National Research Council, 2012). According to these reforms, engagement in argumentation is one science practice essential to today’s K-12 science education (Sampson & Clark, 2011). Engagement in argumentation promotes critical thinking, problem solving and communication skills, and has the potential to promote growth of cognitive and metacognitive reasoning (Venville & Dawson, 2010). Additionally, engagement in argumentation using socioscientific issues provides students with authentic links to contemporary real-world social issues with substantive ties to science. Science education research in argumentation using socioscientific issues examines how typically developing students engage in this practice. However, there is scant research that addresses how students with disabilities engage in this form of argumentation. Accordingly, the purpose of this study was to examine critically the engagement of secondary students with disabilities in argumentation using socioscientific issues.

A multiple probe design replicated across three secondary science classes was used to examine the effects of explicit instruction on group and individual engagement in argumentation using socioscientific issues. Visual analysis and two non-parametric overlap methods (i.e., percent of non-overlapping data and Tau-U) were employed to determine treatment effect. The
results of this study were mixed. Several results were consistent with the way typically developing students engage in argumentation using socioscientific issues. Conversely, other results suggested that disability status, working memory, verbal comprehension, processing speed, and cognitive load may have impacted students’ engagement in argumentation. Conclusions drawn from the data include implications for future research and practice. Limitations of the study are also discussed.
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This dissertation is dedicated to my mother, Sharon, and my Nana. These two sisters overcame much adversity throughout their lives, demonstrating a strength of character to be admired. The older I have become, the more I realize how much their wisdom and fortitude helped shape the person I am today. I credit them for my work ethic, my resilience, my creativity, and yes, my sassiness. I know if my mom were alive today, she would be very proud of me. My hope is to be as inspirational to my children and grandchildren as these two remarkable women have been to me.
ACKNOWLEDGEMENTS

There are many people who have contributed to the successful completion of this dissertation. First and foremost, I need to thank my committee members for their unwavering belief in my research, their accessibility when I needed guidance, their brilliance in offering suggestions, and their high expectations for scholarly work.

My mentor and dissertation chair, Dr. Robert Gable, is the most scholarly individual I have ever had the pleasure of working with. His wealth of knowledge and ability to cite a researcher, regardless of the topic being discussed, is impressive. Equally impressive is his compassionate and kind demeanor. Many times over the course of the doctoral program I needed a shoulder to cry on. Dr. Gable always understood my angst and offered me practical advice for how to navigate through a myriad of issues. His advice always ended with, “Go have a glass of wine,” which I greatly appreciated. I feel humbled that Dr. Gable agreed to be my dissertation chair. I will strive to emulate his scholarly ways and the personal manner in which he interacts with students. Dr. Gable always makes me feel valued as scholar as well as person. I will be forever in his debt.

I would like to express my deepest gratitude to Dr. Peggy Hester, who has a heart of gold. I honestly believe Dr. Hester worked as hard trying to identify a research design for my prospectus as I did. We had several Sunday afternoon phone calls, brainstorming research designs then eliminating them. I thought we had figured out the perfect research design, then I received an email that Dr. Hester wrote at 1:35 a.m. stating, “I know you do not want to wake up to this, but that design will not work.” I could not have made it through the “summer of my prospectus” without the guidance of Dr. Hester. Further, Dr. Hester received a grant to fund the
doctoral program for students. When the funds were exhausted, she resubmitted the grant proposal. Her tenacity in writing, getting rejected, resubmitting, revising, getting rejected, resubmitting (nine times now, I believe), is inspirational to me. I will always remember Dr. Hester’s stories about the grant submissions and as a result will never give up when I believe in something as strongly as Dr. Hester does in the doctoral program at Old Dominion University.

Early in my doctoral studies, Dr. Tonelson was the only person who asked me about my research agenda. I remember giving him a detailed description of my plan and he replied, “That’s a terrible idea.” I was taken aback by his response, but as I listened to him explain why my research agenda was a terrible idea, I began to realize he was absolutely right. Dr. Tonelson really understood what I wanted to do in the future and gave me suggestions for how to achieve those goals. It was that interaction and observing Dr. Tonelson in meetings that made me appreciate what an out-of-the-box thinker he is. I remember asking Dr. Gable, “Do you think I should invite Dr. Tonelson to be on my dissertation committee? I mean, he’s a loose cannon, but I like him.” Dr. Gable thought for a few moments then replied, “Well...I don’t believe anyone has ever called Steve a loose cannon before...but you’re right.” So thank you, Dr. Tonelson, for giving me great advice for my future endeavors and being my loose cannon.

I must also thank my friend and colleague, Dr. Billy McConnell. Words cannot convey my appreciation for his mentorship over the years. Oftentimes it was tough navigating the blurry line between personal and professional friendship. I did not always appreciate the colleague being critical of my work, rather I wanted a friend to say everything I did was great. However, being the true professional that he is, and knowing more so than I did what was in my best interest, Billy never shied away from offering critique that at times seemed harsh to me.
In retrospect, I realize what a great friend and colleague he has been over the years, and that his presence throughout my doctoral program helped shape me into the scholar that I am today.

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Last, but certainly not least, I must thank my family for their support. I remember coming home from work one day in June and telling my husband, Bart, that I wanted to resign from teaching and become a full-time doctoral student. He looked at me quizzically then said, “Okay.” I do not believe many husbands would so readily agree to such an unusual request. Bart’s unwavering support over the years helped me navigate through unchartered territory time and time again. I remember literally crying while Bart patiently wrote formulas on a white board trying to teach me statistics. He read every chapter in my statistics books before I did, so he could explain what I consider the inexplicable, ridiculous information to me. He never complained when I wrote papers or did homework at baseball games, on our boat, at the beach, on vacation, in the car on road trips, or in hotels. I took work with me wherever we went and Bart just accepted that as our new norm. He learned SPSS to help me with my Pilot and dissertation research. He attended conferences with me and always found great places for us to eat to celebrate the successful completion of my presentation. He cooked dinner almost every night for the past three years while I sat at my desk banging on the keyboard of my laptop. I could go on and on, but suffice to say, I never would have made it through the doctoral program without the support of my amazing husband, Bart.
I need to also thank my children Candace, Jessica, and Bartie and my sons-in-law, Sean and Scott. They collectively were the best cheerleaders a person could ever have! Whenever I got discouraged their response was, “You’ve got this, Mom,” or “You can do it!” The girls offered me tech support on a regular basis and my son, Bartie cheered me on from the West Coast. Finally, thank you to my grandchildren David, Tyler, and Margot for always making me smile. David said recently he can’t wait to have a Dr. Pop Pop and a Dr. Nana in the family. I concur. Thank you to everyone for your unwavering support and love as I pursued my dream.
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CHAPTER 1

INTRODUCTION

Chapter one describes new science education reforms that state all students must be provided adequate opportunities that promote scientific understanding in order to increase their knowledge of how the world works (Mastropieri et al., 2006, National Research Council [NRC], 2012). One practice deemed essential to contemporary K-12 science education is engagement in argumentation, which promotes critical thinking and problem solving (Sampson & Clark, 2011). Engagement in argument using socioscientific issues (SSI) offers a way to develop student participation in argument by allowing students not only the opportunity to consider and evaluate evidence and apply critical thinking skills, but to develop positions on various SSI (Cavagnetto, 2010; Sadler, 2004; Zeidler, Walker, Ackett, & Simmons, 2002). Notably, students with disabilities (SWD) may have difficulty engaging in the process of argumentation due to deficits in executive functioning ([EF]; Gropen, Clark-Chiarelli, Hoisington, & Ehrlich, 2011). There is insufficient research on SWD and engagement in argument in general, and engagement in argument using socioscientific issues (SSI) specifically. This chapter will provide an overview of the problem, a rationale for the study, a statement of the purpose, and will include a glossary of key terms.

The expansion of contemporary understandings in science education over the past 15 years has necessitated the development of a new conceptual framework for science (NRC, 2012; Next Generation Science Standards [NGSS], 2013). According to the NRC (2007) the nature of science education and what it means to “know” science have changed significantly. Researchers developed the NGSS from the new conceptual Framework for science. One goal of the NGSS (2013) is to improve student interest and engagement in science through inquiry-based activities
and experiences. This engagement allows students to acquire a richer understanding of how to apply science to their daily lives. However, a paradigm shift is needed from the emphasis on student learning as a series of discrete facts through memorization of a body of knowledge, to an emphasis on students’ engagement in authentic science practices (NRC, 2012).

**Argumentation in Science Education**

Engagement in argumentation, commonly defined as an assertion, or claim, made in conjunction with a justification (Driver, Newton, & Osborne, 2000; Toulmin, 1958), is a key component to scientific literacy (NRC, 2012). Students construct new knowledge when they offer rebuttals and counterarguments requiring them to compare and contrast information and examine different points of view (Osborne, 2010). The merger of old ideas with new understandings allows students to construct and reconstruct not only their own knowledge, but also examine new meanings (Berland & McNeill, 2010). Duschl and Osborne (2002) suggest that a classroom devoid of argumentation hinders students’ learning, thus making a strong case for promoting argumentation in the science classroom.

Engaging in argument from evidence is considered an authentic science practice (NGSS Lead States, 2013). Included in the NGSS is the expectation that starting in kindergarten all students will construct and critique arguments and make claims based on evidence collected (NGSS Lead States, 2013). This engagement improves critical thinking and problem solving, communication, and reasoning abilities (Sampson & Clark, 2011; Zeidler & Nichols, 2009). Moreover, it has the potential to promote growth of cognitive and metacognitive reasoning, development of scientific literacy, and practices of the science culture (Jiménez-Alexandre & Erduran, 2008; Grooms, Sampson, & Enderle, 2018).
Engagement in argumentation is an inquiry-based activity that offers students the opportunity to participate in discourse on real-world problems, collaborate with peers to develop reasoning and communication skills, and learn about science in a non-traditional manner (Berland & McNeill, 2010; Driver, Newton, & Osborne, 2000; Sampson & Clark, 2011). During argumentation sessions, the teacher facilitates students’ learning by guiding discussions rather than providing explicit instruction. This practice allows students to form and communicate their own opinions based on their knowledge of science and their personal connection with the SSI presented.

The topic, process, and goals for argument are determined by the type of argument students engage in, either scientific argumentation or argumentation using socioscientific issues (SSI). Both types of argument share similarities (e.g., claim, evidence, use of persuasion) yet have distinct differences (e.g., topic, process, goals). Engagement in argumentation using SSI was the focus of the dissertation research and is described in the subsequent paragraphs.

**Socioscientific Issues**

Dewey (1916) stated that it is crucial that young people are educated to construct and analyze arguments relating to the social applications and implications of science. Over 25 years ago researchers (Norris & Phillips, 1994; Solomon, 1991) suggested that the paucity of argument opportunities in science education failed to empower students with ways to examine critically important SSI in their everyday lives. In their seminal article, Driver, Newton, and Osborne (2000), contended that a consideration of contemporary issues and disputes is essential in science education. Driver and colleagues (2000) suggested it is through argumentation that students develop the confidence and skills in argument that are necessary for making informed life decisions and contributing to a democratic society. Additionally, through the process of
argumentation students are provided a more authentic image of what is involved in science inquiry. Several educational scholars (e.g., Davies, 2004; Hodson, 2003; Roth & Lee, 2004) suggested that science education is questionable when the focus is on science in the school context without regard to links beyond the school. Simply stated, science education must include practical application to students’ lives. According to Lederman and Lederman (2014), a scientifically literate person must have the ability to make informed decisions about SSI. One solution to provide a link between science and students’ everyday lives is engagement in discourse on SSI (Sadler, 2004).

Socioscientific issues are contemporary issues that incorporate two main elements: connections to science content and social significance (Eastwood et al., 2012). The issues are ill-structured and may have multiple solutions, or uncertain solutions. Students must not only assimilate scientific data and knowledge, but also must consider economic, social, ethical, and moral aspects of the issue (Eastwood et al., 2012; Kuhn, 1991; Ratcliff & Grace, 2003; Sadler, 2004; Zeidler, 2003; Zeidler & Nichols, 2009; Zohar & Nement, 2002). These ill-structured issues tend to be controversial in nature due to their connections to society (Sadler & Zeidler, 2005). The issues can range from local environmental problems to energy sources, to questions concerning healthcare (Eastwood et al., 2012; Sadler, 2004; Zeidler & Nichols, 2009). One outcome of engaging in argument using SSI is for students to develop an opinion and engage in discourse about issues and problems that affect their lives by addressing real-world, social issues with substantive ties to science (Driver, Newton, & Osborne, 2000; Ratcliff & Grace, 2003; Sadler, 2004; Zeidler, 2003; Zeidler & Nichols, 2009; Zohar & Nement, 2002).

Engagement in argumentation using SSI not only allows students to focus on contemporary social issues that require scientific knowledge, but also requires informed
decision-making and the ability to discern reliable evidence and data (Zeidler & Nichols, 2009). This type of engagement offers students a way to practice critical thinking and problem solving by using their knowledge of science to discuss and debate authentic problems occurring in their everyday lives (e.g., environmental issues, genetically modified organisms; Dawson & Carson, 2017). A focus on real-world issues improves students’ engagement in argumentation by connecting science to their everyday lives. Further, it allows students to understand there is a human element to the practice of science, dispelling the notion that only scientists engage in science practices (Evagorou, Jiménez-Aleixandre, & Osborne, 2012).

**Framework for Socioscientific Issues-Based Education.** The Framework for Socioscientific Issues-Based Education informed the dissertation research by identifying essential elements for student engagement in argument using SSI in a science classroom. The framework includes three concentric circles placed around the center circle that is labeled Socioscientific Issue (see Figure 1.1).

![Figure 1.1 Graphical Representation of Socioscientific Based Framework](image)

**Figure 1.1.** Important factors that shape SSI education. Adapted from “A Framework for Socioscientific Issues Based Education,” by Presley et al., 2013, *Science Educator*, 22, p. 28.
The inner layer of the circle includes Design Elements, Teacher Attributes, and Learner Experiences which are three core characteristics of the framework. Design elements incorporate four essential features

- identifying a compelling issue and creating instruction around it;
- presenting the issue prior to SSI-based instruction to provide an authentic context;
- providing scaffolding for higher order practices such as engagement in argumentation;
- allowing students to integrate their new-found knowledge with their prior knowledge and relate both to the SSI (Pressley et al., 2013).

Teacher attributes consist of

- being knowledgeable about the issue, yet honest about the limitations of knowledge;
- willingness to act as a knowledgeable contributor rather than an authority;
- awareness of social considerations (e.g., economic, moral, ethical) inherent in the issue (Pressley et al., 2013).

Learner experiences and opportunities encompass

- engaging in higher-order practices (e.g., reasoning, argumentation, decision-making);
- relating the issue to scientific ideas and theories;
- collecting and/or analyzing scientific data related to the issue;
- debating social facets related to the issue (Pressley et al., 2013).

The middle circle, Classroom Environment, subsumes the core characteristics and incorporates essential features such as
• high expectations for student engagement;
• collaborative and interactive environment;
• providing a safe environment and one of mutual respect between students and teacher (Pressley et al., 2013).

The outer layer of the SSI framework is *Peripheral Influences*. They influence significantly the impact the inner layers and are comprised of

• support and encouragement for teachers implementing SSI instruction (e.g., access to materials, curriculum flexibility);
• awareness of local community issues;
• strategies for addressing concerns of SSI-based instruction;
• connections between local and state SSI-based curricula (Pressley et al., 2013).

The Socioscientific-based framework informed the current dissertation research and illustrates how argument using SSI was incorporated into a science classroom.

**Problem Context**

**Students with Disabilities and Science Education.** Research indicates that a gap exists in science achievement between students with and without learning disabilities and, based on assessment results, the gap continues to widen over time (Morgan, Farkas, Hillemeier, & Maczuga, 2016). The Individuals with Disabilities Education Act (IDEA, 2004) and the Every Student Succeeds Act (ESSA; 2015) mandate that students with disabilities (SWD) are held to the same high educational standards as their typically developing peers. The expectation is that SWD will attain a similar level of proficiency as their classmates without disabilities. Additional national initiatives (i.e., Common Core State Standards, NGSS) mandate *all* students, including SWD, are held to a high educational standard (Mastropieri et al., 2006) As a result of these
mandates, the emphasis on content area instruction is a major priority in education (Lee, 2017). This new emphasis poses difficulties in science for SWD who struggle to keep up with the demands of the science curriculum.

Due to the curriculum, the acquisition of science knowledge is particularly difficult for SWD. Students’ lack of background knowledge, problems in the areas of reading and writing, difficulty with inductive and deductive thinking, and acquisition of science content (e.g., vocabulary) are factors that can inhibit students’ engagement and consequently, acquisition of science knowledge (Scruggs & Mastropieri, 2007; Thierrien, Benson, Hughes, & Morris, 2017). Further, many SWD also have learning challenges associated with executive function (EF) skills. Executive function skills are the attention-regulation skills that make it possible to pay attention, keep goals and relevant information in mind, refrain from responding immediately, resist distraction, tolerate frustration, consider the consequences of different behaviors, reflect on past experiences, and plan for the future (Zelazo, Blair, & Willoughby, 2016). Learners of all ages and abilities need help applying their EF capacity in order to learn new knowledge and skills, but for some SWD this is exceedingly difficult (Gropen, Clark-Chiarelli, Hoisington, & Ehrich, 2011).

Research documents that inquiry-based activities improve understanding and retention of science concepts in SWD (Aydeniz, Graham, & Retinger, 2012; Holahan & DeLuca, 1993; Mastropieri & Scruggs, 1993; 1994). Minner, Levy and Century (2010) conducted a comprehensive review of inquiry studies in science education. They identified three essential components to inquiry instruction: (1) substantive science content; (2) student engagement with science content; and (3) personal responsibility for learning, active thinking, or motivation that includes at least one component of instruction in the scientific inquiry process (p.478). Scruggs
and Mastropieri (2007) suggest that inquiry-based learning encompasses not only an emphasis on real world problems, but also hands-on learning. They further propose that hands-on, inquiry-based activities for SWD may not only help them develop positive attitudes toward science, but also help clarify misconceptions regarding scientific concepts and assist in the acquisition of science skills. Researchers theorize that even if a student with a high-incidence disability lags in reading or math achievement, on an inquiry-based task they will perform similarly to their typically developing peers (Mastropieri, Scruggs, Boon, & Carter, 2001).

Collins and Fulton (2017) suggest that a guided, or structured, inquiry approach is effective for supporting SWD in science. In guided inquiry, the teacher helps students develop inquiry investigations in the classroom. Through a gradual release of responsibility, the SWD will able to engage in inquiry activities without teacher directives. Further, a combination of inquiry instruction with embedded explicit instruction has been shown to be an effective instructional approach in science (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). Therrien and colleagues (2017) also suggest that inquiry instruction is effective for students with LD if the approach is structured. Notably, two areas of difficulty for students with LD in science are effectively engaging in scientific argument and collaboratively working in group (Thierren et al, 2017).

Explicit instruction is an effective, structured, and systematic methodology for teaching academic skills (Archer & Hughes, 2011). This direct approach to teaching includes both instructional design and delivery. Instructional supports, or scaffolds, are provided through modeling, guided and independent practice, and corrective feedback. Students are instructed throughout the learning process with a clear a rationale and expectation(s) for learning a new skill (Archer & Hughes, 2011). Explicit instruction and the practice of argumentation has been
shown to improve the complexity of students’ argumentation (Osborne, Erduran, & Simon, 2004). Results of a study by Venville and Dawson (2010), suggested that explicit instruction in argumentation as well as content (i.e., human genetics) enhanced performance in both argumentation skills and biological knowledge. Similarly, Khisfe (2014) investigated the effect of explicit instruction in argumentation and the Nature of Science (NOS) on students’ argumentation skills and NOS understandings. Results indicated that explicit instruction in argumentation led to improved skills in argumentation. Results from several other studies (Bell & Linn, 2000; Yerrick, 2000; Zohar & Nemet, 2002) revealed that including explicit instruction within science contexts indicates positive improvements in learning and/or the quality of an argument. The present study utilized a combination of inquiry-based activities (e.g., engagement in argumentation) and explicit instruction.

**Rationale for this Study**

The proposed research will investigate how SWD engage in argumentation using SSI. The study is important and timely for two reasons. Firstly, according to the new science education reforms, *all* students must be provided with adequate opportunities to learn and engage in activities that promote science understanding (NRC, 2012). Engagement in argumentation is one of the essential scientific practices for K-12 science education designed to promote science understanding and improve student interest and engagement in science. Secondly, given the number of SWD educated in today’s general education classrooms, researcher must conduct studies that determine how SWD are accessing the curriculum (National Science Foundation, 2002).

While there is a paucity of research on explicit instruction in science education with SWD, preliminary results suggest that explicit instruction is potentially beneficial as an effective
instruction technique within the science classroom (Archer & Hughes, 2011). Despite current science reforms, there is little documentation to indicate how SWD engage in argumentation using SSIs. Findings from this dissertation research may provide practitioners with strategies to better address challenges of SWD and their engagement in argumentation using SSI.

**Statement of Purpose**

The purpose of this study was to investigate the engagement of secondary SWD in argumentation using SSI. Thus, this study had three research questions:

1. Is there a functional relation between explicit instruction in argumentation using SSI and an increased level of student engagement (e.g., use of behaviors that reflect scientific thinking) during group argumentation sessions for ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

2. To what extent will engagement (e.g., use of behavior that reflects scientific thinking) in group argumentation using SSI change the individual behavior of ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

3. What are the perceptions of the ninth and twelfth grade SWD regarding their engagement in argumentation sessions during science class?

**Glossary of Terms**

The present study used the following definitions to establish operational definitions. These operational definitions not only defined the concepts, but also established consistency throughout the study.
**Appropriate group interactions.** Appropriate group interactions include: (a) respecting what each other has to say (e.g., “That’s a good point,” or “That is an interesting idea,” or “I hadn’t thought of that.”); (b) discussing rather than ignoring an idea presented; (c) encouraging or inviting others to share or critique ideas (e.g., “What do you think?” or “Do you agree?” or “It’s okay to disagree with me.”); and (d) equal participation from all group members (Sampson, Enderle, & Walker, 2012).

**Argument session.** A 20-minute time period for groups to engage in argumentation. Engagement in argumentation refers to verbal interaction aimed at resolving a controversy (Newton, Driver, & Osborne, 1999).

**Behavior that reflects scientific thinking.** Thinking, speaking, and acting like a scientist. When students *think* like a scientist, personal knowledge related to science is constructed. Students use metacognitive skills (e.g., questioning) to construct personal knowledge. When students *speak* like a scientist, they use scientific language (e.g., claim, evidence, science vocabulary) to explain and solve a problem related to a phenomena. When students *act* like a scientist they behave in a manner consistent with the norms of science (e.g., use of evidence or scientific theories; Sampson, Enderle, & Walker, 2012).

**Claim.** A statement that answers the Guiding Question (e.g., Should parents vaccinate their children? Claim: *I claim parents should vaccinate their children*). Student does not need to use the word claim in his/her statement to make a claim. “Yes, I think that...” or “No, I do not think that...” would also be acceptable as a claim (McNeill, 2011; Zembal-Saul, McNeill, & Hershberger, 2013).
Evidence. Student provides data (e.g., numbers, measurements, observations, facts) as evidence to support the claim (e.g., 4000 new measles cases have been reported this year). Evidence provided must be scientifically accurate and relevant to the stated claim (Sampson, Enderle, & Walker, 2012).

Explicit instruction. A step-by-step presentation of the strategy including:
(a) activating students’ prior knowledge; (b) presenting material in small steps using modeling; (c) providing timely feedback, cues, and prompts; (d) offering guided practice; (e) giving correctional feedback and reteaching when necessary (Archer & Hughes, 2011; Zohar & Nemet, 2002).

Guiding Question. The fundamental question that guide student discourse during argument sessions. The question is important because the claim that is constructed answers the guiding question (Zembal-Saul, McNeill, & Hershberger, 2013).

Reasoning. Statement of how the evidence supports the claim. It indicates why the data counts as evidence. Appropriate reasoning must be relevant to the claim stated. Non-examples would include using phrases such as “It proves,” or “It just makes sense.” The quality of reasoning impacts the overall quality of an argument. (Berland & McNeill, 2010).

Socioscientific issue. Contemporary societal issues that have a basis in science. SSI are subject to moral, ethical, political, or social considerations, are personally meaningful and engaging to students, provide a context for understanding science information, are ill-structured problems that can lead to multiple solutions, and tend to be controversial in nature (Kuhn, 1991; Ratcliff & Grace, 2003; Sadler,

**Student Engagement.** A demonstration of behavior that reflects scientific thinking (e.g., answering a guiding question, making a claim, providing more than one piece of evidence to support a claim, making a connection to science, demonstrating appropriate group interactions (Sampson, Enderle, & Walker, 2012).

**Summary**

The purpose of this dissertation research was to examine the engagement of secondary SWD (e.g., attention deficit hyperactivity disorder [ADHD], autism spectrum disorder [ASD], specific learning disability) in argumentation using SSI. This study is organized into five chapters. Chapter one provided an overview of reforms in science education, presented argumentation using SSI, and identified characteristics of SWD that may impede their ability to engage in argumentation. Chapter two consisted of a focused 10-year review of the literature on argumentation using SSI. Chapter three described the single case methodology used for the current study. Included in chapter three are: (a) research questions; (b) participant demographics; (c) research design; (d) measures; (e) materials; (f) procedures; and (g) treatment fidelity, inter-observer agreement, and social validity. An analysis of the data and a discussion of the findings are presented in chapter four. Chapter five encompassed study conclusions, limitations, implications of the study, and recommendations for future research. Finally, a list of references and appendices of materials used in the study were provided.
CHAPTER 2

REVIEW OF THE LITERATURE

This chapter will present a review of the literature to explore how SSI-based interventions as a context for science education affects student learning outcomes and experiences. The aim is to summarize and synthesize research on SSI from the past decade to identify how students participate in real world science in a manner consistent with the practices of current science reform. Finally, empirical gaps in the literature are discussed.

Method

In order to identify empirical studies to be included in the review, searches of peer-reviewed journals using the EBSCO Host database (i.e., Education Research Complete, Education Source, ERIC, Psych Info) and Google Scholar were conducted. One aim of the analysis was to review recent studies. Thus, searches for appropriate papers focused on studies published between the years 2009-2019. Searches were conducted including full and truncated versions of argument*, socioscientific issue, middle school, high school, secondary, discourse, disabilit*, attention deficit hyperactivity disorder, autism spectrum disorder, learning disabilit*. The initial search yielded no results. The search criteria then excluded the special education descriptors (i.e., disabilit*, attention deficit hyperactivity disorder, autism spectrum disorder, learning disabilit*), resulting in 54 peer reviewed articles being available for review. Next, the abstract and method sections of each study was read to verify studies met the inclusion criteria. Following full text analysis, the final selection of an article for inclusion in the literature review indicated the research (a) was conducted in the last ten years, (b) shared a common focus on SSI, (c) was empirical in nature, (d) involved classroom interventions that documented student oral engagement in SSI, and (e) included participants in middle or high school. A study was excluded
if (a) there was no evidence that students engaged in oral argumentation, (b) the focus was professional development for teachers, or (c) web based interventions were utilized. Finally, a review of works cited in the papers already identified was conducted. This search identified four potential studies for the review. Following the inclusion and exclusion process, a total of 13 studies were selected for the present review of the literature (Albe & Gombert, 2012; Arvola & Lundegård, 2012; Eastwood et al., 2012; Felton, Garcia-Mila, & Gilabert, 2009; Gilabert, Garcia-Mila, & Felton, 2013; Grace, 2009; Khishfe, 2014; Knight & McNeill, 2015; Molinatti, Giralut, & Hammond, 2010; Nielsen, 2012; Rundgren, Eriksson, & Rundgren, 2016; Sadler, Romaine, & Topçu, 2016; Venville & Dawson, 2010). Appendix A presents brief descriptions of the reviewed studies. Specifically, the outcomes investigated, the nature of the intervention, the SSI topic, and participants are described.

**Study Characteristics**

The 13 studies reviewed were conducted in seven different countries: United States (Eastwood et al., 2012; Khishfe, 2014; Knight & McNeill, 2015; Sadler et al., 2016); Spain (Felton et al., 2009; Gilabert et al., 2013); Sweden (Arvola & Lundegård, 2012; Rundgren et al., 2016); France (Albe & Gombert, 2012; Molinatti et al., 2010); England (Grace, 2009); Australia (Venville & Dawson, 2010); and Denmark (Nielsen, 2012). The reviewed articles included a range of 12-19-year-old participants in grade seven (Felton et al., 2009; Gilabert et al., 2013; Khishfe, 2014; Knight & McNeill, 2015); grade nine (Arvola & Lundegård, 2012); grade 10 (Sadler et al., 2016; Venville & Dawson, 2010); grades 10-12 (Rundgren et al., 2016); grades 11-12 (Eastwood et al., 2012); and grade 12 (Albe & Gombert, 2012). Three studies (Grace, 2009; Molinatti et al., 2010; Nielsen, 2012) identified participants by their ages which were 15-16-year-olds, 16-year-olds, and 16-19-year-olds, respectively.
Seven different research designs were reported in the studies reviewed. Four of the 13 studies included a quasi-experimental design (Eastwood et al., 2012; Felton et al., 2009; Khishfe, 2014; Molinatti et al., 2010). Venville and Dawson (2010) reported a quasi-experimental design embedded within a case study, while Sadler et al. (2016) and Grace (2009) reported a pretest/posttest design with no control group. Arvola and Lundegård (2012) utilized a qualitative research design and Albe and Gombert (2012) reported a design-based research methodology. The study by Gilabert et al. (2013) used a between groups design. Researchers for three of the studies reviewed reported an exploratory study as their research design (Knight & McNeill, 2015; Nielsen, 2012; Rundgren et al., 2016). After a review of research on argumentation using socioscientific issues spanning a decade, four themes were identified (a) argumentative discourse goals, (b) nature of science and role of context on argumentation, (c) conceptual knowledge, and (d) instruments to support students and teachers.

**Argumentative discourse goals.** Argumentative discourse provides a context for learning by offering an opportunity for students to (a) prompt one another to produce evidence for a claim, (b) evaluate the credibility of scientific claims, and (c) challenge each other to consider alternative perspectives (Erduran, Simon, & Osborne, 2004; Felton et al., 2009; Garcia-Mila & Anderson, 2008). When students consider alternative perspectives on a topic, they produce questions, statements, and objections that prompt each other to clarify information and provide evidence to support claims and counterclaims (Felton & Kuhn, 2001). This type of discourse helps to scaffold scientific reasoning and construct scientific knowledge (Kuhn, 2005; Vygotsky, 1978). When students discuss SSI, they learn to appreciate that evidence must be used to advocate a position and that alternative positions must be considered (Felton et al., 2009). In argumentative dialogue, there are two types of discourse: dispute and deliberation. In dispute,
the goal is to undermine alternatives and defend a point of view using persuasion. Participants
are tasked with the challenge to persuade others to adopt their opinion. In deliberation, reaching
consensus is the goal and participants collaborate to achieve that goal (Felton et al., 2009;
Gilabert et al., 2013; Knight & McNeill, 2015). Two studies in the current literature review
addressed the impact of two types of discourse goals on students’ engagement in argumentation.

The quasi-experimental design used by Felton and associates (2009) examined whether
discourse goals (i.e., dispute or deliberate) had an effect on students’ engagement in
argumentation and on learning. One hundred one 7th grade students from five classes participated
in the study. Students were assigned randomly to one of two experimental conditions: (a)
disputative group, where the goal was to argue to convince a partner; or (b) deliberative group,
where the goal was to argue to reach consensus. Students were placed in dyads with a
disagreeing partner based on their positions on three dilemmas. They remained in that condition
throughout the study. When the two experimental conditions were full, the remaining students
were assigned to the control group, where students read text on the SSI and answered questions.

The intervention consisted of eight 50-min. sessions conducted in a science class.
Researchers worked closely with the teacher who taught all five classes. Students took a pretest
and the intervention was introduced in sessions one and two. Students were presented one
dilemma for sessions three, five, and seven. In these sessions, students were provided
background information on the dilemma (i.e., fuel sources, climate change) and wrote a short
essay stating their initial position. In sessions four, six, and eight, dyads were formed based
students’ initial positions on the dilemmas. Students were given 15 minutes to argue the dilemma
based on their assigned condition (i.e., deliberative or disputative), then 15 minutes to write their
final position. Students in the control group read the text for each dilemma and were given 15
minutes to write the advantages and disadvantages of the options described in the dilemmas and explained their position in the essay. After session eight, all students took a posttest which was identical to the pretest.

The pretest/posttest included two parts. The first part consisted of six open-ended questions about science content regarding energy sources presented in class. The second part included a writing prompt for students to propose an energy plan that argued in favor of using one or more energy sources. Data were analyzed for content learning and argument quality. Results indicated task goals facilitate content learning and argumentative dialogue. The deliberative (i.e., consensus) group outperformed the both the disputative and the control group in content learning. The significant difference between the deliberative and control group suggested that deliberation was effective in promoting student learning. Both deliberative and disputative discourse prompted students to make more robust arguments. However, students in the deliberative condition were more likely to retain information, acknowledge opposing viewpoints, revise their initial conclusions, and cite evidence for their claims. Finally, results revealed task instructions can mediate content learning when students engage in different types of discourse.

Gilabert and colleagues (2013) collaborated on a second study in which they examined the effect of task instructions on students’ discourse. Similar to their previous study (Felton et al., 2009). The current study included 7th graders (n = 65), eight 50-min. sessions, and task instructions to convince an opposing partner or to reach consensus. However, the between-groups design analyzed whether the rate of repetitions was higher in the persuasion group and if students repeat one idea many times or if they offer unique ideas in the argument structure. Argument repetition is defined as a speech act in which the content and argument structure,
which includes two elements of argumentation (e.g., claim, data, rebuttal) is reiterated without elaboration. The SSI for the study was renewable energy.

Students were placed in dyads according to their opinions on a dilemma prior to each argument session and randomly assigned to the persuasive group or the consensus group. The study took place in a science classroom and consisted of eight 50-minute sessions. In sessions one and two, students were given a pretest and were presented information about climate change and energy sources. In sessions three, five, and seven, students were presented with dilemmas regarding energy plans. In session four, six, and eight, students were grouped into dyads and asked to argue the dilemma for 15 minutes according to their condition (i.e., persuasion or consensus). After session eight, students were given a posttest identical to the pretest. Data were analyzed using a rubric assessing 11 argument structures. Results revealed the persuasion group made significantly more claim repetitions than the consensus group. Further, the students’ claims in the consensus group demonstrated a higher diversity of ideas than did the students in the persuasion group. Conversely, students in the persuasion group repeated the same ideas and showed poorer discourse than the consensus group. The results suggested that a task goal did mediate the effects of argumentative discourse.

Summary

Two studies examined whether the context for learning affected students’ engagement in argumentation. Felton and associates (2009) included two discourse goals in their study: to argue to convince a partner or to reach consensus with a partner. Similarly, the discourse goal in the Gilabert and colleagues (2013) study was to convince an opposing partner or to reach consensus. Results indicated that discourse goals did affect the outcomes of students’ arguments. Specifically, that task goal such as utilizing different types of discourse can mediate content
learning and enhance argumentative discourse. Moreover, when students are asked to reach consensus, they demonstrate a higher diversity of ideas.

**Nature of Science and Role of Context on Argumentation.** An important part of science literacy is understanding nature of science (NOS; American Association for the Advancement of Science, 1993; NGSS, 2013; NRC, 2012), thus an emphasis on teaching NOS is part of today’s science education worldwide (Lederman, 2007; NRC 2012). Lederman (1992), defined nature of science as “the values and beliefs inherent to scientific knowledge and its development” (p.328). While there is no absolute consensus on a NOS definition (Khishfe, 2014; Lederman, 2007), there are seven aspects that are generally accepted that characterize the nature of scientific knowledge. The aspects include an understanding that: (a) scientific knowledge is tentative, or subject to change based on new knowledge or evidence; (b) scientific knowledge is empirical and based on observations of the natural world; (c) scientific knowledge is subjective and can be influenced by scientists’ biases, experiences, and background knowledge; (d) scientific investigations use a variety of methods; making observations and inferences are distinct activities; (e) scientific laws and theories are a different kind of scientific knowledge and explain natural phenomena; (f) scientific knowledge is inspired by creativity and imagination; and (g) scientific knowledge is influenced by social and cultural factors (Eastwood et al., 2012; Khishfe, 2014; Lederman, 2007; NGSS, 2013).

Several researchers contend that a students’ understanding of NOS can impact their ability to engage in argumentation (Nussbaum, Sinatra, & Poliquin, 2008; Sandoval & Millwood, 2008; Zeidler, Walker, Ackett, & Simmons, 2002). Conversely, several researchers (Eastwood et al., 2012; Khishfe, 2014; McDonald, 2010) suggest that engagement in argumentation can lead to the development of improved understandings of NOS. For example, Khishfe (2014) proposes
that when a student offers a counterargument, he/she is addressing the subjective, empirical, and tentative NOS. Being cognizant of alternative points of view addresses the subjective aspect of NOS. Further, students’ counterargument(s) based on evidence addresses the empirical aspect of NOS (Khishfe, 2014). The tentative NOS is illustrated when students offer counterarguments that are subject to change based on argument discourse. Although some researchers propose a link between students’ NOS understanding and decision-making in argumentation using SSI, the lack of empirical evidence provides little support for that claim (Sadler, 2009). Three studies in the current literature review examined the impact of NOS on students’ argumentation using SSI.

Khishfe (2014), using a mixed-methods research design, examined the effect of explicit instruction in NOS and explicit instruction in argumentation on seventh grade students’ understandings and transfer of NOS knowledge and argumentation skills from a familiar context to an unfamiliar context. Two teachers trained in NOS and argumentation as part of a graduate methods course instructed the students over an eight-week period. Teachers worked with four intact classes of seventh grade students ($n = 121$) in two public schools. The seventh grade classes in each school were randomly assigned to the two treatments (a) explicit NOS instruction and explicit argumentation instruction, and (b) explicit NOS instruction with no argumentation instruction. Participants in all treatment groups received explicit instruction in the following three aspects of NOS: empirical, tentative, and subjective, and engaged in the same SSI about water safety and usage. The treatment groups had additional explicit instruction on argumentation (i.e., arguments, counterarguments, rebuttals). Students worked in triads and they practiced the generation of arguments, counterarguments, and rebuttals. The teacher supported and facilitated argument through scaffolding with the use of open-ended questions. The Water
Usage and Safety unit was selected for the study because it addressed a real-world SSI and was important to students as members of their local communities.

Student NOS and argumentation were assessed in a pretest/posttest questionnaire. Two open-ended scenarios addressed the controversial topics of water fluoridation and genetically modified food. Each scenario was followed by two questions related to NOS and argumentation. The water fluoridation topic was ‘familiar’ to the students since the issues were presented as part of the science content. The topic of genetically modified food was not addressed in the science unit, thus chosen as the ‘unfamiliar’ scenario. Students’ argumentation components (argument, counterargument, and rebuttals) on the questionnaire were categorized into three levels of response (a) naïve, (b) intermediary, or (c) informed based on a rubric. At the beginning of the study, there were no significant differences between the groups in terms of showing naïve, intermediary, or informed components of argumentation. By the end of the study, more participants in the treatment groups were identified as constructing informed arguments and fewer showed naïve components when responding to the scenarios. To assess students’ overall understanding of the practice of NOS, responses in each questionnaire were categorized as: (a) naïve (e.g., views inconsistent with NOS views), (b) intermediary (e.g., responses that represented an informed view as well as a naïve view), or (c) informed (e.g., a view that represents contemporary views of NOS). Results indicated that comparison of pretest to posttest instruction showed significant gains of participants demonstrating informed views of NOS. There were understandings of NOS in both the familiar and unfamiliar contexts. Gains in transfer to the unfamiliar topic of argumentation skills were not as pronounced, but results suggested some transfer did occur.
Similarly, Eastwood and associates (2012) included explicit instruction in NOS in their study in two different contexts: SSI driven and Content driven. The study examined the influence that the different contexts had on students’ NOS conceptions and whether students’ responses revealed qualitative differences in NOS understanding. Participants included students from four 11th and 12th grade Anatomy and Physiology classes \( (n = 108-124) \). The study was conducted over the course of one school year and data were analyzed using pretest/posttest results of the Views of Nature of Science (VNOS) questionnaire. Both the SSI curriculum and the Content curriculum were organized around the anatomy and physiology content and featured explicit-reflective NOS instruction. Classes were randomly assigned to each condition (i.e., SSI group or Content group). The same teacher taught all four classes.

In the SSI group, activities were designed to teach science content through SSI using contemporary issues such as stem cell research, euthanasia, fluoridation of pubic water supplies, safety of marijuana use, and fast food and health. Students engaged in discussion, argumentation, role-play, small group activities, and research. Little class time was spent on lectures and traditional lab activities. In the Content group, traditional instruction was presented following the organization of the textbook. The topics included how the human body is organized (i.e., cells, tissues, organ systems) as well as the body systems (i.e., skeletal, muscular, cardiovascular). Classroom activities included lectures, lab assignments, discussions, and completion of worksheets.

Results indicated the SSI group demonstrated more understanding of fundamental anatomy and physiology concepts than did the Content group. Pretest/posttests results from the VNOS indicated that both groups demonstrated significant gains in NOS understandings with the exception of two aspects. No conclusive results could be drawn regarding whether the SSI
context or Content driven context was *more* effective in students’ improvement in NOS understandings. However, the findings indicated that both contexts were equally effective in promoting improved NOS understandings. Eastwood and associates (2012) suggested findings of their study conducted over one school year have pragmatic importance. Results further indicated instruction in SSI does not have to be taught in isolation. Rather, SSI instruction can be an integral part of science without detracting from students’ ability to master content instruction.

Molinatti and colleagues (2010) used two different contexts to analyze students’ arguments using SSI. The researchers posited that an understanding of the tentative NOS is essential when engaging in controversial issues inherent in SSI. Students from seven high school science classes participated in the study \((n = 196)\) over three one hour sessions. The purpose of the study was to determine the consequences of debate contextualization on students’ argumentation involving the SSI: *the use of human embryonic stem cells* (hESC). Each class was divided into a control and a contextualized group. Four to six weeks in advance of the debate (e.g., argument session) students were assigned the theme *Embryonic stem cells and human brain repair* and were asked to write a definition of embryonic stem cells on a pretest. They were then given a time period of four to six weeks to accumulate background information on stem cells to be used in the debates. Sessions one and three were identical for both groups. In session one, students were provided a three-day protocol which included (a) the objective to improve argument skills, (b) the objective to formulate a position regarding a SSI, and (c) the elementary rules of a debate. Also in session one, students identified background questions and two major issues they would like to ask an expert regarding hESC. The debates occurred in session three and students incorporated the background information and questions identified in session one. The experiences of the control and contextualized groups differed in session two. Control groups
met with a neuroscientist to discuss the questions/issues they generated in session one. The contextualized group met the same neuroscientist together with a representative of an organization of patients suffering from a neurodegenerative disease (i.e., Parkinson’s disease, Huntington chorea, multiple sclerosis). After the third session where students engaged in the debate, students completed a posttest on their definition of embryonic stem cells. Students also were asked to make the argument for or against the use of hESC in research as well as in the treatment of neurodegenerative diseases.

Posttest results indicated that more than 75% of students from the control and contextualized groups’ voted in favor of hESC, but overall, students’ demonstrated weaknesses in decision-making when making arguments; specifically students lacked justifications for their arguments (i.e., ‘Hooray for science and progress.’). Notably, regardless of students’ weaknesses in argumentation, students from the contextualized group included more justifications in their written opinions. Concerning NOS, while students were in favor of the progress of science, they did not appear to understand fundamental differences between clinical research and therapeutic applications. The researchers submitted that contextualization helped students develop argument skills (e.g., paying attention to other opinions, motivation to promote their own opinions, more involvement in debates) and suggested that the emotion generated by meeting a person with a neurodegenerative disease promoted a higher sense of motivation and responsibility when debating hESC issues. However, no definitive conclusions about the influence of contextualization on the quality of oral debates could be drawn as there were no significant differences detected between the two groups.
Summary

Two studies utilized explicit instruction in NOS (Eastwood et al., 2012; Khishfe, 2014) to identify links between students’ argumentation using SSI and NOS conceptualizations. While the study by Molinatti and colleagues (2010) did not explicitly teach NOS, the researchers also sought to identify the links between NOS and students’ engagement in argumentation. Further, the three studies examined what role context played on students’ NOS understanding and argument using SSI. Khishfe (2014) used a familiar and unfamiliar context (i.e., topic) for argument. Two different contexts for the study by Eastwood and associates (2012) were SSI curriculum and Content curriculum. Molinatti and colleagues (2010) utilized individuals (i.e., researcher, person with a neurodegenerative disease) to provide different contexts for argumentation. Overall, findings from the three studies suggested that while students’ NOS conceptions and argumentation improved across all groups, context did not have a statistically significant impact on students’ NOS understanding or their skills in argumentation.

Conceptual Knowledge. There is much debate in science education as to whether engagement in argumentation improves students’ conceptual knowledge (Eastwood et al., 2012; Sadler, 2004; Sadler & Fowler, 2006; von Aufschnaiter, Erduran, Osborne, & Simon, 2008). The relationship between conceptual knowledge (e.g., content understanding) and argumentation seems to be a conundrum. Researchers suggest (a) the quality and complexity of arguments one constructs may influence a person’s understanding of a topic and (b) a person’s understanding of a topic may influence their engagement in argumentation (Venville & Dawson, 2010). Scholars (Arvola & Lundegård, 2012; Nielsen, 2012; Venville & Dawson, 2010; von Aufschnaiter, Erduran, Osborne, & Simon, 2008) also suggest that students’ engagement in relevant, real world
issues (e.g., SSI) is likely to improve conceptual understanding. Four studies in the research reviewed examined the impact of argumentation on students’ conceptual understanding.

Venville and Dawson (2010) conducted a quasi-experiment embedded within a case study to examine whether students could engage in meaningful argumentation about a SSI and if that type of engagement improved their conceptual understanding. Four 10th grade classes (n = 92) participated in a 10-week unit on sexual reproduction and genetics. Two classes (i.e., argument groups) received explicit instruction on argumentation during their genetics unit.

Argumentation classes were taught by an experienced biology teacher who received a two hour one-on-one session on how to teach argumentation. Students in the argumentation classes participated in three argument sessions. The comparison group did not participate in argumentation rather, they participated in library research on genetic disease, genetic engineering, and cloning. Teachers for the comparison group were also experienced biology teachers but did not receive instruction in argumentation.

The teacher for the argument classes taught one session on argumentation and incorporated whole class argumentation in two 50-minute lessons based on the following scenario:

A couple went into a genetics clinic for prenatal diagnosis for cystic fibrosis. DNA analysis indicated that the fetus had two copies of the cystic fibrosis allele, but one of the alleles was different from both parents making it virtually certain that the man was not the baby’s biological father.

Students must decide whether the genetics counselor should tell both the wife and the husband about the results.

A pretest/posttest survey was administered to students. The survey included two parts. In Part 1 students were provided with a short scenario about a genetics-based SSI of designer babies. Students were required to use their genetics knowledge to argue their point of view. Part
Data were analyzed using a four-level analytic scheme that included the components of an argument (i.e., claim, data, warrant/backing, qualifier). Part 2 of the survey analyzed students’ understanding of genetics and included 18 multiple choice questions and three short answer items. Results indicated that the argumentation intervention had a positive impact on students’ argumentation, but the results were not statistically significant. These results are consistent with literature on argument in science education and the researchers posit that it is not surprising that students who received explicit instruction in argumentation would be better able to argue than students in the comparison group. Notably, this intervention included only one lesson on argumentation and two sessions to practice argumentation, thus was relatively short. Additionally, it included whole class argumentation as opposed to small groups, which is in contrast to much research on argument in science education. Both groups improved their scores on the genetics survey thus, findings suggested the intervention had a modest impact on students’ conceptual understanding of genetics.

Arvola and Lundegård (2012) used a qualitative study to also examine the process of argumentation using SSI on students’ conceptual knowledge. Specifically, the researchers analyzed in what way during argumentation students have the opportunity to include their personal point of view and expand on meanings in the content. How scientific knowledge was integrated in students’ arguments also was examined. The study was conducted over the course of one semester and participants included 9th grade students from one biology class (n = 15). Two weeks prior to beginning the unit, the teacher gave a brief introduction and the students chose their subject for argumentation using the following guidelines (a) consider including a short historical review, (b) use newspapers, (c) present your own point of view, (d) tell how something should be and why, (e) the argument must have some connection to the body, (f) the
argument must use scientific concepts, and (g) the audience must be active and ask questions.

Students worked independently for two weeks to prepare their argument. On the presentation day, students had five minutes to argue for or against a SSI that included the body (i.e., use of a bicycle helmet, cloning, for or against professional boxing, age limit for drinking alcohol, blood and organ donation, tobacco use, abortion).

One female student’s argument about abortion was analyzed for the study. A tool used in data analysis was value relations. These relations often are value-laden or emotional and when a student takes a stand on an issue, using value relations as an analytical tool helps discern when a student had the opportunity to include his/her personal point of view and expand on meanings in the content. Statements such as ‘I think, I find, yes, no, but’ would indicate that a student is making a value judgement. A second tool used for data analysis to show how students produced or used content knowledge in a given situation was deliberative educational questions (DEQs).

In the reviewed study, human conflicts of interest constructed from the values relations created DEQs. For example, ‘Should an abortion be allowed or not?’ or ‘Should a woman be allowed to have an abortion only until the fetus has reached a certain age or should it be performed even later?’ Results indicated that the student used value relations when discussing the state of pregnancy and the possible social consequences. An analysis of DEQs showed that the student’s argument prompted 13 new questions. The researchers suggested the new questions asked by the audience were evidence of student engagement in the argument process. The results were deemed to be a representation of all students in the study. In the final analysis, the unit did not help students include more scientific concepts either appropriately or extensively in their argument.
Nielsen (2012) conducted an exploratory study to examine if students’ articulation of ‘nature’ when arguing a SSI included factual science content. Three Biology teachers incorporated the SSI whether human gene therapy should be allowed in their course on genetics. Thirty-six 11th and 12th grade students engaged in eight 40-60 minute argument sessions. Groups of four to five students were given background material for their argument that included (a) a description of the differences between two types of gene therapy, (b) a description of how the technologies work, and (c) some real-life positions that had previously been debated. The students’ goal was to decide on future legislation regarding human gene therapy. Data analysis followed a four step procedure that (a) identified the talk turns featuring the terms ‘nature’ and ‘(un)natural’, (b) identified the turn talks where students articulated science content either overtly or inferentially, (c) identified thematic issues, and (d) analyzed individual talk turns and their contribution to the overall argument. Results identified 3,333 talk turns in all eight discussions and 70 explicit mentions of ‘nature’, ‘natural’, or ‘unnatural’. The researchers posited that ‘nature’ played a minor role in the discussions, but that nature played key roles in the argumentation sequences. However, while the students in the study invoked nature at key places in the discussions, most of their invocations involved little or no science content.

Sadler, Romine, and Topçu (2016) conducted a study to explore the efficacy of teaching argumentation using SSI and student conceptual knowledge related to molecular biology and genetics. The SSI intervention was a pretest-posttest design with no comparison group. Two participating teachers taught biology and one teacher taught integrated science. All three teachers were instructors in different high schools. Sixty-nine secondary students participated in the study which lasted approximately three weeks. A research team developed a SSI intervention around a narrative case involving the emergence of a novel strain of a sexually transmitted disease, human
papilloma virus (HPV). The science content learning goals were aligned with state science standards. Students examined and analyzed scientific data, used several different forms of media to identify major characteristics of HPV, and worked with peers to develop an understanding of issue and science principles related to the issue. Gains in content knowledge were evaluated before and after the intervention using proximal assessments (i.e., multiple choice items directly related to the science content covered in the SSI intervention) and distal assessments (i.e., science concepts aligned with state science standards similar to high-stakes testing). Results from the study showed statistically significant gains ($p < .001$) in conceptual knowledge on both proximal and distal assessments. Simply stated, students learned significant science content directly aligned with the SSI intervention (e.g., proximal assessment) as well as on a distal instrument that assessed more generalized science ideas.

**Summary**

Four studies in the present review examining whether engagement in argumentation using SSI improves conceptual knowledge showed mixed results. While results from the study by Venville and Dawson (2010) indicated that both the argument and the comparison group improved their scores on the genetics posttest, there was no statistical significance between the two groups in their conceptual understanding of genetics. The study by Arvola and Lundegård (2011) revealed that students used values when making an argument, which is consistent with research on SSI. Further, the questions asked by the audience indicated students were engaged in the process of argumentation. However, in answer to whether engagement in argumentation using SSI improved conceptual knowledge, students did not include more appropriate or extensive scientific concepts at the conclusion of the unit of study. Similar results were reported by Nielsen (2012) who examined how students’ different articulations of ‘nature’ may impact
conceptual knowledge. The results suggested that the use of the word ‘nature’ played an essential role in argument sequences, but that little or no science content was associated with how ‘nature’ was used in an argument. Conversely, results from the study conducted by Sadler, Romine and Topçu (2016) support the assertion that argument using SSI can result in students’ improved conceptual understandings in science.

Notably, the outcome of two other studies in the current literature review also indicated the groups engaging in argument using SSI demonstrated more conceptual understanding than the groups that did not engage in argumentation using SSI (Felton et al., 2009; Knight and McNeill, 2015). These studies are categorized by themes based on the interventions and are discussed in detail in a previous and a subsequent section based on the identified theme.

**Instruments to Support Students and Teachers.** Engagement in SSI during science instruction can benefit students in multiple ways. One benefit is to be able to encourage students to see science as something relevant in their everyday lives (Chang Rundgren, & Rundgren, 2010). Another benefit of engagement in argument using SSI is to prepare students for a life as citizens who may be confronted by science-related controversial issues in the future (Sadler & Zeidler, 2005). This type of engagement challenges students to analyze evidence to support a claim, develops skills to be able to argue constructively, and exposes students to different perspectives inherent in the SSI, thus giving them the opportunity to evaluate different viewpoints (Chang Rundgren & Rundgren, 2010; Sadler, Barab, & Scott, 2007; Sadler & Zeidler, 2005). In order to examine students’ and teachers’ participation in argumentation regarding SSI, four studies reviewed examine the use of an instrument or framework to scaffold and evaluate the argument sessions.
Albe and Gombert (2012) utilized designed-based research to examine 12-grade students’ engagement in a global warming debate. Fifteen students participated in five sessions. The intervention simulated a citizens’ conference on global warming. The first two instructional sessions lasted one day and a half and focused on listening and empathy (e.g., non-violent communication). The third session took place one and a half months after the second session and lasted two hours. This session was dedicated to viewing and debating a film on global warming. The fourth session took place two weeks later and lasted two hours. In this session students engaged in a simulation of a citizens’ conference on global warming. The final session was focused on the role of citizens regarding science and political issues based on the previous sessions.

A three dimensional model was developed for the study to analyze students’ debates according to the following dimensions (a) communication, (b) classroom activities, and (c) epistemological. The communication dimension of the model accounted for students’ ideas and discourse when engaging in argument using SSI as well as their non-violent communication. The classroom activities dimension of the model incorporated organizational aspects such as grouping of students and their roles, resources used, and assessment of knowledge related to global warming. The epistemological dimension of the model referred to the way knowledge was shared between the students and the teacher. Results revealed the model was productive in developing a teaching sequence that takes into account students’ difficulties with communication and ability to engage in argumentation using a SSI. The model successfully provided a coding scheme for student’s rhetorical as well as non-violent communication. According to the results, the researchers believed the goal of engaging students in a non-violent study of global warming
was achieved. Lastly, results suggested that properly designed curriculum could improve students’ understanding of argumentation (Albe & Gombert, 2012; Lewis & Leach, 2006).

Rundgren et al. (2016) used an instructional framework to scaffold student learning. Participants in the four week exploratory study were students in grades 10-12 ($n = 7$). The aim of the study was to explore factors that impact students’ decision-making processes when engaging in argumentation using SSI. The SSI concerned the environmental toxins in the Baltic Sea, which was an authentic SSI in Sweden where the research was conducted. The Swedish National Food Agency reported high levels of toxins considered to pose serious health risks in humans and other species in the Baltic. There was a ban put on these fish being sold in the European market, but Sweden received a permanent exemption because of the job opportunities and the argument that tradition would be lost. The SSI question posed to students was: Did the Swedish government make the right decision when offering a permanent exemption regarding the continued sale of fish in the Baltic Sea?

The six-step instructional framework utilized in the current study was named “Post it” (Chang Rundgren & Rundgren, 2010). In Step 1, the teacher presented the SSI and its scientific content. Norms of argumentation were presented. In Step 2, the students sought out relevant information and began to formulate their arguments based on different perspectives. Each group was given sets of two-colored post it notes to write their arguments and supporting reasons. At the end of the session, the groups switched post it notes. In Step 3, students categorized the different arguments based on the post it notes. In Step 4, students engaged in argumentation based on the visual representation of the post it notes. Students made their own decision about the SSI in Step 5. The students then submitted a form on which they answer yes or no to the SSI presented in Step 1, and why they chose the answer they did. The teacher provided feedback in
Step 6 and summarized key points from the activity. Data were collected during the audio taping of group discussions, students’ written reports in Step 5, and semi-structured interviews conducted two weeks post-intervention.

Results indicated that students were capable of productively evaluating contradictory information to inform their decision-making. Students used evidence provided to support their claims. However, while students all had access to the same information, they used it differently based on their pre-existing personal values and experiences. Results further suggested that the six-step SSI instructional model could be used to introduce a complex SSI. The instructional design allowed students to identify the factors that influence SSI and to recognize that people weigh the evidence in many different ways based on their values and beliefs. Moreover, the instructional model was helpful in scaffolding students’ SSI arguments and skills of evaluation.

Grace (2009) used a framework to identify decision-making during arguments about biological conservation issues among four classes of 15 to 16 year-olds (n = 131). Grace worked within the constraints of the classroom to have participants engage in 30-40 minute sessions over five weeks to examine if peer group decision-making can help develop students’ personal reasoning in regard to a conservation issue. Twenty-four groups of four to six students were instructed to reach consensus about a conservation issue. The study included an individual pretest questionnaire about a conservation scenario, audio-taping of group arguments where groups followed the decision-making framework, and a posttest completed individually. In both the pretest and posttest students were asked what they thought should be done about the problem, how, and why? The why and how questions were included and indicated key features of high-quality reasoning.
Prior to engagement in argumentation, the six-step decision-making framework was given to each group. Students were asked to write down the answers to the questions. The steps were (1) Options (i.e., What are possible solutions to the problem?), (2) Criteria (i.e., How are you going to choose between those options?), (3) Information (i.e., Do you have enough information? What science is included in the problem?), (4) Advantages/disadvantages, (5) Choice (i.e., What option does your group choose?), (6) Review (i.e., What do you think of your decision? How could you improve the process?).

Results revealed that the 40-minute sessions facilitated students’ decision to modify their proposed views to the conservation problem. About 75% of the students ($N = 98$) modified their proposed solution following argument. The changes in attitude are consistent with research by Solomon (1992) that suggest group discussion can benefit attitude change. Further, there was a noticeable increase in the number of higher-level responses following the discussions. Findings indicated that personal reasoning could be developed over a relatively short amount of time within a normal classroom setting. Moreover, providing a decision-making framework, which encouraged students to write down their answers as they progressed through the discussion, not only reinforced skills for the students, but allowed teachers to see students’ engagement throughout the process. Researchers suggested the decision-making framework was instrumental in keeping students focused and engaged with the SSI.

Knight and McNeill (2015) used a theoretical learning progression to evaluate the similarities and differences between group oral argumentation and individual written argumentation. The learning progression specifically addressed the following parts of an argument: (a) claim (i.e., the answer to a question); (b) justification (i.e., support for the claim); and rebuttal (i.e., a justification of how or why a response was incorrect). Seventh grade students
(n = 17) participated in three 35-100 minute argument sessions over three months. The first SSI introduced was whether the Belo Monte dam should be built on the Xingu River in Brazil. Some considerations were the dam could supply hydroelectric power or the destruction of the rainforest. The second SSI addressed: Should people drink tap or bottled water? The students’ school was originally plumbed with lead pipes and provided bottled water to prevent lead poisoning. For the third unit, students prepared presentations for a community fair where they shared the SSIs they had researched throughout the year and tried to inform and persuade the attendees.

Data were collected from videotaped sessions of students’ collaborative oral argumentation and students’ individual written arguments. Point values were assigned to the parts of an argument based on the sophistication of the student responses. Results revealed that while students included justifications in their arguments, they were often not supported by evidence or were irrelevant. More students provided higher-level arguments using justifications and rebuttals in their writing. This finding suggested while students did not justify their arguments orally, they knew how to do so in their written work. Overall, students’ written worked showed more sophistication, according to the learning progression, than did their collaborative oral arguments.

**Summary**

Four studies included in the studies reviewed utilize an instrument or framework to explore connections between students and/or teachers, as well as evaluate some processes inherent in argumentation (e.g., decision-making). Albe and Gombert (2012) developed an instrument with three dimensions: communication, classroom activities, and epistemological. This instrument was used to analyze student responses, the organization of the activity, and
assessed how knowledge is shared between students and teachers. The researchers posited that the instrument enabled students to improve their understanding of argumentation and provided teachers with a framework to follow when engaging in argumentation. Rundgren and associates (2016) and Grace (2009) both developed instructional frameworks to scaffold student learning. Results from “Post it” (Rundgren et al., 2016) and Grace’s (2009) six-step decision-making framework indicated that providing students with a framework as a scaffold kept students focused, thus increasing their engagement in SSI. Moreover, the frameworks helped develop students’ personal reasoning and decision-making. The theoretical learning progression utilized by Knight and McNeill (2015) enabled the researchers to evaluate student engagement in argumentation and provided teachers with useful information for future argumentation using SSI similar to the classroom activities dimension of the instrument developed by Albe and Gombert (2012).

**Strengths and Weaknesses of the Studies**

Trying to make feature-by-feature comparisons among the reviewed studies is difficult, due to the diversity of the studies. However, there were several strengths apparent in the studies reviewed. First, researchers appeared to select a SSI that would appeal to secondary students. Topic selection is a crucial element when arguing a SSI in science, as students engage in discourse about issues and problems that affect their every-day lives. It should be noted that no researcher reported asking students their opinion of a SSI they found interesting. A second strength of the reviewed studies was the thorough methodology sections. Third, all of the studies included a limitations section except Grace (2009). Fourth, the coding for the quantitative studies was presented in sufficient detail to allow for replication.
Many weaknesses were identified when trying to make comparisons between the reviewed studies, although one could argue that the elements subsequently described as weaknesses are inherent to the manner in which science education research is conducted, thus should not be classified as weaknesses. Again, trying to make feature-by-feature comparisons among the reviewed studies is difficult, due to the diversity of the studies. One of the 13 studies addressed the What Works Clearinghouse (WWC) Guidelines for implementing a randomized controlled trial (Sadler, Romine, Topçu, 2016). Interestingly, the researchers chose not to follow the WWC Guidelines, as they stated that it was not feasible to conduct a true randomized controlled trial due to the complex realities of modern schools. Further, no researcher(s) reported they used any WWC quality indicators to guide their study.

The reviewed studies used many different analyses to examine the quality of argumentation. Several researchers used Toulmin’s Argument Pattern (TAP) model to analyze the quality of students’ arguments (Gilabert, Garcia-Mila, & Felton, 2013; Molinatti, Girault, & Hammond, 2010; Venville & Dawson, 2010). However, there has been criticism in the field of science education regarding the use of TAP. Researchers suggest the model does not examine the quality of an argument, but the presence or absence of argument elements (e.g., claims, data; Erduran, Simon & Osborne, 2004; Zohar & Nemet, 2002). Qualitative data collected in the reviewed studies included researcher-designed instruments (e.g., rubric, learning progression), or coding protocols (Albe & Gombert, 2012; Arvola & Lundegård, 2011; Felton, Garcia-Mila, & Gilabert, 2009; Grace, 2009; Knight & McNeill, 2015). Nielsen (2012) examined the quality of students’ arguments based on turn talks. The variation in the instruments used to examine the quality of students’ argumentation makes comparisons between studies problematic.
There is little consensus on operational definitions for terms associated with argumentation. For example, studies may define the following terms differently (a) utterances, (b) rhetorical process, (c) reasoning, or (d) quality, thus making comparisons between studies challenging. Comparisons of studies between countries using SSI must be made with caution. For instance, the SSI for the study by Arvola and Lundegård (2011) was abortion. Students in different countries may have a range of background knowledge, experience, and/or opinions about abortion, making comparisons of argumentation sessions between students from different countries impractical. A final weakness identified in many of the studies reviewed, was the selection of discourse of students’ argumentation chosen for analysis. Researchers typically selected a section of a video transcript that served as an exemplar. No study offered transcribed discourse that was either closely related to the purpose of the study or not related at all. Non-examples can be a finding as important as exemplars.

**Additional Finding**

**Roles of Teachers.** In many of the studies reviewed, researchers reported information regarding the role of teachers in their study. In four studies (Albe & Gombert, 2012; Eastwood et al., 2012; Knight & McNeill, 2015; Venville & Dawson, 2010), researchers offered teachers professional development prior to commencement of the study. Albe and Gombert (2012) also spent two hours before and after the five teaching sessions to analyze every decision regarding content and classroom activities. In two studies, researchers reported that they collaborated with teachers to design NOS or SSI curriculum (Khishfe, 2014; Nielsen, 2012). Several other studies reflected a collaboration between teachers and researchers (Albe & Gombert, 2012; Felton et al., 2009; Grace, 2009; Molinatti et al., 2010; Rundgren et al., 2016; Sadler et al., 2016). A review of the studies revealed the researchers collaborated with teacher in an effort to provide a curriculum
using SSI that incorporated the academic goals of the classroom. For example, the content for the SSI intervention by Sadler, Romaine, and Topçu (2016) was aligned with state science standards. Arvola and Lundegård (2012) used the science curriculum designated by the school when teaching argument using SSI. The intervention designed by Grace (2009) worked within the constraints of the classroom (e.g., one 40-minute session). Researchers ensured teachers played a critical role in determining how SSI curricula were implemented in the classroom. Sadler (2009) suggested that the more invested teachers were in the goals of a project, the more likely students would have positive experiences. Overall, researchers also appeared to be cognizant of the fact that teachers need to be comfortable with the nontraditional instruction inherent in the use of SSI in the classroom. Collaboration between the researchers and the teachers may have offered the best opportunity for successful implementation of the intervention (Venville & Dawson, 2010) and an opportunity to bridge the research to practice gap.

**Discussion**

One outcome of the studies reviewed focused primarily on the effects of using SSI when engaging in argument on student conceptual knowledge (Arvola & Lundegård, 2012; Nielsen, 2012; Sadler, Romaine, & Topçu, 2016; Venville & Dawson, 2010). Other studies investigated the effect of explicit instruction in NOS and the context of the intervention (Eastwood et al., 2012; Khishfe, 2014; Molinatti et al., 2010). Still others examined whether discourse goals have an effect on students’ argumentation (Felton et al., 2009; Gilabert et al., 2013). Finally, several researchers investigated the effects of using an instrument or framework to support students and teachers (Albe & Gombert, 2012; Grace, 2009; Knight & McNeill, 2015; Rundgren et al., 2016). Some of the results of the studies were mixed, suggesting a need for further research.
None of the reviewed studies indicated SWD were participants. Thus, one could surmise that all the participants in the studies reviewed included only typically developing students. In fact, Rundgren et al. (2016) reported selecting participants due to their strong academic background. Participants in the Grace (2009) study were in the top 50% of their school in science. In the Albe and Gombert (2012) study, students attended a school that specialized in technologies for agriculture and the environment. The omission of SWD in the studies reviewed reveals an empirical gap.

**Empirical Gaps in the Selected Literature**

There were several empirical gaps identified in the current study. First, according to the new science reforms, *all* students must be able to access the science curriculum. This curriculum includes engagement in argumentation, yet there was no indication that SWD were included in any of the reviewed studies. This omission is in contrast to the ideology of IDEA (2004), NRC (2012), NGSS (2013), and ESSA (2015), which all stipulate SWD should be offered the same academic opportunities as their typically developing peers. Second, one out of 13 studies referred to the WWC guidelines. Thus, in the studies reviewed seven different research designs offered varying levels of methodological rigor making comparisons for outcomes difficult at best. Finally, in terms of instrumentation, comparisons between studies are challenging due to the nature of SSI. Many researchers designed their own pretests/posttests based on the content of the SSI or developed their own coding scheme. The study conducted by Eastwood et al. (2012) was the only study in the studies reviewed that included a validated instrument (VNOS).

In sum, in an attempt to narrow the current empirical gap that exists, SWD must be included in future research on argumentation. Several studies offer potential for teaching argumentation using SSI to SWD. The six-step instructional framework by Rundgren and
associates (2016) and the six-step decision-making framework by Grace (2009) offer ways to organize information, much like a graphic organizer, which is an evidence-based practice used by special educators to enhance learning of SWD (Smith & Okolo, 2010). Further, if researchers deem the current research design guidelines as prescribed by WWC too impractical for research in today’s schools, other quality indicators must be created to enable researchers to make comparisons between studies. Last, additional validated instruments are needed to make comparisons between studies more empirically sound.

This chapter presented a review of studies on SSI from the past decade. The research was summarized and synthesized to examine argument using SSI and (a) argumentative discourse goals, (b) NOS and role of context in learning, (c) conceptual knowledge, and (d) instruments used to support students and teachers. Finally, empirical gaps in the literature were discussed.
CHAPTER 3

METHODOLOGY

Introduction

This chapter presents the methodology for the dissertation research examining the effects of explicit instruction on student engagement in argumentation using SSI. It includes the research questions and a description of the research design. It also provides detail about the participants, setting, and materials used in the study. This chapter explains the procedures for the baseline, probe condition, intervention, and maintenance phases of the multiple probe design. Implementation fidelity, inter-observer agreement, and social validity also are addressed. A description of data analyses is provided. The research methodology described in this chapter was preceded by a pilot study conducted for 20 hours during the Summer 2017 semester. This study will be briefly summarized prior to describing the methodology for the dissertation research.

The pilot study focused on: (a) if students with and without disabilities engaged in written scientific argumentation (SA) using claim, evidence, and justification similarly, (b) if students with and without disabilities would able to transfer the knowledge of claim, evidence, and justification in SA to their individual written discourse (e.g., persuasive writing), and (c) if elementary students with and without disabilities differed in attitude toward science before and after the intervention. The results of the pilot study provided preliminary data to assess the effectiveness of explicit instruction on the argumentative abilities of SWD. The pilot study also provided the researcher an opportunity to evaluate and refine the procedures (e.g., teaching protocol) and measures (e.g., student assessment, data collection tools, reliability, treatment fidelity, social validity) for the dissertation research. The independent variable for the pilot study was explicit instruction in scientific argumentation (SA). The dependent variable was students’
use of three elements of scientific argumentation (i.e., claim, evidence, justification) and students’ attitude toward science.

The 14 participants chosen for the pilot study were rising third, fourth, and fifth grade students from several public and private schools in southeast Virginia. The participants included five girls and nine boys ranging in ages from eight to 11. Seven SWD (i.e., attention deficit hyperactivity disorder, autism spectrum disorder, specific learning disability) as well as seven typically developing students participated in the study.

Pretests/posttests for the pilot study included a writing prompt for scientific argumentation, a persuasive writing prompt, and a modified attitude toward science inventory (mATSI). Pretest/posttest data of the writing prompt for scientific argumentation indicated SWD showed significant gains with a $p$ value of 0.02. In comparison, data from the typically developing students were not significant with a $p$ value of 0.06. On the pretest/posttest assessing transfer of scientific argumentation elements (i.e., claim, evidence, justification) to persuasive writing, SWD showed modest gains, while typically developing students showed no gains. On the mATSI, results suggested both groups demonstrated an improved attitude toward science. The results of the small pilot study indicated statistically significant gains in engagement in SA for SWD. The SWD showed modest gains on transfer of SA elements to persuasive writing and the typically developing students showed no gains. On the mATSI, both groups of students showed improvement, although the gains were not statistically significant.
Table 3.1

Comparison of Pilot Study Pretest/Posttest Results for Students with Disabilities and Typically Developing Students

<table>
<thead>
<tr>
<th>Participants</th>
<th>Pretest SA</th>
<th>Posttest SA</th>
<th>Pretest Persuasive Writing</th>
<th>Posttest Persuasive Writing</th>
<th>Pretest mATSI</th>
<th>Posttest mATSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students with Disabilities</td>
<td>3.71</td>
<td>6.25</td>
<td>5.71</td>
<td>6.79</td>
<td>69.42</td>
<td>75.12</td>
</tr>
<tr>
<td>Typically Developing Students</td>
<td>4.71</td>
<td>7.71</td>
<td>6.71</td>
<td>6.71</td>
<td>79.86</td>
<td>83.86</td>
</tr>
</tbody>
</table>

Results of the small pilot study may suggest the need for future research on the effectiveness of explicit instruction in SA for SWD and the transfer of SA elements to persuasive writing. In addition to providing data about how SWD engage in SA to add to the literature, the pilot study allowed the researcher the opportunity to evaluate several instruments. Further, fidelity checklists were amended for utilization in the current dissertation research.

The remainder of this chapter will describe the methodology for the dissertation research to examine the effectiveness of explicit instruction in argumentation for secondary SWD using socioscientific issues. The chapter includes research questions, a discussion on the research design, a description of the participants and materials used, and the procedures for the study. Procedural fidelity, data collection, interobserver agreement, and social validity are described as well.

The purpose of the current study was to extend the pilot research that investigated the engagement in argumentation of SWD. The dissertation research addressed three questions:
1. Is there a functional relation between explicit instruction in argumentation using SSI and an increased level of student engagement (e.g., use of behaviors that reflect scientific thinking) during group argumentation sessions for ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

2. To what extent will engagement (e.g., use of behaviors that reflect scientific thinking) in group argumentation using SSI change the individual behavior of ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

3. What are the perceptions of the ninth and twelfth grade SWD regarding their engagement in argumentation sessions during science class?

Research Design

A multiple probe design replicated across three classes was used to examine the effects of explicit instruction in argumentation on students’ engagement during group argumentation sessions. The multiple probe design requires planned intermittent data collection prior to the introduction of the intervention. Horner and Bear (1978) recommend intermittent probe data be collected rather than collecting “unnecessary” baseline measures, making multiple probe a practical alternative for research conducted in a classroom setting. In order for multiple probe to be considered an appropriate research design, there must be a strong a priori assumption that behaviors will not be learned outside the instructional session, as is the case with many academic skills. The multiple probe design: (a) is rigorous in the evaluation of threats to internal validity; (b) assists in determining the efficacy of an intervention; (c) has no withdrawal of intervention requirements to demonstrate experimental control; (d) requires the collection of data during the
same time period of behaviors in the natural environment (thus providing a close approximation of goals of most classroom teachers); (e) is a useful method to evaluate effects of an independent variable that is irreversible, such as an academic skill; and (f) provides a means for evaluating behavior over time (Ledford & Gast, 2018).

In contrast to multiple baseline designs, multiple probe designs have additional criteria to conform to What Works Clearinghouse Pilot Singles-Case Design Standards without Reservations due to the intentional omission of baseline data points. In addition to the three consecutive probe points at the beginning of each baseline and prior to the introduction of the intervention across cases (i.e., classes), each case not receiving the intervention must have a probe point in a session where another case receives the intervention. This probe point must be consistent in level and trend with the case’s previous data points (WWC, 2017). For example, when Class 2 receives the intervention, there must be one probe point in Class 1 and one probe point in Class 3 during the intervention period. The probe points for Class 1 and Class 2 must be consistent with their previous data points, meaning the new data point should continue to indicate that the data remain stable. The proposed study was designed to meet WWC Pilot Singles-Case Design Standards without Reservations, as well as the Council for Exceptional Children Standards for Evidence Based Practices in Special Education (Cook et al., 2014).

Measures

The independent variable for the dissertation study was explicit instruction in argumentation. Explicit instruction is an evidence-based practice shown to be effective in teaching SWD (Gleason, 1999; Scruggs, Mastropieri, Berkeley, & Graetz, 2010) as well as typically developing students (Simon, Erduran, & Osborne, 2006; Zohar & Nemet, 2002). Explicit instruction is defined by Archer and Hughes (2011) as an effective systematic,
structured methodology of delivering academic instruction. Literature indicates that explicit instruction and the practice of argumentation processes improves the complexity of students’ argumentation (Osborne, Erduran, & Simon, 2004; Zohar & Nemet, 2002). The elements of explicit instruction are: (a) reviewing prior knowledge; (b) presentation of material in small steps using modeling; (c) providing timely feedback, cues, and prompts; (d) guided practice; (e) correctional instruction and reteaching when necessary; and (f) independent practice (Zohar & Nemet, 2002).

The dependent variable for the proposed study was student engagement during scientific argumentation sessions. Student engagement was defined as a demonstration of behaviors that reflect scientific thinking (i.e., answering a guiding question, making a claim, providing evidence to support claim, making a connection to science, demonstrating appropriate interactions with group members; Sampson, Enderle, & Walker, 2012). Students demonstrated their engagement by working together on a common task of constructing and presenting an argument (Evagorou & Osborne, 2013). The duration for each argument session was 20 minutes and SSI were used as the topics for argument.

**Participants**

This study was conducted in a K-12 independent school in Southeastern Virginia. The school was licensed by the Virginia Department of Education to operate as a private day school for students with attention deficit hyperactivity disorder (ADHD), autism (AUT), developmental delays (DD), other health impairment (OHI), specific learning disability (SLD), speech and language impairment (SLI), and/or comorbid disabilities (see Table 3.2).
Table 3.2

*Participant Demographic Characteristics*

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.1</td>
<td>Male</td>
<td>White</td>
<td>ADHD, Asperger’s Syndrome, Dysthymic Disorder</td>
</tr>
<tr>
<td>18.9</td>
<td>Male</td>
<td>White</td>
<td>Autism Spectrum Disorder</td>
</tr>
<tr>
<td>18.6</td>
<td>Male</td>
<td>White</td>
<td>Autism Spectrum Disorder</td>
</tr>
<tr>
<td>18.2</td>
<td>Male</td>
<td>White</td>
<td>ADHD, Autism</td>
</tr>
<tr>
<td>18.8</td>
<td>Male</td>
<td>White</td>
<td>Nonverbal Learning Disability</td>
</tr>
<tr>
<td>15.4</td>
<td>Female</td>
<td>Black</td>
<td>ADHD, Autism Spectrum Disorder</td>
</tr>
<tr>
<td>16.7</td>
<td>Male</td>
<td>Black</td>
<td>Learning Disability</td>
</tr>
<tr>
<td>16.9</td>
<td>Female</td>
<td>Black</td>
<td>ADHD</td>
</tr>
<tr>
<td>16.5</td>
<td>Male</td>
<td>Black</td>
<td>ADHD, Adjustment Disorder, Specific Learning Disability</td>
</tr>
<tr>
<td>15.1</td>
<td>Male</td>
<td>White</td>
<td>Autism Spectrum Disorder, ADHD</td>
</tr>
<tr>
<td>15.8</td>
<td>Male</td>
<td>Black</td>
<td>ADHD, Autism Spectrum Disorder</td>
</tr>
<tr>
<td>16.4</td>
<td>Male</td>
<td>Black</td>
<td>Specific Learning Disability</td>
</tr>
</tbody>
</table>

*Note.* P = Physics; ES = Earth Science; ADHD = Attention Deficit Hyperactivity Disorder
Prior to the study implementation, the researcher submitted a university Institutional Review Board (IRB) application and subsequently received university IRB approval and approval from the headmaster of the cooperating school. Other forms signed by the parents of participants or the participants themselves included (a) Informed Consent, (b) Student Assent, and (c) Informed Consent for use of Photos/Video Materials (see Appendices A-F). Additionally, all parents of the participants signed an authorization form for the researcher to gain access to students’ Individual Instruction Plan, similar to an Individualized Education Program, as well as their Psycho-Educational Evaluation (see Table 3.3). When students returned the signed consent forms, they received a $10 Visa gift card.

Table 3.3

*Information Summary Table of Psychological Testing Results*

<table>
<thead>
<tr>
<th>Student</th>
<th>Disability</th>
<th>Working Memory</th>
<th>Verbal Comprehension</th>
<th>Processing Speed</th>
<th>Relevant Testing Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ADHD, Asperger’s Syndrome, Dysthymic Disorder</td>
<td>Low average</td>
<td>Superior</td>
<td>Borderline low</td>
<td>Competently evaluates and analyzes text</td>
</tr>
<tr>
<td>2</td>
<td>Autism Spectrum Disorder, Dysgraphia</td>
<td>Average</td>
<td>Superior</td>
<td>Low average</td>
<td>Challenged by higher order thinking; struggles in class discussions that require him to hear opinions of others</td>
</tr>
<tr>
<td>3</td>
<td>Autism Spectrum Disorder</td>
<td>Average</td>
<td>Average</td>
<td>Low average</td>
<td>Significant area of need is ability to process information quickly</td>
</tr>
<tr>
<td>4</td>
<td>ADHD, Autism</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Struggles with higher-order thinking skills</td>
</tr>
<tr>
<td>5</td>
<td>Nonverbal Learning Disability</td>
<td>Low</td>
<td>High average</td>
<td>Low</td>
<td>Processing weaknesses</td>
</tr>
<tr>
<td>6</td>
<td>ADHD, Disruptive Mood Dysregulation Disorder</td>
<td>Average</td>
<td>Average</td>
<td>High average</td>
<td>Significant social difficulties including difficulty responding in</td>
</tr>
</tbody>
</table>
The intervention took place in one science classroom, but at three different times throughout the day. Eligible participants attended a twelfth grade Physics class or one of two ninth grade Earth Science classes (see Table 3.2). The number of students enrolled in Class 1, 2, and 3 were 10, 4, and 3 respectively with a broad range of abilities represented in the three classrooms. Ten students with disabilities were enrolled in the twelfth grade Physics class.

Research indicates an appropriate group size for argument in science often consists of groups of three or four students (Fowler, Zeidler, & Sadler, 2009; McNeill & Krakcik, 2007; Nielsen, 2012; Osborne, Erduran, & Simon, 2004), thus, one group of ten students was deemed too large for the current study. Further, research conducted on both groups in such close proximity would have been a threat to internal validity, as the question of whether the independent variable and only the independent variable was responsible for the observed changes in behavior could not be answered definitively (Ledford & Gast, 2018). Students in either group may have overheard the other argument session resulting in a change in their behavior. Thus, the teacher and the 

<table>
<thead>
<tr>
<th>7</th>
<th>Learning Disability</th>
<th>Significantly Low</th>
<th>Low-average</th>
<th>Low</th>
<th>Verbal comprehension area of strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>ADHD</td>
<td>Average</td>
<td>Average</td>
<td>Very low</td>
<td>Strengths verbal comprehension and working memory</td>
</tr>
<tr>
<td>9</td>
<td>ADHD, Adjustment Disorder, Specific Learning Disability</td>
<td>Average</td>
<td>Low average</td>
<td>Low average</td>
<td>Processing speed a deficit</td>
</tr>
<tr>
<td>10</td>
<td>Autism Spectrum Disorder</td>
<td>Not reported</td>
<td>Average</td>
<td>Average</td>
<td>Apt to become obsessive in his interests</td>
</tr>
<tr>
<td>11</td>
<td>ADHD, Autism Spectrum Disorder</td>
<td>Average</td>
<td>Average</td>
<td>Average</td>
<td>Strength in critical thinking skills</td>
</tr>
<tr>
<td>12</td>
<td>Specific Learning Disability</td>
<td>Below average</td>
<td>Average</td>
<td>Not reported</td>
<td>Learns best when information presented verbally</td>
</tr>
</tbody>
</table>

Note. ADHD = attention deficit hyperactivity disorder; Working Memory measures ability to hold orally presented information in memory, perform an operation with it, and produce a result; Verbal Comprehension measures verbal concept formation, verbal reasoning, and depth of knowledge regarding previously learned facts and procedures; Processing speed measures ability to quickly and correctly scan, sequence, or discriminate visual information without making errors.
researcher randomly assigned each twelfth grade student to Group One or Group Two. Once the
groups of five were determined, the researcher randomly chose Group One for the dissertation
research. The group that was not chosen, Group 2, also participated in the intervention and their
argument sessions were videotaped. This was a practical decision made by the teacher and
researcher to ensure that all students were engaged during the time period set aside for the
dissertation research. The parents of one twelfth grade student declined his participation in the
study. The student watched science videos on his laptop during the argument sessions. The
researcher facilitated both groups during the argument sessions. There was no attrition in the
study.

One doctoral student researcher served as the intervention agent. The researcher is a
licensed special educator with 18 years of experience teaching special education students in
public and private school settings. She has taught students in preschool through grade 12. The
researcher is conducting the current study as part of the required dissertation research. She has
completed rigorous coursework and in-depth research on the topic of argumentation using SSI,
making her qualified to be the interventionist. One science teacher instructed all three classes
participating in the dissertation research. As a practical consideration for the loss of instructional
time, it was predetermined by the teacher and the researcher that there would be a 19 session
limit for the dissertation research to be conducted in each participating classroom.

The research took place in one classroom at the private day school where the teacher
assigned to the classroom taught Physics, Marine Science, Biology, and Earth Science. The
space was approximately 20 feet wide by 24 feet long with one doorway in the front of the class.
There were two rows of six by two and one half foot tables placed end to end. Two to three
chairs were included at each table. There was a two and one half foot by seven foot laboratory
island in the front of the room with a sink in it. The whiteboard where the PowerPoint was projected during instruction was behind the island approximately four feet. One entire wall is encompassed by windows. Two adjacent walls were encased in upper and lower cabinets with pictures of DNA taped on them. There was a turtle in a fish tank and several whale, dolphin, and seal pictures were hung throughout the room. There was a catfish skill, a turtle shell and a spiny dogfish in a jar on the laboratory island. A poster of the Periodic Table of Elements was hung to the left of the whiteboard. The classroom housed a pair of eight feet tall by four feet wide aquaponic steel wire utility racks. The top two rows included plastic trays filled with growing cucumber, bell peppers, and bean plants. A 200 gallon plastic tank with 20 bluegill occupied the bottom third of each rack.

**Materials**

The identification of common science content for argument in which ninth and twelfth grade students possess similar knowledge was deemed impractical by the teacher and researcher. Thus, SSI were chosen as topics for the argument sessions (see Appendix H). Utilizing SSI during argument sessions allowed the researcher to control for the difference in grade levels by providing each grade the same topic for argument. Prior to commencement of the study, a list of SSI were assigned randomly to sessions one through 19. Each class received the same argument topic that corresponded to their session number.

A crucial part of engaging in argument is the ability to distinguish between credible and non-credible evidence (Fowler, Zeidler, & Sadler, 2009; Lin & Mintzes, 2010; Rose and Barton, 2012; Zeidler, Sadler, Applebaum, & Callahan, 2009). Thus, the evidence provided to students for use in the argument sessions included both types of evidence. The credible and non-credible evidence consisted of information: (a) downloaded from the internet (e.g., Google, WebMD);
(b) identified from social media (e.g., blogs, Twitter, Facebook); (c) from magazines (e.g., Time, Newsweek); and (d) from current local and national newspapers.

The researcher used a feature on her Apple iPhone 8 to time each 20 minute session. A Sony Digital HD Video Camera Recorder with an Insignia 6” Tripod and a Canon EOS Rebel T6 with a Targus Grypton Pro XL Tripod were used to record the sessions. The video cameras and iPhone were placed adjacent to the table where the students were sitting. All baseline, probe, intervention, and maintenance sessions were videotaped and uploaded onto a Google Drive for coders to access.

**Procedures**

The following table identifies the data sources utilized in the current research, the type of data analysis conducted, and the research question associated with each data source.

Table 3.4

*Pre-Intervention and Intervention Data Sources and Data Analysis*

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Data Analysis</th>
<th>Research Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views of the Nature of Science-E (Chen, 2006)</td>
<td>Rubric (i.e., naïve, transitional, informed)</td>
<td>No specific RQ association; assessment of relevance of science to students’ everyday lives</td>
</tr>
<tr>
<td>Assessment of Scientific Argumentation in the Classroom Observation Protocol (ASAC; Sampson &amp; Enderle, 2012)</td>
<td>Descriptive Statistics</td>
<td>Research Question 1</td>
</tr>
<tr>
<td>Individual Student Coding Protocol</td>
<td>Coding (i.e., frequency counts)</td>
<td>Research Question 2</td>
</tr>
<tr>
<td>Social Validity Survey</td>
<td>5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)</td>
<td>Research Question 3</td>
</tr>
</tbody>
</table>

**Pre-baseline.** Prior to baseline data collection, the researcher administered the VNOS-E to all three classes. Each test was administered on the same day. All three classes took the
VNOS-E on Monday during their regularly scheduled class. The students had the entire class period to complete the pretest. No student took longer than 40 minutes. The tests were not read aloud, but students were told they could ask for clarification of questions, if needed. No student asked for clarification.

**Baseline and Probe Conditions Prior to Intervention.** During baseline and probe conditions prior to intervention, the researcher greeted the students and set a timer for 20 minutes. The researcher told students they would have the opportunity to address a moral or social dilemma about a current science problem. Each student was handed a scenario. The text was underlined and/or bulleted as a visual cue for students to follow as the researcher read the information aloud. Charts, graphs, photos, and other informational graphics were included on the pages and the captions were read aloud. The source for each piece of evidence was also read aloud but not commented on by the researcher in terms of credibility (see Appendix M). After the read aloud, students were told they would have approximately 15 minutes to consider different courses of action related to the complex socioscientific problem just read. Then the researcher told students to “get started.” When the timer rang at the end of the allotted time, the researcher collected the papers and thanked students for working hard (see Appendix N). The researcher did not intervene or intrude during the baseline or probe conditions prior to the intervention other than using close proximity to students or redirecting negative or off-task behavior.

After Class 1 completed five sessions of baseline, they began intervention with the researcher. In Class 2 and Class 3, probes were administered three times in succession at the outset of the study. Following this, Class 2 and Class 3 were probed every fourth session as they remained in baseline. When criterion-level performance (i.e., a score of 80% or higher on the
ASAC over three sessions) was achieved for Class 1, the intervention commenced in Class 2. Notably, three consecutive baseline data points for Class 2 were collected prior to the introduction of the intervention for Class 2. During intervention for Class 2, at least one probe point was collected for Class 1 and Class 3. When criterion-level performance was achieved for Class 2, the intervention commenced in Class 3. Three consecutive baseline data points for Class 3 were collected prior to the introduction of the intervention in Class 3. During intervention for Class 3, at least one probe point was collected for Class 1 and Class 2.

**Intervention.** Intervention procedures are described in two sections: Explicit Instruction in Argumentation Using Socioscientific Issues and Instructional Sequence During Argument Sessions.

**Explicit Instruction in Argumentation Using Socioscientific Issues.** The researcher introduced a 45-minute lesson on argumentation using explicit instruction by: (a) activating students’ prior knowledge of the nature of science and addressing students’ misconceptions; (b) presenting material in small steps using modeling; (c) providing timely feedback, cues, and prompts; (d) offering guided practice, and (e) giving correctional feedback and reteaching when necessary (Archer & Hughes, 2011; Zohar & Nemet, 2002). Instruction in argumentation also included a discussion on appropriate group interactions.

The researcher introduced the lesson using a PowerPoint presentation, which is the instructional delivery most commonly-used by the classroom teacher. The PowerPoint presentation included *guided notes*. Guided notes are sentences or phrases that include blanks where key words/concepts are written (Konrad, Joseph, & Itoi, 2011). Guided notes included in the PowerPoint had the key words/concepts written in red for ease of identification for students. Students filled in the blanks on their laptop using Endnote, a digital platform for note taking, as
they listened to instruction. The use of guided notes was a typical instructional delivery used by the classroom teacher.

To begin the lesson, the researcher discussed the nature of science with students and addressed students’ misconceptions about the nature of science. For example, some students believe that scientists are not creative, and experiments are the only route to knowledge. Then the researcher showed a video clip from a television show, *The Big Bang Theory*, to illustrate that many people perceive argument to be a verbal and/or physical fight between family and friends that ends with a clear winner. After the video, the researcher asked students to share their experiences with argument. Next, the researcher introduced scientific argumentation (SA) and discussed the similarities and differences between everyday argument and SA. Then the researcher introduced argumentation using SSI and discussed the similarities and differences between all three types of argument. Two PowerPoint slides identified examples of what constitute a SSI. The subsequent four PowerPoint slides identified parts of an argument (i.e., guiding question, claim, evidence, reasoning) and gave multiple examples of each. A video clip from *Harry Potter and the Prisoner of Azkaban* was shown to introduce evidence. The video was shown to emphasize that one cannot “just know” something but one needs to provide evidence to back up a claim. The researcher then read students a SSI and modeled how to use the guiding question, claim, evidence, and justification in an argument. Reaching consensus or defending a point of view were presented as two outcomes of argumentation and examples of each were offered, first by the researcher then by the students. The importance of appropriate group interactions was emphasized. First the researcher, then the students modeled examples of appropriate and inappropriate group interactions based on their personal experiences. After that, a slide depicting ways to make connections between science and school using SSI was discussed.
Next, the researcher showed students several scaffolds available for use during argument sessions. One scaffold was a set of cards with sentence starters that reminded students of the elements of an argument (i.e., guiding question, claim, evidence). Another set of cards had questions written on them (i.e., Is there anything that you are unsure about?) that students could use to engage peers in discourse. A final set of cards included questions used to promote a specific type of talk (i.e., Inviting Questions, Probing Questions). Finally, the students played Socioscientific Showdown! a researcher-made game that reviewed: (a) the nature of science; (b) differences between everyday argument, scientific argumentation, and socioscientific argumentation; (c) appropriate group interactions; and (d) the elements of an argument. Each student had a different sounding buzzer and when s/he knew the answer, s/he rang the buzzer. All students received a package of animal crackers at the conclusion of the game.

Instructional Sequence During Argument Sessions and Probe Sessions Subsequent to Intervention. The researcher thanked students for working with her, placed the scaffolds on the table, and set the timer for 20 minutes. The researcher told students they would have an opportunity to address a moral or social dilemma about a current science problem. Then the researcher reminded students of behaviors that are used in argumentation (a) making a claim that answers the guiding question, (b) providing more than one piece of evidence for the claim using observations or measurements, and (c) demonstrating appropriate group interactions. The researcher set a goal for groups to reach consensus or defend a point of view, handed students a written scenario, and read the information aloud. The underlined or bulleted information was read aloud as in baseline as were the captions of charts, graphs, photos, and other informational graphics. Lastly, the source for each piece of evidence was read aloud but not commented on by the researcher in terms of credibility.
At the conclusion of the read aloud, the researcher asked if there were any questions and answered them. Students were told to use the scaffolds during the session. Students were reminded they would have approximately 15 minutes to consider different courses of action related to the complex socioscientific problem just read aloud. The researcher told students to “get started” (see Appendix N). The researcher used timely, corrective feedback, cues, and prompts during the argument episodes, as appropriate. When the timer rang signaling the conclusion of the session, the researcher thanked students for working hard and collected all of the materials.

**Probe Condition.** Multiple probe designs do not require continuous measurements of all behaviors, conditions, or participants prior to introduction of the independent variable; data are collected intermittently prior to the introduction of the intervention (Horner & Bear, 1978). Further, a probe condition differs from baseline condition in that probe conditions do not occur for the duration of pre-intervention for each tier (i.e., class). This distinction makes the multiple probe design well-suited for conducting research in a classroom environment (Ledford & Gast, 2018). In the current dissertation research, planned intermittent measurement of probe conditions occurred every fourth session subsequent to each class receiving a minimum of three baseline sessions. Probe conditions were implemented to determine if the data remained stable and unchanged across tiers.

**Maintenance.** Maintenance data were collected on an argument session one week post-intervention. During maintenance, students were given a socioscientific issue and engaged in a 20-minute argument session following the same protocol as the intervention sessions. Student behavior during maintenance was measured by the same analyses (i.e., ASAC, individual
coding) as during the intervention sessions. Maintenance data measured the sustainability of the newly acquired skills at one week post-intervention.

**Data Analysis**

**Pre-Intervention analysis.** Pretests/posttests were administered using the Views of Nature of Science-Elementary (VNOS-E; Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). The VNOS is an open-ended survey that categorizes students’ views about the nature of science into seven beliefs/attitudes. The VNOS-E (elementary) assesses (a) distinction between observations and inferences, (b) empirical nature of scientific knowledge, (c) creativity in science, (d) subjectivity in science, (e) cultural and social influences, (f) tentative nature of science, and (g) distinction between scientific laws and theories (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). One example from the VNOS-E creativity category is the following question: *Do you think scientists use their imaginations when they do their work. If NO, explain why. If yes, then explain why you think they use their imaginations* (see Appendix I). Students’ scores on the VNOS-E are characterized as naïve, transitional, or informed in terms of understanding the nature of science. The designers of the instrument, Lederman, Abd-El-Khalick, Bell, and Schwartz (2002), suggest a high confidence level in the validity of the VNOS for assessing the nature of science understandings.

The science teacher was provided with several iterations of the VNOS (i.e., VNOS-B, VNOS-C, VNOS-D, VNOS-E) to determine which version would be the most appropriate for the participants in the study. The teacher chose the VNOS-E, indicating an elementary version, due to the straightforward wording of the questions (see Appendix I). The font on the original VNOS-E appeared childlike to the teacher and researcher (e.g., Microsoft Word Version 16-Chalkboard), so the questionnaire was retyped using Times New Roman 12 font. Additionally,
one question addressed weather pictures on television. The weather picture was shown on an old-fashioned looking television with three dials. The researchers modified the VNOS-E to include an updated picture of what a weather map might look like on television in 2019 (see Figure 3.1).

Figure 3.1. Sample question from VNOS-E before (top) and after (bottom) revision

6. TV weather people show pictures of how they think the weather will be for the next day. They use lots of scientific facts to help them make these pictures.


A final question asking students to rank the topics used for argument from least to most favorite

Baseline and Intervention Analysis

Coders used the modified Assessment of Scientific Argumentation in Classrooms Observation Protocol ([ASAC]; Sampson, Enderle, & Walker, 2012) to determine students’ engagement in argument sessions. The ASAC is a validated instrument that allows researchers to
score a session, or episode, of scientific argumentation (SA) in terms of its overall quality, based on student engagement. The instrument is divided into three subscales that target the cognitive, epistemic, and social aspects of scientific argumentation (e.g., behaviors that reflect scientific thinking). Notably, the ASAC assesses engagement in SA, not engagement in argument using SSI, as was the dependent variable for the current study. However, the researcher deemed most of the information on the instrument applicable to the dissertation research, with a few exceptions. Based on the researcher’s pilot study, six questions were omitted from the 19 question ASAC in an attempt to modify the instrument for the current study (see Appendix J).

Group performance on the ASAC was treated as a single data point on a graph. The higher the group score, the higher the engagement in argumentation.

Grooms and associates (2018) suggested that if the goal of a study is to determine how students engage in argumentation, individual outcomes as well as group outcomes must be assessed. Coders used a researcher-developed protocol to code students’ individual engagement in the argument sessions (see Appendix K). The following were tallied and analyzed: (a) number of individual occurrences of the three argumentation processes (i.e., claim, evidence, reasoning); (b) appropriate group interactions; and (c) whether students added barely substantive, or unrelated information. Lastly, perceptions of all participants were measured through a social validity questionnaire.

Visual Analysis

Using Microsoft Excel, three graphs were constructed for the dependent variable, one graph for each group (i.e., Physics, Earth Science 1, Earth Science 2). First, data were examined with regard to the level (i.e., absolute and relative) changes within and between phases. Level refers to the average of the data calculated within a condition (Kennedy, 2005). Second, the
immediacy of effect was examined, with measurements of both absolute and relative changes in level between baseline and intervention conditions. The absolute level change between phases assesses the impact of intervention on the dependent variable. When a large change in level is demonstrated after the introduction of a new condition (i.e., intervention), the intervention is considered effective (Ledford & Gast, 2018). Absolute level change within a condition was calculated by (a) identifying the values of the first and last data points of a condition, (b) subtracting the smallest from the largest, (c) identifying whether the change in level was improving or deteriorating (Ledford & Gast, 2018). Relative level change within a condition is considered more representative and was determined by: (a) calculating the mean value of the first half of the data in a condition; (b) calculating the mean of the second half of the data in the same condition; (c) subtracting the smallest median value from the largest median value; and (d) noting the difference between median values (Ledford, & Gast, 2018). In a third analysis, the trend line in each phase was examined to make a reliable determination of experimental control indicated by systematic increases or decreases in data points over time (Ledford & Gast, 2018; Kadzin, 1982). In the current research, a decelerating or zero-celelerating trend line during baseline and an accelerating trend line during intervention would be optimum. Trend lines were drawn first using the freehand, split-middle method. To confirm results, trendlines were then calculated using Microsoft Excel. According to White and Haring (1980), the split-middle method provides a more reliable estimate of trend and is recommended when data are variable. The split-middle method uses middle sessions and median ordinate values in a single condition, never across adjacent conditions, to estimate trend. To calculate the split middle line of progress, data points were divided in half within each condition. Second, the intersections of the mid-rate and mid-date for each half were identified. Third, a line was drawn through the data which
included mid-rate and mid-date data points. Fourth, the line drawn line was moved up or down so there was an equal number of data points above and below the line. The line represents the split-middle line of progress. A fourth analysis used to determine stability of level (i.e., the amount of variability in a data series) and level change was the calculation of a stability envelope. Typically, if 80% of the data points in a condition fall within a 25% range of the median level of all data points in a condition, data are considered stable (Cakiroglu, 2012; Ledford & Gast, 2018). A stability envelope was identified by drawing one parallel line drawn above the median line and one parallel line drawn below the median line. The distance, or range, between the two lines indicated the variability of the data. A fifth method of analysis considered the proportion of overlapping data (PND); that is the extent to which data in adjacent phases overlap (Maggin, Cook, & Cook, 2019; Scruggs & Mastropieri, 2013). The percentage of nonoverlapping data is still commonly used in single subject research design, although well-documented limitations exist (i.e., reliance on a single score in baseline). Some researchers (Kratochwill et al., 2010) suggest the discontinuation of its use. PND was calculated by identifying the most extreme value in the baseline phase in the intended therapeutic direction and comparing it to all data points in the subsequent intervention phase. If the baseline data equals or exceeds an intervention data point, it is considered overlapping data. The number of nonoverlapping data points in the intervention phase, divided by total intervention phase points is the PND. Ranges of PND are from 0% to 100%, with values greater than 80% indicating an effective intervention, values between 60% and 80% indicating a moderate effect, and values below 60% suggesting no effect (Scruggs & Mastropieri, 2013). Generally, the lower the PND, the more effective the intervention. Notably, calculation of PND has received criticism because there are circumstances (i.e., inclusion of outliers) where overlap does not accurately depict the
effects of an intervention (Maggin, Cook, & Cook, 2019). To address limitations when calculating PND, specifically insensitivity to positive baseline trend, researchers developed a relatively new type of analysis, the Tau-U (Manolov & Moeyaert, 2017; Wolery, Busick, Reichow, & Barton, 2010). This analysis represents the proportion of data that improved between baseline and intervention phases after controlling for trends in the baseline data. Tau-U ranges from 0 to 1.0, with values greater than 0.90 are considered a large effect, values between 0.60 and 0.90 are considered a moderate effect, and values below 0.60 are considered a small effect. An online calculator was used to determine Tau-U values.

**Treatment Fidelity, Inter-Observer Agreement, and Social Validity**

All baseline and intervention sessions were videotaped. One doctoral student and one public school teacher viewed 100% of the taped sessions to ensure that the researcher who was delivering the intervention adhered to the procedural fidelity checklist during (a) baseline and probe conditions, (b) explicit instruction, and (c) argument sessions. The coders were trained to evaluate the videotapes using the ASAC, an instrument that measured group engagement in argumentation (Grooms, Sampson, & Enderle, 2018; Sampson, Enderle, & Walker, 2012). A collection of videos from the researcher’s pilot study were utilized for training the coders. Each coder scored a video independently, then the two coders compared scores. Any differences in scoring were discussed until agreement on a score was reached. Once coders reached at least 80% agreement on the first video, they coded three additional pilot videos achieving a minimum of 80% interobserver agreement. Similarly, coders scored the individual behaviors of students using a coding protocol designed by the researcher. All inter-observer agreements (IOA) achieved 83% or greater for each measure and was calculated on 100% of the sessions. The
formula for calculating IOA is the total number of agreements, divided by the total number of agreements plus disagreements, multiplied by 100.

Upon the completion of the study, a social validity survey was administered to participants (see Appendix O). The survey consisted of eight questions that employed a five-point Likert scale (i.e., 1 = No! I strongly disagree!, 5 = Yes! I strongly agree!) to measure students’ attitude about learning argumentation using SSI. One open-ended question was included at the end of the survey.

Data from baseline, probe, intervention, and maintenance sessions for each class were collected, graphed, and assessed daily for purposes of formative and immediate evaluation of treatment effects. Visual analyses were conducted on graphs to evaluate the level change, trend, and variability. The percentage of non-overlapping data points (PND) in each phase were calculated to determine effect size. These analyses determined whether a functional relation existed between the independent variable and the dependent variable. Individual data from baseline, probe, intervention, and maintenance sessions were coded at the conclusion of the study. Pretests and posttest comparisons were used to examine summative growth over time regarding students views on the nature of science. The social validity survey was also analyzed.

Summary

This chapter presented the results of a small pilot study conducted by the researcher. It also included the methodology for the current dissertation research examining the effects of explicit instruction for secondary SWD in argumentation using SSI. It included the research questions and a description of the research design. It also provided detail about the participants, setting, and materials used in the study. The chapter explained the baseline, probe, intervention, and maintenance phases. Implementation fidelity, inter-observer agreement, and social validity
were also addressed. Finally, a detailed description of data analyses was provided to evaluate intervention effects.
CHAPTER FOUR

RESULTS

This study investigated how students with disabilities (SWD) engaged in argumentation using socioscientific issues (SSI). This chapter is divided into seven sections (a) methods of analysis, (b) analysis of preintervention results, (c) analysis of baseline and intervention results, (d) intervention results reported by subsections on the ASAC, (e) individual results, (f) results of social validity survey, and (g) treatment fidelity and interobserver agreement.

The research activities took place over a five month period, starting with recruiting participants and ending with collecting social validity data. Data were collected from 12 student participants to examine group and individual engagement in argumentation. A multiple probe design replicated across three classes was used to evaluate whether there was a functional relation between explicit instruction in argumentation using SSI and an increased level of student engagement. First, the types of analyses used to evaluate treatment effects are presented in the Methods of Analysis section. Second, the results of each research question are analyzed and reported in the Analysis of Intervention Results section.

Methods of Analysis

A pretest/posttest assessing students’ understanding of the Nature of Science before and after the intervention was administered. Analyses of the single-case research design were examined both visually and statistically to evaluate the functional relations that may have been established in the study (Cakiroglu, 2012; Levin, Ferron, & Kratochwill, 2012; Maggin, Cook, & Cook, 2019; Parker, Vannest, & Davis, 2011; Parker, Vannest, Davis, & Sauber, 2011). Descriptive statistics were utilized in addition to visual analysis.
Data from the Assessing Scientific Argumentation in the Classroom (ASAC) Observation Protocol were analyzed using mean and standard deviation to examine group changes between baseline and intervention scores in each targeted section of the ASAC. Individual data were collected during group sessions and a sociogram was constructed to represent the individual dialogic interactions among group members. Last, a social validity survey was administered to participants to examine their perceptions of participation in argumentation sessions using SSI.

Five twelfth grade students and seven ninth grade students participated in the study. Every student in the study had an identified disability (i.e., Asperger’s syndrome, autism spectrum disorder, dysthymic disorder, learning disability, and/or adjustment disorder). Random assignment of students to each class was not an option as the students in each class (one Physics class and two Earth Science classes) was determined at the beginning of the school year. Each tier of instruction consisted of baseline and intervention, along with an evaluation of the intervention effects. Individual and group data were collected and analyzed. In the subsequent sections, each research question is answered individually. Collectively, these methods and analysis were used to assess the effects of the intervention described in the Analysis of Results section below.

Analysis of Pre-Intervention Results

Prior to commencing the study, the Views of Nature of Science (VNOS) survey was administered to participants. The face and content validity of the various versions of the VNOS have been established (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). While aspects of Nature of Science (NOS) were not explicitly taught during the intervention, examining whether participants’ understanding of NOS changed from the beginning to the end of the study offered an opportunity for participants to explain how they feel science is relative to their everyday lives.
Participant responses were scored as either (a) Naïve (i.e., response is not consistent with any part of the NOS aspect), (b) Transitional (i.e., response is consistent with some, but not all, parts of the NOS aspect, or (c) Informed (i.e., response is consistent and addresses ALL parts of the NOS aspect. Most views regarding the question What is science? remained naïve from pretest to posttest (i.e., the way the world works; creation; the meaning of life; everything). However, some views indicated a transitional understanding of NOS on posttests (i.e., a method of obtaining information empirically; the study of the functions of the universe). On the pretest, Student 2 wrote, “Science is a way to explore the universe, through thoughts, theories, and tests, all while creating a story to tell, though honestly that’s just romantization,” indicating both a naïve and transitional view of NOS. Most participants believed that science was different from other subjects because it was more hands-on, interactive or immersive. Those naïve ideas did not change from pretest to posttest. Participants’ answers to “How do scientists know that dinosaurs once lived on the earth?” and “How sure are scientists about the was dinosaurs looked? Why?” demonstrated an understanding that the NOS is tentative. Responses to the previous two questions did not change from pretest to posttest. Results were mixed on whether participants believed scientists use their imaginations when they do their work. Answers did not change from pretest to posttest. Answers indicating a naïve understanding included (a) “No, they have to be factual about their work so it could stay professional,” (b) “No, because science is based on facts and straight to the point research.” Answers indicating transitional understanding included (a) “When developing hypotheses, analyzing data, and designing experiments,” and (b) “creating a hypothesis”. Overall, most students views of the NOS did not change over the course of the study. This result was not unexpected, as NOS was not an emphasis of the intervention,
nor were the NOS aspects explicitly taught in the ninth and twelfth grade Physics and Earth Science curriculum.

**Research Question 1**

Is there a functional relation between explicit instruction in argumentation using SSI and an increased level of student engagement (e.g., use of behaviors that reflect scientific thinking) during group argumentation sessions for ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

**Analyses of Baseline and Intervention Results.** Refer to Figure 4.1 for a graph of the Baseline and Intervention results and to Table 4.1 for summary statistics across phases for each class.
Figure 4.1 Graph of Group ASAC Baseline and Intervention Scores by Class

**Baseline.** Systematic visual analysis of within condition phases indicated that no baseline phase achieved stability. Sheskin (2007) suggests that when data are heavily varied, median level comparison is superior to mean level comparison. The mean, median, range, and standard deviation (SD) for Physics, Earth Science Class 1, and Earth Science Class 2 were $M = 55.8$, median = 53, range = 47% - 65%, SD = 7.35; $M = 50$, median = 47, range = 24% - 82%, SD = 15.98; $M = 48.8$, median = 41, range = 18% - 88%, SD = 20.27 respectively (see Table 4.4). Data analysis for Physics indicated an accelerating trend line with a slope of +0.67. Results of data analysis for Earth Science Class 1 demonstrated an accelerating trend line of +1.7, Earth Science Class 2 indicated an accelerating trend line with a slope +1.28. In baseline the relative change for Physics was +2, Earth Science 1 was +18, and Earth Science 2 was +18. The absolute level change for Physics, Earth Science 1 and Earth Science 2 was +3, 0, and +30 respectively.

Table 4.1

**Summary Statistics for Group Scores on the Assessment of Scientific Argumentation Across Classrooms (ASAC) Observation Protocol**

<table>
<thead>
<tr>
<th>Class</th>
<th>Baseline</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>Median</td>
</tr>
<tr>
<td>Physics</td>
<td>55.8</td>
<td>53</td>
</tr>
<tr>
<td>(N = 5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES1</td>
<td>50.0</td>
<td>47</td>
</tr>
<tr>
<td>(N = 4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES2</td>
<td>48.8</td>
<td>41</td>
</tr>
<tr>
<td>(N = 3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: N = number of students; M = mean; SD = standard deviation; ES = Earth Science*
**Intervention.** Intervention results are reported by class.

**Physics.** The twelfth grade Physics class \((N = 5)\) received a total of eight intervention sessions.

The groups’ mean scores on the ASAC increased immediately from 53\% to 76\% upon implementation of the intervention. Scores for the mean, median, range, and SD during the intervention phase were \(M = 76\), median = 82, range = 53\% to 94\%, SD = 14.63 respectively. An accelerating trend line with a slope of +4.5 was demonstrated using the split-middle method. Fifty percent of the data in the intervention phase fell on or within the stability envelope on the trend line, indicating the data are variable. Conversely, the relative level change within the intervention phase was +18, indicating the data were improving.

**Earth Science Class 1.** The ninth grade Earth Science Class 1 \((N = 4)\) received a total of eight intervention sessions. The groups’ mean scores on the ASAC increased immediately from 47\% to 59\% upon implementation of the intervention. Scores for the mean, median, range, and SD during the intervention phase were \(M = 75.6\), median = 79, range = 59\% to 88\%, SD = 10.55 respectively. An accelerating trend line with a slope of +2.9 was demonstrated using the split-middle method. Thirty-seven point five percent of the data in the intervention phase fell on or within the stability envelope on the trend line, indicating the data were variable. However, the relative level change within the intervention phase was +12, indicating the data were improving.

**Earth Science Class 2.** The ninth grade Earth Science Class 2 \((N = 3)\) received a total of six intervention sessions. The groups’ mean scores on the ASAC increased immediately from 71\% to 88\% upon implementation of the intervention. Scores for the mean, median, range, and SD during the intervention phase were \(M = 77.3\), median = 79, range = 65\% to 88\%, SD = 9.62 respectively. An accelerating trend line with a slope of +2.4 was demonstrated using the split-
middle method. Despite 33% of the data in the intervention phase fell on or within the stability envelope on the trend line, indicating the data were variable, the relative level change within the intervention phase was +6, indicating the data were improving.

**Summary of between condition analysis.** Between condition analyses refers to comparisons of data across adjacent conditions during a study (e.g., baseline and intervention; Lane & Gast, 2013). An immediate and abrupt change in level and trend upon introduction of the independent variable is desirable. Further, for the current research a decelerating or zero-celerating trend during baseline and an accelerating trend during intervention is desirable. Calculating the trend using the split-middle method indicated the trend direction across adjacent conditions was accelerating in both baseline and intervention. The relative changes for each class between conditions increased from -7% to 18%, demonstrating a positive effect. The absolute level changes for Physics and Earth Science 2 between conditions increased from 0 to +19, demonstrating a positive effect. The absolute level changes for Earth Science 2 ranged from 30 to zero. The PND were 75% for Physics, 25% for Earth Science Class 1, and 0% for Earth Science Class 2, indicating a moderate effect of the intervention for the Physics class and no effect for Earth Science Classes 1 and 2. An analysis was conducted using the Tau-U, which controls for trends in the baseline data. Results for Physics showed an effect size of .70, Earth Science Class 1 showed an effect size of .77, both indicating a moderate effect size. Earth Science Class 2 showed an effect size of .57, which is considered a small effect (Maggin, Cook, & Cook, 2019).

**Summary of within-condition analysis.** Within condition analysis refers to an analysis of data patterns within a single condition (e.g., baseline or intervention; Lane & Gast, 2013). Baseline conditions across classes indicated a range of 18% to 88% and a mean of 48.8% to
55.8%. The median level was 47. Baseline data were variable across classes. Trend lines during baseline conditions demonstrated a slope range from .67 to 1.7. Intervention conditions across classes indicated a range of 53% to 94% and a mean of 75.6% to 77.3%. The median level was 79. All three trend lines during intervention were accelerating. Trend lines during intervention demonstrated a slope range from 2.4-2.9, with Physics showing the highest level of acceleration. Positive slope in the intervention phase suggests the likelihood of further improvement in the future (Parker, Vannest, Davis, & Sauber, 2011).

**Summary of visual analysis of data.** Within conditions, between conditions, and across conditions analyses suggest the possibility of a functional relation between the intervention and explicit instruction in argumentation using SSI. In each class, an immediacy of effect was demonstrated upon introduction of the intervention. When analyzing the data within conditions, a mean of 51.5% and a median of 47% for all baseline points rose to a mean from of 76.5% and a median of 79% for the intervention phases. Between conditions analysis showed positive changes in relative levels for all classes from baseline to intervention, rising from -.7% to 18%. A PND of 75% for Physics indicated a moderate effect of the intervention. Results of the Tau-U showed an effect size of 70% for Physics and an effect size of 77% for Earth Science Class 1, indicating a moderate effect size. Earth Science Class 2 showed an effect size of 57%, which indicates a small effect size.

**Maintenance.** One maintenance probe was administered after one week, following the completion of the intervention for each class. Maintenance scores ranged from 71% - 88%, with a mean score of 78%. The data for the Physics class indicated maintenance at the 100% level; however, maintenance data for the Earth Science Class 1 reverted to baseline levels. For the
Earth Science Class 2, though the maintenance data was within the intervention range, it also overlapped within the range of baseline data.

**Intervention Results Reported by ASAC Subsection**

The ASAC was used in the current study to identify how students’ ability to engage in scientific argumentation developed over time (Sampson, Enderle, & Walker, 2012). In an effort to determine which areas of the ASAC showed improvement from baseline to intervention, the means and standard deviations of four subsections of the ASAC were calculated (see Table 4.2). The Conceptual and Cognitive Aspects subsection of the ASAC examined how students used scientific theories, models, or laws and cognitive processes valued in science (i.e., solving a problem, advancing understanding, modifying explanation) when reasoning about a topic. The Epistemic subsection of the ASAC investigated how the group determines what counts as valid or acceptable evidence (i.e., using evidence to support or challenge ideas, examine relevance of evidence, evaluate data). The third subsection of the ASAC is the Social Aspects. This section targets group dynamics (i.e., being respectful, encouraging). The last subsection of the ASAC identified if students were able to make connections between the science content in the current lesson and prior experiences in and out of school. Results indicated that the mean of the Conceptual and Cognitive subsection for Physics, ES1, and ES2 improved. Further, this subsection showed the greatest improvement for all the groups combined (i.e., Baseline $M = 8$; Intervention $M = 15$). On the Epistemic subsection of the ASAC, which is predominantly examining, evaluating, and utilizing evidence and data, the means for the Physics and Earth Science 2 class remained unchanged. Whereas, the mean for Earth Science Class 1 improved slightly (i.e., Baseline $M = 1$; Intervention $M = 2$). Results indicated that the mean of the Social subsection, which targets group dynamics, improved for each class. Additionally, the Social
subsection showed the second highest improvement across all classes from baseline \((M = 12)\) to intervention \((M = 17)\). Results from the final subsection that identified if students were able to make connections between the science content and real-world experiences indicated only the Earth Science Class 2 improved, whereas the mean for Physics and Earth Science Class 1 remained unchanged.

Table 4.2

*Summary Statistics for Assessing Scientific Argumentation in the Classroom (ASAC) Observation Protocol Subsections*

<table>
<thead>
<tr>
<th>ASAC Subsections</th>
<th>Class</th>
<th>Physics</th>
<th>Earth Science 1</th>
<th>Earth Science 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>I</td>
<td>B</td>
<td>I</td>
</tr>
<tr>
<td>M</td>
<td>SD</td>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Conceptual and Cognitive</td>
<td>3</td>
<td>1.10</td>
<td>5</td>
<td>1.72</td>
</tr>
<tr>
<td>Epistemic</td>
<td>2</td>
<td>1.72</td>
<td>2</td>
<td>1.20</td>
</tr>
<tr>
<td>Social</td>
<td>5</td>
<td>2.61</td>
<td>6</td>
<td>2.24</td>
</tr>
<tr>
<td>Real-world Connections</td>
<td>7</td>
<td>0.49</td>
<td>7</td>
<td>2.00</td>
</tr>
</tbody>
</table>

*Note.* B = baseline; I = intervention; \(M\) = mean; SD = standard deviation

**Individual Results. Research Question 2**

To what extent will engagement (e.g., use of behaviors that reflect scientific thinking) in group argumentation using SSI change the individual behavior of ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

Individual student data were collected based on dialogic interactions during group
argument sessions. An utterance was coded as a complete thought on topic, expressed by a student. A complete thought could include multiple, consecutive sentences expressed orally, but would be scored as only one utterance. Further, only dialogue that included a claim, evidence, or justification was coded. Information presented by students that did not include a claim, evidence, or justification, information that was not on topic, or did not address the guiding question were coded as barely substantive (BS). Data were collected in baseline and intervention phases on the number of times students initiated discourse and when they reciprocated by replying to a question or comment posed by a peer. Figure 4.2 includes sociograms that illustrate what these particular interactions looked like during class discussions. A sociogram is made up of nodes (e.g., circles) that represent the times a student initiated or reciprocated conversation (i.e., responded to a peer’s question or comment; González-Howard & McNeill, 2018). The more the student/group was spoken to, the bigger the circle. Moreover, these ties may include one or two arrows that indicate the direction in which a particular type of interaction was directed. Two arrows mean the discourse was reciprocated. The size of the nodes, arrows, and thickness of the lines also are meaningful in that they are proportional to the frequency of utterances (see Figure 4.2). Additionally, if a student made no utterances and were not the recipient of an utterance, their label appears separate from the sociogram (see Earth Science 1 Baseline, Student 9).
During Baseline, Student 2 had the highest number of utterances, followed by Student 5. Discourse from Students 1, 3, and 4 was equal in terms of the number of utterances. Every student, but Student 3, addressed the group, rather than an individual, with a question or comment. Student 1 and Student 5 were the only students that reciprocated discourse. During the Intervention Phase, Students 1 and 2 dominated the argument sessions, with Student 4 offering minimal input. Reciprocity improved from one pair of students to three (Students 1 and 2, Students 1 and 3, and Students 2 and 5). Everyone addressed the group during intervention. The arrow size indicates the number of utterances. In comparison to Baseline results, the number of utterances and reciprocated discourse showed improvement in the Intervention phase. During Baseline, nine utterances were initiated and 11 were reciprocated. During Intervention, 32 utterances were initiated and 19 were reciprocated.
**Earth Science Class 1.** During Baseline, Student 7 and had the highest number of utterances. Students 7 and 8 had slightly fewer. Student 6 had zero utterances on topic that included a claim, evidence, or justification, thus the label for Student 9 appears separate on the sociogram. Only Students 7 and 8 addressed the group. Student 6 only addressed Student 8. Student 9 addressed no one. No discourse was reciprocated during Baseline. During the Intervention Phase, Students 8 and 9 dominated the argument sessions, with Student 6 offering minimal input. Reciprocity improved from zero pairs of students to one pair (Students 8 and 9). Everyone, but Student 6, addressed the group during intervention. The arrow size indicates the number of utterances. In comparison to Baseline results, the number of utterances and reciprocated discourse showed improvement in the Intervention phase. During Baseline, six utterances were initiated and 11 were reciprocated. During Intervention, 32 utterances were initiated and 19 were reciprocated.

**Earth Science Class 2.** During Baseline, the number of utterances was fairly even between Students 10, 11, and 12. All students addressed the group. Students 10 and 12 reciprocated discourse during Baseline. During the Intervention Phase, Students 11 and 12 had slightly more utterances than student 10. Reciprocity improved from one pair of students to three pairs. All students addressed the group during intervention. In comparison to Baseline results, the number of utterances and reciprocated discourse showed improvement in the Intervention phase. During Baseline, 10 utterances were initiated and six were reciprocated. During Intervention, 22 utterances were initiated and 21 were reciprocated.

The majority of students ($N = 8$) improved in the number of individual initiated utterances from Baseline to Intervention, with a range of 1 to 11. Two students showed no change from baseline to intervention. One student’s number of utterances decreased by one.
Half of the students \((N = 6)\) showed improvement in the number of reciprocated utterances from baseline to intervention. Two students showed no change in the number of utterances from Baseline to Intervention, and four students’ number of utterances decreased with a range from -1 to -3. Notably, two of those four students increased their number of initiated utterances, suggesting they may be initiating discourse rather than simply responding to a peers’ discourse.

**Results of Social Validity Survey**

Research Question 3. What are the perceptions of the ninth and twelfth grade SWD regarding their engagement in argumentation sessions during science class?

Participants were given a five-point Likert scale questionnaire with eight statements (see Table 4.3; Appendix P) upon completion of the study to determine their perceptions regarding their engagement in argumentation sessions. Results of the questionnaire are presented in Table 4.3.

Table 4.3

*Social Validity Statements and Mean Scores*

<table>
<thead>
<tr>
<th>Social Validity Statements</th>
<th>Average score (1 = Strongly Disagree, 5 = Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9\text{th} Grade</td>
</tr>
<tr>
<td>I liked arguing about socioscientific issues.</td>
<td>4.2</td>
</tr>
<tr>
<td>Participating in group arguments on socioscientific issues helped me relate to current science issues better.</td>
<td>3.8</td>
</tr>
<tr>
<td>It was difficult for me to remember the parts of argumentation (e.g., making a claim, tying it all back to science).</td>
<td>2.2</td>
</tr>
<tr>
<td>I learned how to argue without getting mad.</td>
<td>3.2</td>
</tr>
<tr>
<td>I am comfortable when my peers disagree with me.</td>
<td>4</td>
</tr>
</tbody>
</table>
I learned how to really listen to what people are saying.  

Results of the mean scores for each grade reveal that the twelfth graders liked arguing about SSI slightly more than the ninth grade participants. The mean scores were 4.8 and 4.2, respectively. The ninth grade participants believed participating in group arguments on SSI helped them relate to current science issues slightly more than did the twelfth grade students. The ninth grade participants disagreed more strongly than the twelfth grade participants that it was difficult to remember the parts of argumentation, suggesting that it was not as difficult for them to remember the parts of argumentation as it was for the twelfth graders. The largest disparity between the ninth and twelfth grade scores was regarding the statement I learned how to argue without getting mad. The twelfth grade participants agreed with that statement, on average, one point more than the ninth grade participants. Based on the mean scores ($M = 4; M = 3.6$), the ninth grade participants appeared to feel more comfortable when their peers disagreed with them than the twelfth grade students. Mean scores of 4.5 and 4.6 indicated that students in both grades agreed that they learned how to really listen to what people are saying. In addition to the survey questions, students were asked to write at least one paragraph about how their engagement in argument sessions changed from the beginning of the study to the end of the study, what they learned, and/or how that knowledge may impact them in the future. Comments from four ninth grade students were:

- My approach didn’t change.
- The way I was changed was I really got taught more about vaccinations and how they are not always bad. The second way I changed was with attentive listening. And finally I learned more about the different types of sciences that I have not looked into.
• I did not really change from the study since I was always an arguer. Though, I feel I improved my arguing skills. Also, the topics that we argued upon were very successful to cause an argument. The end of the study topic started to become harder for a decision to be made.

• When I argue, I usually yell over people and never really listen to reason. Learning how to argue without yelling has helped out a lot. I has helped me to learn that yelling isn’t a way to be social.

Comments from five twelfth grade students were:

• Because I learned to disagree with my classmates without getting angry, I got comfortable with my classmates not agreeing with everything I say. If in the future I decide to do a debate that requires arguing and disagreement. I need to understand not everyone is going to agree and I’m not always gonna be right. Using these skills can be considered professional and can keep my job. I won’t be childish and throw a temper tantrum when one of my peers disagree. I could lose my job.

• Some of the topics, such as zoo funding, were things I’d never thought about until now. I do think I could’ve learned more if I weren’t so tired by the end of the day. That said, I do think I was able to make a more cogent argument as time went on. When I wasn’t tired or having trouble with classmates, I thought I did a decent job. Finally, I really don’t think I changed much. I still argue in largely the same way, and don’t know that I’ve changed much.

• I can’t say that I feel like I’ve changed a whole lot. Things like change don’t happen over the course of a few weeks. At best I can say my ability to argue changes with my mood.
This is something I have trouble controlling as is, much less having to make an argument at the same time. Anyhow, I’ll just do my best and try to keep my voice down.

- I was not very interested in arguing at the beginning. I did not know what I was arguing about. I could not find the right words to do it. Now I love arguing in a good way. Its fun. Thank you Mrs. Gumpert for changing my view of the world.
- I take the information given to me and try to either expand or contrast said argument.

  When I’m asked to start an argument I try to use evidence to back up my claims. I try and stay calm without getting hotheaded or angry. I work off of other people’s arguments. I try and not let my opinion get in the way of facts.

Results suggests several students did not believe their engagement in argument using SSI changed over the course of the study (n = 3). Students who did report a change from the beginning of the study to the end suggested that engaging in argumentation using SSI taught them how to argue without yelling and to disagree with classmates without getting angry. Additionally, according to students’ comments, engagement in argumentation using socioscientific issues improved a) attentive listening, b) arguing skills, and c) use of evidence to back up claims. One student reported learning how to disagree with classmates without getting angry and another student realized she is not always going to be right. Finally, one student reported the skills learned in the argumentation sessions would be useful in a job, and if the skills were not present, a person could lose their job.

**Treatment Fidelity and Inter-Observer Agreement**

All intervention sessions were videotaped. Treatment fidelity (i.e., procedural) was assessed by a doctoral student and a teacher with eight years’ teaching experience. Ledford and Gast (2018) recommend that fidelity data are collected on 20% of the sessions in each condition
and observers achieve a minimum of 80% agreement. Data for the current research was collected on 100% of the taped sessions in each condition (i.e., Baseline, Intervention, Maintenance) to ensure that the researcher adhered to the content and intervention procedures. Refer to the Procedural Fidelity Checklist for Baseline and Probe sessions in Appendix L and Procedural Fidelity for Intervention sessions in Appendix N.

All argument sessions were evaluated by a doctoral student and a teacher to ensure each class reached 80% accuracy on the ASAC over three sessions, which was the criterion set for the intervention, before the intervention was implemented with the subsequent classes. A criterion level of 85% and above inter-observer agreement was established to ensure reliability of data collected (Tankersley, Webb, & Landrum, 2008). Percentage of inter-observer agreement was calculated by reporting agreements on occurrences divided by agreements plus disagreement (A/[A+D]) and multiplying by 100.

Two coding changes were instituted after the initial training for coders, based on discrepancies between coders’ scores. First, in group and individual coding, utterances on the same topic, that were expressed consecutively by one participant before a peer interjected, were counted as one utterance. For example, the following discourse by Student 2 was counted as one utterance (e.g., claim). The guiding question was Why should the Canadian harp seal hunt be continued?

I can say that stopping the hunt altogether is honestly not that much of a concern. Like these Inuit people have been seal clubbing forever, so why not continue? It might have been decreased due to the settlement of Europeans, I won’t deny that, but it certainly isn’t our concern to put any sanctions on the hunters of these animals.

Second, a Barely Substantive (BS) category was added to the individual coding that allowed the coders to tally the number of utterances which showed participants engaged in discourse, but the discourse was not on topic. For example, one Guiding Question was Should a
zoo be built in your city? Students’ off topic comments discussed safaris and the bee exhibit at the Virginia Living Museum. These comments were coded as BS. Second, according to González-Howard and McNeill (2016), a comment of “yes” is considered a claim if it is in answer to a belief about the guiding question. However, a one word affirmative \( (N = 6) \) was the only comment Student 3 made during baseline sessions. It was determined by the researcher that “yes, mmhum, yeah” or any other one word affirmative would not count as an initiated or reciprocated comment unless followed by an explanation for the comment. Third, regarding group coding on the ASAC, it was determined that Items 3-7 on the ASAC could only count as evidence if students used information from the article provided; otherwise, if students used background knowledge, they would score a point for Item 14. Clarification was given on two other coding discrepancies: (a) coding can continue after the timer rings so the student speaking can complete his/her thought, and (b) if a student looked up information on his/her cell phone and it is determined by the coder that the source is credible, it may count as evidence. One final change was instituted; the information read aloud for each session was uploaded onto a Google Document so coders could preview the information prior to coding a session. This gave coders background knowledge on the topic to be able to ascertain whether student comments they deemed questionable were related to the topic. Despite the availability of information, several times coders needed to fact check student’s discourse for accuracy using Google or other resources. All baseline sessions were recoded using the new criteria. In two sessions, coders fell below the 85% inter-observer agreement criteria. Coders viewed videos of the sessions with the researcher. While viewing the video, each target item on the ASAC was discussed as were the disparate scores on each item of disagreement. The videos were recoded during that session with the researcher. After that, the coders watched the videos independently and recoded them. Inter-
observer agreement was 100% on both recoded videos.

Summary

The results of the dependent measures of group and individual engagement in argumentation were outlined in Chapter 4. For each research question, the results were presented for group or individual participants and overall summary of the results for all participants was provided. For research question one, it was found that a mean ranging from 48.8% to 55.8% and a median of 47% rose to a mean ranging from 75.7% to 77.3% and a median of 79%. Results on research question one examining group engagement in argumentation using SSI improved after explicit instruction in argumentation. Although somewhat speculative, results suggest there may be a functional relation between explicit instruction in argumentation and student engagement. For research question two, the results were mixed. The majority of students ($N = 8$) improved in the number of initiated utterances from Baseline to Intervention. Six students improved in the number of reciprocated utterances from Baseline to Intervention, while two showed no change and four decreased in utterances. Notably, two of the four participants increased in initiated utterances. To reiterate a previously stated point, only utterances that are on topic and/or included a claim, evidence, or justification were coded. Some data may suggest that student discourse was decreasing. However, it is possible for students to participate in the argument session, but not offer discourse on the topic or attempt to answer the guiding question by providing a claim, evidence, or justification. Participants may draw upon their background knowledge or personal experiences when engaging in argument sessions, which are not tallied individually. Data from the social validity survey suggest an average to high social validity for the intervention. Chapter 5 will discuss implications of the results, along with recommendations for future research.
CHAPTER 5
DISCUSSION

The purpose of this section is to interpret the results stated in the previous chapter regarding the three research questions posed. The chapter is divided into five sections (a) discussion of results, (b) factors impacting engagement in argumentation, (c) conclusion, (d) implications for research, and (e) limitations.

Summary of the Study

The present study was designed to examine the impact of explicit instruction in argumentation using SSI on the engagement of secondary students with disabilities. Both group and individual data were collected. The following three research questions guided the study:

1. Is there a functional relation between explicit instruction in argumentation using SSI and an increased level of student engagement (e.g., use of behaviors that reflect scientific thinking) during group argumentation sessions for ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

2. To what extent will engagement (e.g., use of behaviors that reflect scientific thinking) in group argumentation using SSI change the individual behavior of ninth and twelfth grade SWD (e.g., autism spectrum disorder, attention deficit hyperactivity disorder, specific learning disability)?

3. What are the perceptions of the ninth and twelfth grade SWD regarding their engagement in argumentation sessions during science class?

As stated in Chapter 1, engagement in argumentation in science includes the social construction of scientific knowledge (Driver, Newton, & Osborne, 2000). Notably, argument as a
form of social interaction is a skill children have developed from their early *everyday talk* with parents, siblings, and peers (Kuhn, Hemberger, & Khait, 2015). Young children learn the meaning of a parent’s firm “no” and over the years develop some skills in persuasive argument to achieve their desires, despite parental objections. Children demonstrate a different form of argument when interacting with peers.

Through the years, children hone their argument skills to accommodate their intentions. Kuhn (1991) suggested that children have latent skills in argumentation, and given minimal opportunity at school, are able to improve the complexity of their argument. Developmental psychology literature suggests that ages 12-13 (e.g., middle school) are the ages in which students spontaneously use elements of argumentation (i.e., arguments, counterarguments, rebuttals) in academic dialogue and the ages in which they become interested in SSI (Felton, 2004). Thus, research supports that the older the student and the more opportunity to engage in argumentation, the more refined his/her skill in argument may become (Sampson, Grooms, & Walker, 2010).

In science class, content knowledge (Sadler & Fowler, 2006; von Aufschnaiter, Erduran, & Simon, 2008), understanding of the nature of science (Eastwood et al., 2012), as well as an understanding of the norms of arguments and argumentation (Kuhn & Udell, 2003) may influence students’ engagement in argumentation. *Confirmation bias* is another factor that may influence students’ engagement in argumentation (Nickerson, 1998; Nussbaum & Kardish, 2005; Zeidler, 1997). Confirmation bias is when a person has a point of view and does not attempt to identify evidence to the contrary. A student exhibits confirmation bias when he/she seeks out only data that support his/her ideas and ignores the rest of the data. Moreover, Zeidler (1997)
suggests that students are more likely to confirm a claim if they believe the premise to be true rather than false.

Additionally, several researchers suggest students’ interest in the topic influences their engagement in argumentation (Nussbaum & Bendixen, 2003). Still others posit that SSI-based decisions are dependent on personal values (Fowler, Zeidler, & Sadler, 2009; Kolstø, 2006; Sadler, 2004) or the intellectual baggage (i.e., moral beliefs; Sampson, Grooms, & Walker, 2010; Zeidler, 1997) students bring into the classroom. As a result, when arguing a SSI, students tend to be most convinced by arguments that are closely aligned with their personal convictions and prior knowledge (Jiménez-Aleixandre & Erduran, 2008).

In looking at group behavior, Zeidler (1997) suggests the way people think does not occur in linear steps. Influences, such as other’s perspectives, alter, or help refine, the student’s personal knowledge he/she may divulge during argumentation. Likewise, interactions during collaborative argumentation are dependent on the issue and the group members (Evagorou & Osborne, 2013; Sampson & Clark, 2011). Results from the current research suggest that during argument sessions, many of the aforementioned factors (i.e., content knowledge, understanding of nature of science, understanding of the norms of argument and argumentation, confirmation bias, interest, and/or personal values, perspectives of others, group interactions) may have impacted not only students’ ability to engage in argument using SSI, but their willingness to participate as well.

Discussion of Results

Research Question 1. It was hypothesized that after explicit instruction in argumentation using SSI, group engagement as indicated by Assessment of Scientific Argumentation in the Classroom (ASAC) observation protocol scores, would increase. Although somewhat
speculative, visual and statistical analysis of group performance during intervention suggests that explicit instruction in argumentation using SSI may be effective in promoting increased student engagement.

**Baseline phases across classes.** Three classes of three to five students participated in the argument sessions (Physics, \(N = 5\); Earth Science Class 1, \(N = 4\); Earth Science Class 2, \(N = 3\)). One group score per session was calculated. Baseline data for all three classes were unstable. However, this resulting instability in the data is not completely unexpected. Research suggests that students’ engagement in argumentation is inherently inconsistent due to the previously mentioned factors (i.e., content knowledge, understanding of nature of science, understanding of the norms of argument and argumentation, confirmation bias, interest, personal values, age) which may have contributed to the instability of the baseline data.

**Physics.** The five baseline data points indicate a range of scores from 47% to 65%. One possible explanation for the high baseline scores may be that the twelfth grade participants were already somewhat skilled in argumentation prior to commencement of the study. During engagement in argumentation, students questioned the credibility of evidence and interjected their prior knowledge and personal values into the discourse. For example, in Session 2, the guiding question was, *Should we use tap or bottled water?* Student 1 questioned the validity of the evidence provided by stating that he would not be surprised if the author of the article who promoted buying bottled water rather than using tap water was “being paid by Dasani.” In Session 4, the guiding question was, *Should parents vaccinate their children?* Student 3 articulated the notion that vaccinations can lead to autism was “highly discredited” and Student 1 again questioned the validity of the website where the provided evidence originated. Student 1
also stated that he was “not a fan of big pharma, which is a capitalist system.” thus introducing his personal values.

Another factor potentially impacting baseline scores was absenteeism. Student 3 was absent in Session 2 and Students 2 and 5 were absent in Sessions 5. It could be surmised that the absence of group members may have resulted in lower scores for those sessions, 47% and 53% respectively. However, Students 2 and 5 also were absent in Sessions 4, which had the highest baseline score of 65%. A review of individual data collected, indicated that Student 4, for the first time, initiated the discourse in Session 4. Student 4, who rarely spoke in previous sessions, asked relevant questions during the argument session and did not stray from answering the guiding question as his peers often did. Student 3 also commented about another “highly discredited” idea that there is mercury in vaccines, which is the second session in which he used the term highly discredited. Seemingly, Students 3 and 4 engaged in more germane discourse during this session than in previous or subsequent baseline sessions, which may have resulted in a higher score for the session.

The students’ discourse often strayed from answering the guiding question. For example, when arguing Should we use tap or bottled water? the discussion evolved into how it is illegal to collect rainwater and how we should not take food away from the homeless. When arguing Should we use wind turbines or coal for electricity? students ruminated over how they did not like bats and suggested bats should be exterminated. Following that digression, students engaged in a lively discussion about birds flying into windows. this finding is consistent with current science education research (Jamaludin, San Chee, & Ho, 2009).

In sum, the high baseline scores suggest students possessed preexisting skills in argumentation. Those skills, combined with students’ prior knowledge and personal convictions,
may have resulted in higher scores on the ASAC. The results indicate a student’s absence affected the group engagement. One student was absent in Session 3 and two students were absent in Session 5, which were the lowest baseline scores (47% and 53% respectively). This would seem to indicate the absence of a group member may negatively impact the overall engagement of group members. Conversely, the same two students were absent is Session 4, which was the highest score of the baseline sessions. A review of session videos and individual data indicate the two students engaged minimally in prior argument sessions and showed far more engagement in the session with two less participants, thus suggesting the absence of two group members may have positively affected the overall engagement of the group. Notably, a review of session videos and individual data revealed Student 1 dominated the discourse in Session 5, and Students 3 and 4 were minimally engaged. Interest, or lack of, in the topic for argument may have been another contributing factor to the high and low scores.

*Earth Science Class 1 (ES1).* The eight baseline data points indicate a range of scores from 24% to 82%. Again, one potential explanation for the higher baseline scores may be that the ninth grade participants were already somewhat skilled in argumentation prior to the intervention phase. Students were somewhat proficient in questioning the credibility of evidence. This finding is consistent with similar findings from the twelfth grade Physics class. When engaging in argumentation about vaccinations, Student 9 referred to the “proof” in the article and Student 8 stated that the information was “inaccurate.” During the argument session on Global Warming, Student 7 challenged the data from the two articles provided. Student 8 also read evidence that supported her claim that global warming does exist. In Session 8, the guiding question was *Should we ban plastic straws?* Student 8 provided a claim as well as a justification for her claim (i.e., “We should ban plastic straws. I feel that certain straws are harmful to the
environment.”). She also referred to the evidence provided and stated, “Plastic is not biodegradable. It said in here it’s not.” Students used their prior knowledge during engagement in argumentation, which was also consistent with findings from the twelfth grade Physics class.

Anecdotal records written by one trained coder with eight years of teaching experience support students’ use of evidence.

Session 4: [Student 8] utilizes text evidence throughout! He [Student 9] and Adrianna [Student 8] have a great moment of debate using the article and the validity of the data.

Session 6: [Student 7] Outstanding argument! Levels of thinking/use of data and relevance/making connections. [Student 8] Use of data in argumentation citing/quoting/making sense of importance in reality is very strong.

In sum, data support two of the four ninth grade students’ ability to not only provide evidence but question the credibility of evidence during the baseline phase.

Student 9 was absent in Session 6, the session with the highest baseline score at 82%. This is in contrast to Physics scores being negatively affected by the absence of one student’s absence in two sessions. Consistent with baseline data from the twelfth grade Physics class, a review of individual data collected, indicated that Students 7 and 8 engaged in more relevant discourse than in previous or subsequent baseline sessions, which may have resulted in a higher score for the session. Interestingly, the ninth grade students rarely digressed from the topic, unlike the twelfth grade students. One could posit that the lack of digressions was age related, meaning the younger students had less prior knowledge and personal experiences on a given topic to include in their arguments. Notably, digressions are not counted on the ASAC, nor are they a desired outcome when engaging in argumentation. Simply stated, the difference in the
number of digressions between the ninth and twelfth grade students was an unanticipated, interesting outcome to the researcher, as the expectation was that the younger students would have more digressions.

Anecdotal records written by one coder as well as observations by the researcher indicate the group displayed immature interactions. One conclusion may be that age was a factor, as none of the twelfth grade students exhibited the same immature interactions (e.g., disrespect for group members, off task behavior precipitated by gesture or inappropriate comment). Further, a dysfunctional group is characterized by abnormal or unhealthy behavior or interaction; both were present to some extent in all baseline sessions and characterized the dynamics of this group. Student 6 in particular, showed the unhealthiest (e.g., inappropriate) behavior. The following are some of the anecdotal records written by the coder:

Session 2: [The entire group demonstrated a] lack of effort, participation, etc. Discussed maybe for two minutes. [Student 8] had a weak claim, but also struggled since other members were lacking involvement and focus.

Session 4: [Student 6] was rude just got up and left the group.

Session 5: [Student 8] really surprised and disappointed at her lack of effort and her disrespect. [Student 6] constantly acting childish and rude, getting group off task. [Student 9] feel like he wanted to put forth effort and held his paper in his hand as though ready to utilize evidence, but groups’ poor behavior never allowed him to-he gave up. [Student 5] made effort in beginning-starting to understand data/evidence etc. but falls into nonsense and childishness.

Session 6: [Student 6] refuses to participate despite group asking/inviting her view. [Student 7] Lots of potential to argue well-group ruins it.
Session 7: [Student 8] disappointing.

Session 8: [Student 6] Not sure what her purpose is in attending-never contributes and only distracts/disrupts the group. [Student 8] Rude-cuts people off physically and verbally. She used to be focused-lack of effort as of late.

In conclusion, the high baseline scores suggest students may have possessed preexisting skills in argumentation. One possible conclusion for the variability in baseline data is both the immaturity and dysfunctionality within the group, as was demonstrated by half the students in ES1. Contrary to findings from the Physics class, one student’s absence in ES1 resulted in a higher ASAC score for the group. Similar to the physics class, perhaps as a result of the absence, two students engaged in more robust argumentation during that session. They essentially picked up the slack for the absent group member.

**Earth Science Class 2 (ES2).** The ten baseline data points indicate a range of scores from 18% to 88%. As consistent with the Physics and ES1 class, it appears that ES2 were already somewhat skilled in argumentation prior to commencement of the study. The students questioned the credibility of evidence, utilized their prior knowledge, included their personal convictions and exhibited confirmation bias during the argument sessions. Table 5.1 exemplifies Student 12 demonstrating his personal convictions and confirmation bias on the topic of immunizations. The vehemence in his argument against immunizations seemed a contradiction to his typical congenial affect. The guiding question for the argument sessions was *Should parents vaccinate their children?*
Table 5.1

Discourse from Student 12 demonstrating personal convictions on the topic of immunizations.

| Student 10: | Yes. |
| Student 12: | No! |
| Student 10: | There are bigger examples of kids getting chicken pox at two because they weren’t vaccinated. And meningitis B. |
| Student 12: | You do realize you can get that by being vaccinated, Do you know how a vaccination works? They put a weaker version of the virus into your body. |
| Student 11: | I know! |
| Student 12: | It’s not always a weaker version. |
| Student 11: | Oh my God! Do you think scientific figures are going to mess up and put a fatal |
| Student 10: | [...] Do you believe they are going to put the equivalent of fatal drugs in your body? |
| Student 12: | Yes. It’s not small all the time. No one is really certain. |
| Student 11: | Hold on one second. When they put in the weaker version they also put in antibodies so your body gets exposed... |
| Student 12: | Your antibodies have to adapt to the virus. |

Student 11 argues antibodies are put in vaccine, Student 12 argues that the body creates antibodies and attacks the virus, which is, in fact true. Student 12 demonstrated a wealth of knowledge on the process of how vaccinations work, frustrating Student 11.

| Student 12: | You can be outside for like three minutes and catch a cold, so it only takes this much (puts thumb and forefinger together indicating a small amount) of a bacteria to just infect your entire body. |
| Student 11: | No! your body is stronger than that! |
| Student 12: | Your body is only stronger when it knows what it is fighting! |

Voices escalate.

| Student 12: | I’m just saying ever since we have had vaccines, things have not been getting better at all. |
| Student 11: | How is it not getting better?! |
| Student 12: | More people are getting diseases. Like it might not be the vaccine they got the disease from. They are like curing diseases but making another one. If you give someone a little bit of rat poison, they’re gonna die! |
| Student 11: | No! They’re gonna get sick but they’re not gonna die. |
| Student 12: | Yes! They’re going to die! |
| Student 10: | That sounds paranoid. |
| Student 12: | How is that paranoid? If you put toxins mixed up with a vaccine that is supposed to help you... |
Student 10: You know how people in certain religions drink snake poison? Yes, there are religions that make you do that.

Student 12: Snake poison is very different than bacteria. Bacteria, they multiply. It says here [pointing to evidence provided] that it’s not proven to be effective or it works.

Student 11: Oh my gosh! They are trying to persuade you!

Student 12: These are scientists!

Student 11: These are not scientists, they are trying to persuade you! You are making up evidence!

Student 12: [...] So again, vaccines can infect you which defeats the whole purpose. That does not make sense, how is it supposed to be helping you and you end up infected?

Notably, Student 12 only looked at the evidence from an author expressing her opinion that children should not be vaccinated. He did not address the empirical evidence from the Center for Disease Control stating children should be vaccinated. Student 11 challenged the evidence by suggesting the author was not a scientist and was simply trying to persuade readers that immunizations are harmful. Clearly, the group never answered the guiding question of Should parents vaccinate their children? and Student 10 was off topic many times throughout the session (i.e., snake poison). Failure to look at all evidence provided (e.g., confirmation bias) and not answering the guiding question were not unexpected results, as it was a baseline session. However, Student 11 challenging the credibility of the evidence was an unexpected phenomenon during a baseline session, as no explicit instruction in how to identify credible and not credible evidence had been provided.

This class, more so than the Physics or ES1 classes, was more reflective about what they knew and how they knew it, respected what each other had to say, discussed an idea when it was introduced into the conversation, and invited others to share ideas, which were all targeted items on the ASAC. The following are some examples:

Session 1: [Student 10] What about you, Nigel?
Session 5: [Student 11] Are you sure? That doesn’t sound realistic...Who said that?

Session 7: [Student 11] Can you explain that?

[Student 12] ...How do you know it won’t?

[Student 10] Name one.

[Student 11] What do you mean?

Session 10: [Student 10] I think we all agree that...

Summary of Baseline Results

In sum, it was expected that the baseline data would be high due to students’ experience in *everyday talk*. Thus, an examination of the baseline data across all three classes indicates participants began the study with some argument skills. Specifically, each class discussed the credibility of evidence, included their prior knowledge, and included personal convictions in their arguments. Further, the absence of a group member(s) appeared to have a definite positive or negative effect on the group score. Additionally, interest may have been a factor that impacted a student’s engagement in argumentation. Moreover, it is conceivable that age contributed to students’ engagement in argumentation, as indicated by the higher mean and median scores for the twelfth grade Physics class (Physics $M = 55.8$, median = 53; Earth Science Class 1, $M = 50$, median = 47, Earth Science Class 2, $M = 48.8$, median = 41 (see Table 4.1). As previously illustrated by the transcription of Earth Science Class 2, Session 4, confirmation bias may have impacted the ASAC scores. Although the results must be interpreted with caution, it appears that all of the previously mentioned factors, in isolation or in combination, likely contributed to the variability of the baseline data.

*Intervention phases across classes.* Although somewhat speculative, visual and statistical analyses suggest there may be a functional relation between explicit instruction in
argument and students’ engagement in argumentation. First, data from all classes indicated an immediate and abrupt change in level and trend upon introduction of the intervention. Second, evidence of a functional relation between the intervention and engagement was observed for the Physics class, as evidenced by visual analysis and supported by a PND of 75%, suggesting a moderate effect. A Tau-U analysis was conducted and results across all three classes indicate a moderate (e.g., Physics, ES1) to small (ES2) intervention effect. Visual analysis of trend lines across conditions indicated accelerating trend lines across classes for all baseline phases and all intervention phases. However, the slopes of the trend lines upon introduction of the intervention for each class were more pronounced, indicating a possible functional relation between the intervention and students’ engagement in argumentation. During baseline, the trendlines for Physics, ES1, and ES2 were .67, 1.7, and 1.28 respectively. During intervention, the trendlines for Physics, ES1, and ES2 were 4.5, 2.9, and 2.4 respectively, demonstrating that the slope increased at a higher rate. This result suggests a positive intervention effect.

**Physics.** In comparison to ES1 and ES2, the Physics class demonstrated the highest level of engagement in argumentation as indicated by ASAC scores. With the exception of two data points, the remaining intervention session scores were above the highest baseline scores. One factor that is important to note is that Student 1 spoke two to three times the number of utterances (e.g., complete thoughts on topic) than any of the other four participants, as shown by individual data collected. Student 1 typically dominated the argument sessions. Conversely, when Student 1 was absent in Sessions 7 and 9, the scores for both sessions were the lowest intervention scores at 53%. One possible conclusion that may be drawn is the absence of Student 1 during Session 7 and Session 9 negatively impacted the ASAC scores for those sessions. To
reiterate a previously stated connection, data from all three classes suggest that the ASAC scores may be negatively or positively affected when a student(s) is absent.

The subsection on the ASAC showing the most improved score, on average from baseline to intervention, included the Conceptual and Cognitive subtest, which examined students’ use of scientific laws, theories and processes valued in science, such as problem solving and modifying an explanation. Participants improved slightly in the social aspects of argumentation. Not surprisingly, the score on the Epistemic subtest remained unchanged, as the participants rarely used the evidence provided during the argument sessions. This finding is consistent with science education research in argumentation conducted on typically developing students (McNeill, 2011). The Real-world Connections subtest on the ASAC also remained unchanged over the course of the study. One possibility may be that the groups’ initial score was high and remained high throughout the course of the study (see Table 4.2). For example, the statements on the ASAC regarding real-world connects include (a) using unrelated concepts to explain SSI, (b) making connections to what is already known in real-world contexts, (c) describing the controversy in terms of possible consequences, and (d) exhibiting skepticism when presented with potentially biased information. Students demonstrated the knowledge of a-d in many of the argument sessions, beginning in baseline, and continued to demonstrate that knowledge throughout the study.

Several factors may have impacted the ASAC scores during the intervention phase. First, the researcher facilitated the sessions by keeping the groups on task. Bell (2004) states

The role of the teacher during a classroom debate should be to moderate equitable interactions, to model appropriate question asking, to probe theoretical positions of the debate in equal measure, and to serve as a translator between students—all in the fewest turns of talk possible. (p.120).
The researcher asked three questions as needed during the argument sessions 1) What is your evidence? 2) What was the guiding question? and 3) What does this have to do with science and/or the real world? A second factor that may have impacted ASAC scores was individual student engagement. Student 1 continually reminded the group to “tie it back to the guiding question” in Session 8 and subsequent sessions. Perhaps the area of greatest improvement in students’ engagement in argumentation, thus the impact on ASAC scores, was students’ consideration of the consequences for controversies they argued. Subsequent to the intervention in every remaining argument session, students identified at least one good and/or bad consequence of each controversy they argued. Notably, the group continued to use their prior knowledge (e.g., Student 3 made a connection between eugenics and CRISPR) and questioned the credibility of evidence. While students questioned the credibility of evidence provided, rarely did they utilize the evidence provided in their argument. Rather, they used their own experiences with the topic, to provide evidence for their argument. Two anecdotal comments from one coder regarding students’ use of evidence were in Session 7, Still, they aren’t using article evidence and in Session 9, Mindy repeatedly asks for evidence and they won’t use it.

To summarize, while results must be stated with some caution, data suggest a functional relation may exist between the intervention and student engagement in argumentation. An accelerating slope during intervention, PND, and Tau-U scores support this assertion. It must be noted, however, that several factors may have negatively or positively impacted students’ engagement in argumentation, creating variability in the data. First, ASAC scores in sessions where group members were absent, suggest the absence of a group member may have impacted students’ engagement in argumentation. For example, in the Physics class, the absence of a group member had a negative impact, whereas in ES1, the absence of a group member had a
positive impact. Second, researcher facilitation may have had a positive impact on argument sessions (Albe & Gombert, 2012). Third, student engagement as measured on individual coding protocol likely contributed to the variability of the data. Next, as assessed on the ASAC, the following items may have impacted student engagement (a) consideration of the consequences for controversies they argued (Kuhn & Udell, 2003), (b) prior knowledge (Jiménez-Aleixandre, & Erduran, 2008), (c) understanding of the norms of argumentation (Driver, Newton, & Osborne, 2000), (d) age (Sampson, Grooms & Walker, 2010), and (e) personal values (Fowler, Zeidler, & Sadler, 2009). Finally, observations, video recordings, and anecdotal records suggest interest may have contributed to student engagement during argument sessions.

**Earth Science Class 1 (ES1).** Data for ES1 during the intervention phase were variable, but did show a positive trend. As previously mentioned, the four participants did not function as a cohesive group. One student in particular, Student 6, consistently made disparaging remarks under her breath, kicked students under the table and was generally noncompliant for the duration of the study. Several times when the group tried to engage her in the discourse her responses were, “Leave me alone” or “Why you askin’?” Despite being offered reinforcements (e.g., animal crackers, gummy bears), an explicit goal to contribute two ideas during the argument sessions, and being directly asked a question (e.g., What do you think?), the students’ engagement did not improve, causing much frustration to the rest of the group. In fact, in Session 16, the group members demonstrated their frustration with Student 6. Prior to the argument session, Student 6 asked the researcher if she could have her snack during the session. The researcher allowed the snack if Student 6 agreed to talk at least two times during the session. The guiding question for the session was How were the fines levied against British Petroleum (BP) sufficient to compensate for the impact the oil spill had on the economy? When Student 6 was
asked a direct question, she quickly picked up a cookie to put in her mouth. Student 8 saw what Student 6 was about to do and said, “No.” in a stern voice. Instead of putting the cookie down, Student 6 put the cookie in her mouth and indicated she could not speak, then started laughing. The following is a transcript of the group response:

   Student 8: Nobody say nothing.
   Student 7: Lauren?
   Student 8: What do you think, Lauren?

At that point the two students across from Student 6 leaned forward and folded their arms on the table. Student 7, who was sitting at the end of the table, moved his chair to the side with the other two group members and folded his arms on the table.

   Student 8: Talk.

Student 9 kicked Student 8 under the table and was redirected by the researcher.

   Researcher to Student 6: Was the settlement offered fair?

   Student 6: Yes.
   Student 8: Why do you think it was a fair settlement?

   Student 6: Shut up.
   Student 8: I’m just asking why do you think it was a fair settlement?
   Student 9: Go ahead.
   Student 7: Do you think they should have paid more or less?

Student 9 started to talk and Student 8 told him to stop talking so Student 6 could answer.

   Student 8 to Student 6: You said if we let you eat, you would participate.

   Student 6: I did participate.

   Students 8 and 9 in unison: You said one word.
Student 8: And we asked you why.

Student 7: What is your reason?

Student 9: Yeah, what is your reason?

**Student 6:** Fine with you.

Student 9: What is your support?

Student 6 mumbles something unintelligible under her breath.

**Student 6:** Because I said so, that’s why. I have Jesus on my side. I have Jesus on my side, so yes, I said so.

The exchange took approximately three minutes. After the Jesus statement made by Student 6, the researcher and the group chose to ignore Student 6 for the duration of the session.

The behavior of Student 6 during Session 16 was the manner in which she typically behaved. Individual data indicates Student 6 scored a zero in one third of the sessions, meaning she provided no claim, evidence, or reasoning during six of the argument sessions. Although Student 6 was minimally engaged in argumentation, she appeared intent on being a distraction to the group members (e.g., mumbling under her breath, kicking). It could be argued that Student 6 created the dysfunction in the group, thus potentially impacting the ASAC scores, which in turn contributed to the variability of the data.

Similar to the Physics class, researcher facilitation may have impacted the groups’ ASAC scores. ES1 needed to be redirected more than the other classes, and students were often reminded to provide evidence for their claims. This class also was proficient in identifying non-credible evidence (i.e., beachlust.com, Twitter). Students continued to include prior knowledge and personal experience in some of their arguments. For example, the father of Student 8 lived in the Tidewater area discussed in Session 10, so she included her knowledge of the area in her
argument. During the session on genetically modified organisms (GMOs), Student 7 was convinced that his grandmother developed cancer because she drank genetically engineered milk, thus argued against GMOs. Confirmation bias was present in his arguments.

The strength of this group was their argument style. At the beginning of the session they often said, “I claim...” and then stated their claim as they were instructed to do. They also said, “My evidence is...” then stated the evidence to support their claim, as instructed. This was the only class that verbalized their claim and evidence in that manner. This class also tied the controversy back to science more than Physics or ES2. For example, in Session 9 the guiding question was Should the speed limit be reduced in half to safeguard children? When asked “What does this have to do with science?” Student 6 replied, “Kinetic and potential energy.” In the session regarding the BP oil spill, the group made the science connection to pollution in the ocean and damage to the ecosystem.

The average scores on the ASAC more than doubled on the Conceptual and Cognitive subsection, which examined students’ use of scientific laws, theories and processes valued in science, such as problem solving and modifying an explanation. When focused, the students could problem solve and showed a willingness to listen to alternate explanations. Scores for the Epistemic subsection, which investigates how a group evaluates data and uses relevant evidence increased slightly. While students were proficient at identifying credible evidence, they rarely used the evidence provided in their arguments. It is a surprise that the Social Aspect of the ASAC subsection increased, based on the transcription from Session 16 and the groups’ dysfunction. Lastly, on the subsection connecting science to real-world problems, the scores remained the same from baseline to intervention (see Table 4.2).
In sum, a review of the data suggests a possible functional relation may exist between the intervention and student engagement in argumentation, although the results must be interpreted with caution. First, there was an immediacy of effect upon implementation of the intervention, next, the slope during intervention improved from 1.7 to 2.9, and finally a Tau-U score of 77% indicated a moderate effect size. As consistent with findings from the Physics class, several factors may have impacted students’ engagement in argumentation, negatively or positively, creating variability in the data. First, in contrast to findings from the Physics class, the absence of a group member may have positively impacted the groups’ engagement, as the session in which one student was absent attained the highest ASAC score. Second, researcher facilitation may have positively impacted students’ engagement in argumentation (Albe & Gombert, 2012). Third, student engagement as measured on individual coding protocol likely contributed to the overall variability of the data. For example, one student in ES1 demonstrated consistently inappropriate behavior creating dysfunction in the group, which may have negatively affected the engagement of all group members. Other factors potentially impacting engagement as measured by the ASAC were (a) prior knowledge (Jiménez-Aleixandre, & Erduran, 2008), (b) understanding of the norms of argumentation (i.e., argument style; evidence; Driver, Newton, & Osborne, 2000), (c) age (Sampson, Grooms & Walker, 2010), (d) personal values (Fowler, Zeidler, & Sadler, 2009) and (e) confirmation bias (Nussbaum & Kardish, 2005). Finally, observations, video recordings, and anecdotal records suggest interest may have contributed to student engagement during argument sessions.

**Earth Science Class 2 (ES2).** Data for ES1 during the intervention phase were variable, but did show a slight upward trend. Notably, the PND showed no effect size and the Tau-U indicated the intervention had a small effect (.57). Several factors may have impacted the ASAC
scores during the intervention phase for ES2. First, anecdotal comments written by one coder suggest that the ES2 class received the most facilitation from the researcher.

Session 11: Mindy bring back. Mindy-evidence?

Session 12: Mindy asking credibility of Web MD.

Session 13: Mindy guided the boys into discussing many of the points in following pages.

Session 14: Mindy prompted a lot of discussion to argue points within bulleted list.

Session 15: Overall weakness in all three groups is using provided materials and textual evidence. Also, rarely or never used scaffolds....they used Mindy verbal prompts.

Session 16: Mindy-claim? Mindy-evidence?

Interestingly, Sessions 13 and 14 appeared to have the highest facilitation from the researcher, yet those sessions did not receive the highest ASAC scores.

Second, more so than any other group, this group of three students challenged each other with statements like (a) How do you know it won’t?, (b) Name one., (c) What do you mean?, (d) Are you sure?, (e) Who said that?, (f) That doesn’t sound realistic. and, (g) Can you explain? These challenges encouraged continued engagement in argumentation. A third factor potentially impacting ASAC scores and consistent with findings from Physics and ES1, was students’ use of prior knowledge (e.g., When skimming the articles before a session on immunizations, Student 10 discussed the measles outbreak in the news. This student also compared genome editing to Murphy’s Law). A fourth factor possibly contributing to ASAC scores and similar to findings from the previous classes was students’ questioning the credibility of evidence provided, but not utilizing the evidence provided in their argument. Another factor that may have affected ASAC scores and one consistent with findings from ES1, was a student’s behavior negatively affecting
the argument sessions. Student 10 continually made unusual comparisons that would send the group off on a tangent, often moving the discourse away from the guiding question (see Table 5.1, Student 10). Moreover, Student 10 compared a person whose genes had been edited to Leatherface, a character from the movie The Texas Chainsaw Massacre. His explanation for the connection was nonsensical. While the digressions did not count negatively toward the overall ASAC scores, the time lost during his pontifications and the time spent redirecting the group back to the guiding question, may have impacted the scores.

The subtest on the ASAC showing the most improvement included the Conceptual and Cognitive subtest, which examined students’ use of scientific laws, theories and processes valued in science, such as problem solving and modifying an explanation. The Real-world Connections subtest on the ASAC improved from baseline to intervention, making ES2 the only class that improved in that area. The score on the Epistemic subtest remained the same and the Social subsection increased slightly (see Table 4.2).

In conclusion, a review of the data suggests a possible functional relation may exist between the intervention and student engagement in argumentation, although the results are somewhat speculative. Consistent with findings from the Physics and ES1 classes, there are several factors which may have impacted students’ engagement in argumentation, negatively or positively, creating variability in the data. First, student engagement as measured on individual coding protocol likely contributed to the overall variability of the data. One student in the group was consistently off-topic. Other factors potentially impacting engagement as measured by the ASAC were (a) prior knowledge (Jiménez-Aleixandre, & Erduran, 2008), (b) understanding of the norms of argumentation (i.e., inviting and challenging discourse, evidence; Driver, Newton, & Osborne, 2000), (c) age (Sampson, Grooms & Walker, 2010), and (d) personal values
(Fowler, Zeidler, & Sadler, 2009). Lastly, observations, video recordings, and anecdotal records suggest interest may have contributed to student engagement during argument sessions.

In contrast to findings from Physics and ES1, researcher facilitation may not have impacted students’ engagement in argumentation (Albe & Gombert, 2012). Students in ES2 received the greatest amount of researcher facilitation, yet did not attain the highest ASAC scores, so this finding seems a contradiction.

**Summary of Intervention Results**

Anecdotally, based on the researcher’s observations and notes from coders after viewing 50 argument sessions, it can be stated unequivocally that students in the Physics class offered more content knowledge (i.e., knowledge of genetics to argue CRISPR), more prior knowledge (i.e., “It is highly discredited that vaccinations cause autism.”), and less confirmation bias (e.g., willingness to listen to opinions and look at evidence contrary to their point of view), than ES1 and ES2. Research suggests that age may be a factor in a students’ ability to engage in argumentation (Sampson, Grooms & Walker, 2010). The participants in the twelfth grade Physics class were more skillful in their ability to argue and that their interactions were more socially appropriate during argument sessions than the ninth grade classes, as indicated by the ASAC scores.

Several factors may have impacted students’ ability to engage in argumentation, thus creating variability in the data. First, ASAC scores in sessions where group members were absent suggest the absence of a group member may have impacted students’ engagement in argumentation. Absence of a group member appeared to have a negative impact in the Physics class and a positive impact in the ES1 class. Second, researcher facilitation may have had a positive impact on argument sessions (Albe & Gombert, 2012). Although, it is perplexing that
ES2 received the highest amount of facilitation, yet the ASAC scores did not show more improvement than Physics or ES1. Third, student engagement as measured on individual coding protocol likely contributed to the variability of the data. One student’s behavior in ES1 was consistently inappropriate, creating dysfunction in the group. Additionally, as assessed on the ASAC, the following items may have impacted student engagement (a) consideration of the consequences for controversies they argued (Kuhn & Udell, 2003), (b) prior knowledge (Jiménez-Aleixandre, & Erduran, 2008), (c) understanding of the norms of argumentation (Driver, Newton, & Osborne, 2000), (d) age (Sampson, Grooms & Walker, 2010), (e) personal values (Fowler, Zeidler, & Sadler, 2009), (f) confirmation bias (Nussbaum & Kardish, 2005).

One final factor that may have contributed to the variability of the data is interest in the SSI chosen for argumentation. The 19 topics selected for the argumentation sessions were intentionally diverse (i.e., Should we ban plastic straws?, Should parents vaccinate their children?, Should we conduct research on animals?) Refer to Appendix H for a complete list of topics. The topics were selected to reveal students’ content knowledge, interest in a topic, personal values, and prior knowledge. Thus, it is not surprising that the scores for one twelfth grade classroom (N = 5) and two ninth grade classrooms (N = 4; N = 3) remained inconsistent across argument sessions.

Simply stated, variability in the data seems a foregone conclusion. Of importance to the analysis is the immediacy of effect each class demonstrated upon introduction of the intervention. Additionally, all classes during intervention showed a steeper accelerating trend during intervention than during baseline. Moreover, the last two data points for each class during the intervention phase were higher than the previous data points, suggesting improvement may
have continued. In sum, both individual and group factors may have been attributed to the variability of sessions across phases and classes for the current research.

**Research Question 2.** To what extent will engagement (e.g., use of behaviors that reflect scientific thinking) in group argumentation using SSI change the individual behavior of ninth and twelfth grade SWD? Data were collected on individual discourse in the areas of (a) providing a claim, (b) providing evidence to support the claim, (c) providing a reason why the evidence supports the claim, (d) appropriate group interactions, and (e) barely substantive discourse (e.g., off topic). When comparing baseline data to intervention data in the areas of a-d using the individual coding protocol, the results are mixed. In the Physics group, three students’ scores decreased from baseline to intervention and two students’ scores improved. This may suggest the students’ whose scores increased were more engaged in argument sessions than the others. If that were the case, one would expect the intervention data (e.g., ASAC scores) to be lower. In ES1, two individual scores decreased from baseline and two scores increased. Similar to the Physics class, the two student whose scores increased were very quiet students at the outset of the study. They may have felt more comfortable as the argument sessions progressed, thus showing an increase in engagement. Conversely, the students who were the most engaged in argument included fewer claims, evidence, reasoning, and/or appropriate group interactions in their arguments over time. One noticeable difference in engagement during argument sessions was with Student 8. She was very engaged in the argument sessions at the beginning of the study. However, beginning in Session 7, her level of engagement started to decrease and she sometimes mimicked the inappropriate behavior of Student 6. In ES3, all individual data decreased from the baseline to intervention. Fatigue may have been a factor in their group scores. It is a conundrum that while some individual scores decreased during intervention, some group
scores increased. Perhaps the students whose individual scores increased were engaged in the sessions enough to mitigate the lower scores of the participants who were not as engaged. A second consideration is the effect of group engagement on individual behavior cannot be effectively examined using the ASAC or the researcher designed instrument, making comparisons difficult. Further research needs to be conducted to more definitively answer the research question.

**Research Question 3.** What are the perceptions of the ninth and twelfth grade SWD regarding their engagement in argumentation sessions during science class? Results of a social validity survey seem to suggest that overall students appeared to like arguing about SSI and that the twelfth graders liked arguing slightly more than the ninth graders (see Table 4.3). Mean scores indicated that ninth grade students felt more comfortable when their peers disagreed with them. In addition to the eight question social validity survey, students were invited to write a paragraph about how they had changed in the way they engaged in argument from the beginning of the study to the end. One surprising reflection came from Student 6, whose individual data indicated she had the lowest engagement at 5.3%. This student disrupted ES1 in almost every session and her behavior clearly indicated she did not want to engage in argumentation with her group. Student 6 wrote, “When I argue, I usually yell over people and never really listen to reason. Learning how to argue without yelling has helped out a lot. It has helped me to learn that yelling isn’t a way to be social.” One possible explanation for why Student 6 would write such a constructive reflection based on past negative behavior is “positive illusory bias” which gives an inflated view of one’s self (Gage & Lierheimer, 2012, p.2). Another possible example of positive illusory bias came from Student 3, whose individual data indicated he had the second lowest engagement at 23.8% in the Physics group. He sometimes offered evidence for a claim, but most
often said, “yeah” or “yes” in response to others’ comments. His demeanor never suggested that he got angry during a session.

I take the information given to me and try to either expand or contrast said argument. When I’m asked to start an argument I try to use evidence to back up my claims. I try and stay calm without getting hotheaded or angry. I work off of other people’s arguments. I try and not let my opinion get in the way of facts.

According to his reflection, Student 4 may have experienced the Hawthorne Effect, which refers to when a student’s behavior is not representative of their natural behavior (Ledford & Gast, 2018). Students may change their behavior to match the behavior they perceive is desired by a teacher. Student 4 wrote:

I was not very interested in arguing at the beginning. I did not know what I was arguing about. I could not find the right words to do any of it. Now, I love arguing in a good way. Its fun. Thank you, Mrs. Gumpert for changing my view of the world.

Data suggests the intervention had a positive effect on participants, however, results from the social validity survey should be interpreted with caution. Some students may have written what they felt they were supposed to write or what they thought the researcher wanted to read. A follow-up semi-structured interview may have helped to confirm validity of findings on the survey.

**Other Factors Potentially Impacting Engagement in Argumentation.**

Engagement in argumentation for the majority of the participants ($N = 9$) in the study could be characterized as similar to that of typically developing students based on research in science education. This is a somewhat remarkable finding due to students’ overall low scores in the areas of working memory and processing speed. Table 3.2 summarizes information provided by the school in which the participants attended (i.e., Psychological Evaluation, Individual Instruction Plan). Notably, the disability status of several students ($N = 3$) may have had an effect on their engagement in argumentation.
**Working memory.** Working memory is where information is temporarily stored, processed, and manipulated and is needed to sustain attention (Reid, Lienemann, & Hagaman, 2013). Individuals with working memory deficits may not be able to sustain attention to an activity for an age appropriate amount of time (Berninger & Wolf, 2016). In the Physics class, two students were identified with average working memory, while two students scored in the low range and one student scored in the low-average range (see Table 5.2). This would suggest that over half of the group may have had difficulty sustaining attention during the argument sessions. Results of psychological tests indicated students in ES1 and ES2 (N = 2) had below average or significantly below average working memory (see Table 3.3), suggesting they also may have had difficulty sustaining attention during the argument sessions. Working memory is not an area of cognitive functioning that would likely improve over the course of the study.

**Verbal comprehension.** Verbal comprehension is the ability to access and apply acquired word knowledge (Mayes & Calhoun, 2006). Specifically, it reflects one’s ability to verbalize meaningful concepts, think about verbal information, and express oneself using words. The verbal comprehension skills of all three classes indicate a range from low to superior, with the majority of students (N = 9) scoring in the low to average range. This data would suggest verbal comprehension may not have negatively impacted students while engaging in oral argumentation. Notably, two twelfth grade students scored in the Superior range. Student 1 demonstrated superior verbal skills during engagement in argumentation. Student 2 exhibited atypical speech patterns identified as palilalia, which is a speech disorder characterized by involuntary repetition of words, phrases, or sentences. The ability of Student 2 to verbalize information was extremely impacted by palilalia, thus his superior verbal comprehension was not demonstrated during argument sessions.
**Processing speed.** Low processing speed index (PSI) scores may occur for many reasons, including visual discrimination problems, distractibility, slowed decision-making, motor difficulties, or generally slow cognitive speed (Fry & Hale, 2000). Psychological testing results for the Physics group shows that all students \((N = 5)\) scored in the low to low average range in processing speed. Scores for students in ESI identified three students scoring in the very low to low average range. Interestingly, Student 6 who had the lowest participation of any student according to individual data collected, scored in the high average range on processing speed. Results from students in ES2 indicated average processing speed.

To understand how processing speed may impact engagement in argumentation, a review of an argument session is warranted. In a typical argument session the researcher gave students two to five stapled handouts with important information bulleted and/or underlined. The researcher advised students the bulleted and underlined information would be read aloud and they could use the remaining information not read aloud in their argument. The average time information was read aloud by the researcher ranged from 7:47 minutes for Physics, 6:01 for ES1, and 5:03 for ES2. Information was paraphrased more in the ES1 and 2 classes due to the difficult content presented (i.e., CRISPR). At the conclusion of the read aloud, students had the remaining 20 minutes to skim quickly the information not read aloud and engage in argumentation. Data shows that on average the length of time during the sessions that students literally engaged in argument was 13:25 for Physics, 10:29 for ES1, and 9:20 for ES2. Simply stated, students had 20 minutes to listen to a controversy read aloud, identify their point of view, verbalize their point of view, possibly reevaluate and change their point of view based on information presented by peers, and offer a conclusion at the end of the session. The skills involved in argumentation may have been impacted by low processing speed, specifically in
terms of slowed decision-making and slow cognitive speed, but the conclusion of the researcher is that processing speed was not a large factor in students’ ability to engage in argumentation. First, despite the low to low-average processing speed reported for the majority of the participants, students were able to engage in argumentation under the time constraints given. Further, it seems if processing speed were a factor in students’ engagement in argumentation, the data would show less variability as students gained experience in argumentation over time. In conclusion, processing speed may have played a minor part in students’ ability to engage in argumentation.

**Cognitive load.** Cognitive load can be described as a construct that represents the amount, or load, that performing a particular task has on the cognitive system of the learner. Examples of tasks with high-cognitive load specific to the current research include novelty and time pressure (Pass & Van Merriënboer, 1994). Students were presented a novel controversy at the beginning of each argument session and, as previously mentioned, time constraints were imposed. Moreover, Kuhn (2010) submits that engagement in argumentation can result in cognitive overload for students due to the expectation they will (a) engage in discourse, (b) process the discourse of others, (c) respond to discourse of others, (c) remember information to use later in argument, and (d) continually revise argument based on information presented by peers. Research supports the assertion that tasks required of participants in the current research have a high cognitive load, which may have been a factor in students’ ability to engage in argumentation using SSI (Kuhn, 2010; Pass & Van Merriënboer, 1994). A statement by Student 2 exemplifies the implications of a high cognitive load. “My temper is something I have trouble controlling as is, much less having to make an argument at the same time.”
**Disability status.** The disability status of one student in each class \((N = 3)\) appeared to have an effect on their engagement in argumentation. Student 2 and Student 10 were both diagnosed with autism spectrum disorder (ASD), which appeared to impact their ability to engage in argumentation, yet in very different ways. As previously mentioned, Student 2 was diagnosed with palilalia, a speech disorder characterized by atypical speech patterns (Benke & Butterworth, 2001). The following is an excerpt from a session that is typical of the way Student 2 repeated “um uh” then paused and repeated phrases:

...but I mean history is uh (pause) I wouldn’t say exactly like um uh (pause) like science but it certainly does like uh (pause) have some key key aspects of which uh (pause) we do we do require in order to have an argument about it.

Students appeared frustrated while waiting for Student 2 to complete his thought, yet many times he offered valuable discourse during the argument sessions. Time constraints on the argument sessions clearly affected this students’ engagement. During one session, when redirected back to the guiding question, he said, “I find that it is very difficult to talk. I feel like I can’t talk about this if I can’t go into the broader spectrum and you keep on saying no,” then he walked out of the classroom in frustration. Characteristics of ASD that positively affected the ability of Student 2 to successfully engage in argumentation were his repetitive patterns of behavior and insistence on sameness (Diagnostic and Statistical Manual of Mental Behaviors, Fifth Edition [DSM-5], 2013). In every session, Student 2 repeatedly summarized the information, on average, four to seven times. This skill kept the students focused by updating the status of the argument and presenting information that needed clarification or further explanation. In Session 2, some of the summarization comments included, “So, can we all agree that...?” This was asked twice in one minute. “So, we seem to be in agreement...” “We’ve already established that...” “So, what you’re
saying is...” This students’ repetitive pattern of behavior and insistence on sameness, using the same terms over and over, was beneficial to the argument sessions.

Student 10 was also diagnosed with ASD. He exhibited deficits in social communication and interactions as well as a preoccupation with objects (DSM-5, 2013). These deficits negatively impacted his engagement in argumentation. During argument sessions, he often blurted out inappropriate comments when referring to people in the articles (i.e., stupid idiots, dumb parents, hillbilly, nut jobs). During one session, he was convinced information presented by another student was incorrect. While the other student tried to locate the evidence, Student 10 stated, “If he’s right I’m gonna eat my shorts. Here they are,” and took the shorts out of his backpack. The other student read the correct evidence aloud and much to the consternation of this researcher, Student 10 put the waistband of his shorts in his mouth and began chewing. This student had a preoccupation with Legos and always had a Lego action figure to manipulate during the argument sessions, which did not distract him from engaging in argumentation. In fact, the teacher reported if Student 10 was unable to keep the Legos during a session, he likely would not participate. The student reported he has a Lego Channel on You Tube. Lastly, the student had a preoccupation with fantasy (i.e., Leatherface, The Dark Web, video games, conspiracy theories, superheroes). His digressions when speaking about different characters, places, or objects detracted from the argument sessions by directing the discourse away from the guiding question and frustrating his peers.

Last, the disability status of Student 6 appeared to impact greatly her engagement in argumentation. Student 6 was diagnosed with Disruptive Mood Dysregulation Disorder (DMDD) which is characterized by verbal rages and physical aggression toward people or property. The mood between temper outbursts is persistently irritable or angry most of the day (DSM-5, 2013).
This student’s behavior was consistently irritable over the course of the study. Rather than loud verbal rages, she mumbled hurtful things about the other students under her breath. She routinely kicked other students under the table when they tried to engage her in discourse. The classroom teacher reported her behavior during the argument sessions was consistent with the way she behaved in all of her classes. In sum, it appeared that the presence of a disability positively and negatively affected some students’ engagement during argument sessions.

To summarize, there are several additional factors not related to science education that may have impacted students’ ability to engage in argumentation. First, the majority of students’ working memory was in the low to average range, indicating working memory may have had a modest impact on students’ engagement. Second, students’ scores on Verbal Comprehension ranged from low to superior, with the majority of scores in the average range. This would suggest verbal comprehension may have had a minimal impact on students’ engagement in argumentation. Third, Processing Speed scores ranged from very low to high average. In Physics and ES1, the majority of students scored in the low or low average range indicating processing speed had an effect on argumentation engagement. Fourth, one conclusion that can be drawn from research on argument and research in science education is that engagement in argumentation carries a huge cognitive load for students. Thus, cognitive load may be one of the most impactful factors inhibiting students’ engagement in argumentation. Finally, empirical and observational data would support the notion that the diagnosis of a disability, specifically ASD and DMDD, had either a negative or a positive impact on students’ engagement in argumentation.
Limitations

The findings from the current research should be interpreted in light of several limitations. First, the study was conducted with five twelfth grade students and seven ninth grade students with disabilities, so the generalizability of the results to students in other grades and with other disabilities is limited. Second, the researcher was the interventionist, creating a realistic threat to the validity of the study and potentially creating a Hawthorne Effect for some of the participants. It is possible that the researcher’s demeanor during baseline and intervention sessions impacted student engagement. For example, the researcher may have shown little enthusiasm for a topic during baseline sessions and more enthusiasm during intervention sessions. This would be demonstrated by the way the SSI was read aloud and the manner in which the groups were facilitated. Further, understanding the scores that needed to be attained to reach criterion, may have impacted the researcher’s demeanor during baseline and intervention phases. The researcher may have facilitated groups more during intervention phases in an effort to increase group scores. Third, the trendlines during baseline showed a therapeutic direction which may suggest that students’ engagement in argumentation would have continued to improve, despite the intervention. Notably, the contrast in trend lines between baseline and intervention indicates a sharper accelerating line during intervention phases. Fourth, external validity may be questioned due to the small sample and the restricted classroom setting (i.e., one science classroom). The results cannot be generalized to other settings. Fifth, the instruments chosen for the study (i.e., ASAC, researcher-made individual coding sheet) may not have assessed individual and group engagement effectively. For example, the meanings of many of the terms on the instruments appeared to overlap, making distinctions between items (i.e., arguing and explaining; Neilson, 2012) difficult to ascertain, and determining which area
count as data difficult at best. Sixth, the operational definitions needed further refinement. For example, it is unclear whether the complexity of an argument is included in the operational definition of engagement. Finally, while one coder was very engaged in the coding process, the other coder appeared indifferent, bringing into question the accuracy of inter-observer agreement. It could be posited that the indifferent coder acquiesced to the engaged coder when discussing coding in order to finish the task quickly. For each limitation, there should be corresponding avenues for future research. These avenues will be discussed in the subsequent section.

**Implications for Research and Practice**

This study is one of the first to examine the engagement in oral argumentation using SSIs among secondary SWD. The most compelling finding is the manner in which SWD engaged in argumentation and the issues they encountered were similar to the findings from science education research conducted on typically developing students. Similar to studies by Nielsen (2012) and Arvola & Lundegård (2011), SWD rarely included factual science content in their arguments. Further, when arguing an issue, students focused on practical concerns not science (Grace, 2009). Researchers suggest that confirmation bias can influence students’ engagement in argumentation (Nussbaum & Kardish, 2005; Zeidler, 1997). Confirmation bias was identified several times in the current study. Other factors from the current research that suggested similarities in argumentation between SWD and typically developing students include, but are not limited to: (a) inclusion of personal values and intellectual baggage (Fowler, Zeidler, & Sadler, 2009; Kosolo, 2006; Sadler, 2004; Sampson, Grooms, & Walker, 2010); (b) age (Sampson, Grooms, & Walker, 2010); (c) understanding of the norms of argumentation (Kuhn & Udell, 2003); (d) interest (Nussbaum & Bendixen, 2003); and (e) prior knowledge (Jiménez-
Aleixandre, & Erduran, 2008). These findings suggest that both groups of students engage in argumentation in a similar manner, thus future research should be conducted with SWD and typically developing students as participants in the same study. Logistically, since the majority of SWD spend their day in the general education classroom, the inclusion of all students in one research study is a practical consideration.

There are many implications for future research. First, while the multiple probe single subject research design enabled the researcher to examine small groups, as well as individuals, the results are not generalizable to other populations. Thus, future research conducted with a larger sample size, using an experimental or quasi-experimental design, may improve the generalizability of the results. Second, research conducted in inclusive classrooms would be timely, as the majority of SWD spend their day in the general education classroom. Third, future research should include validated instruments specially designed to assess both group and individual socioscientific argumentation and a refinement of operational definitions. Fourth, future research should examine ways to compel students to use credible evidence to support their arguments. Fifth, researchers should examine the effect argumentation has on conceptual knowledge, as much of the science education research examines the argumentation process, but not the impact on conceptual knowledge. In an era of emphasis on standardized testing, educators often do not feel there is time to include argumentation in science in their curriculum (Knight & McNeill, 2015). Venville and Dawson (2010) conducted a study that included two intervention sessions. The study by Knight and McNeill (2015) included three intervention sessions. These studies show it is possible to conduct research in a limited amount of time. Researchers should consider the length of these studies as exemplars when planning future studies. Lastly, Sadler et al (2016) used standardized tests to examine whether argumentation had
an effect on conceptual knowledge. Including an assessment of argumentation in the existing standardized tests, is not only appealing to educators, but a way to close the research to practice gap.

Implications for practice are numerous. Molinatti et al (2010) suggests that the lack of opportunity to practice argumentation in science classrooms, as well as the lack of teachers’ pedagogical skills in argumentation as a discourse are significant impediments in the field of science education. To address those impediments, educators must find ways to include argumentation in science classrooms. It is imperative that professional development (PD) on argumentation be provided to improve teachers’ pedagogy in argumentation. Through the PD, teachers will understand and be equipped to face the challenge of no longer being the *conveyor of knowledge*, but a facilitator of knowledge construction (Driver, Newton, & Osborne, 2000). Science education research suggests this shift in thinking is a difficult one for teachers to make (Molinatti, Girault, & Hammond, 2010). Further, an understanding of the norms of argumentation is crucial for teachers, so they can then convey that knowledge to their students (Driver, Newton, & Osborne, 2000). Other essential PD topics include but are not limited to: (a) how to introduce argumentation using SSI, (b) how to introduce complex issues with multiple answers, and (c) modeling open and receptive approaches to opposing viewpoints. As reported previously, interest plays a large part in students’ willingness to engage in argumentation, meaning students are more likely to engage in argument on a SSI if it is based around social issues relevant to their lives. How to choose SSI topics of interest to students is another consideration for teachers when engaging students in argumentation.

The current research included all of the aforementioned professional development suggestions. The researcher (a) was a facilitator of knowledge construction, (b) modeled an
understanding of the norms of argumentation, (c) introduced argumentation using SSI (e.g., complex issues with multiple answers), and (d) modeled open and receptive approaches to opposing viewpoints. Results of the current research can be used to refine PD and as a result, improve teacher pedagogy.

Several argumentation models, or frameworks, have been developed for teachers. Employing the decision-making framework by Grace (2009) or the learning progression by Knight and McNeill (2015) are two examples of how research can be applied to practice. Further, in the science classroom, teachers can refine the tools they already have in their arsenal. One tool teachers use frequently is goal setting. Gilabert et al (2013) suggest task instructions (i.e., goal setting) or lack of task instructions, can affect the quality of argumentation. In addition, teachers must make the purpose of the goals explicit. Teachers can refine their goal setting skills and use the evidence-based practice to improve the quality of students’ argumentation.

Research suggests teachers are apprehensive about incorporating argumentation in science class (Fowler, Zeidler, & Sadler, 2009; Sampson, Grooms, & Walker, 2010). Oftentimes, the inclusion of SWD in the general education classroom compounds their apprehension. Teachers must be given tools to manage issues inherent with having SWD in the general education classroom, and participation in argumentation specifically. In the current study, several behavioral issues arose (i.e., student left class, inappropriate interactions with peers). Teachers need tools to address different situations that may transpire during argument sessions. Skillful management of groups is especially important when arguing SSI. The SSI are intentionally open-ended, which may be difficult for some ASD students who need an answer to the question. Additionally, students bring their emotions into the arguments, and ADHD students who have
difficulty with self-regulation of emotions, may have issues with engagement. Finally, working memory, verbal comprehension, processing speed, and cognitive load were issues for SWD in the current study. Teachers must be taught how to address these issues and make modifications to meet the needs of SWD.

**Conclusion**

Science education research identifies explicit instruction in argumentation as an effective way to improve student engagement for typically developing students (Kuhn, 2010; Sadler, 2004, Venville & Dawson, 2010). The current study examined whether explicit instruction in argumentation using SSI improved the engagement of SWD in argumentation. Results from the current study align with science education research regarding the factors that may impact students’ engagement in argumentation: (a) confirmation bias (Nickerson, 1998; Nussbaum & Kardish, 2005; Zeidler, 1997); (b) little or no science content included in argument (Arvola & Lundegård, 2011; Grace, 2009; Nielsen, 2012); (c) use of prior knowledge (Jiménez-Aleixandre, & Erduran, 2008); (d) understanding of the norms of argumentation (Driver, Newton, & Osborne, 2000); (e) interest (Nussbaum & Bendixen, 2003); (f) age (Sampson, Grooms, & Walker, 2010); and (g) personal values (Fowler, Zeidler, & Sadler, 2009; Kosolo, 2006; Sadler, 2004; Sampson, Grooms, & Walker, 2010). The current research identified several additional factors potentially impacting students’ engagement in argumentation. These factors included: working memory, verbal comprehension, processing speed, and cognitive load. Moreover, the diagnosis of a disability may have had a negative and a positive impact on three students’ engagement in argumentation. Finally, students’ willingness to participate in the sessions may have been influenced by their feelings or emotional condition at the time (Grace, 2009). Or, stated simply by Student 2, “At best I can say my ability to argue changes with my mood.”
In conclusion, *scientific thinking is complex and messy* (Driver, Newton, & Osborne, 2002; Zeidler, Sadler, Simmons, & Howe, 2005). Scientific research also is complex and messy, but that should not deter educators from continuing to conduct research on argumentation using SSI with SWD. This type of engagement challenges SWD, but also affords them the opportunity to make informed decisions about contemporary social issues related to science, to practice critical thinking and problem solving, and debate problems occurring in their everyday lives. Finally, when we teach SWD to engage in argumentation using SSI, we are cultivating future citizens and leaders who will serve their community and provide leadership for future generations.
References


special education. *Teaching Exceptional Children, 46*(6), 206-212.

doi:10.1177/0040059914531389


Evagorou, M., Jiménez-Aleixandre, M., & Osborne, J. (2012). ‘Should we kill the grey
squirrels?’ A study exploring students’ justifications and decision-making. *International Journal of Science Education, 34*(3), 401-428. Retrieved from https://hal.archives-ouvertes.fr/hal-00734533/document


Fry, A. F., & Hale, S. (2000). Relationships among processing speed, working memory, and fluid intelligence in children. *Biological psychology, 54*(1-3), 1-34. Retrieved from https://www.jstor.org/stable/pdf/40062952.pdf?casa_token=HIAALkVTTUAAAAA:g2cTmL8XeBkCCsH8POqBmBFyFcqLfsj0nyK8pw8bKitvVkNiwD17i7h9shXmCnq5s5eQhU3hEGasUgeRphBxLWoK-C9Z_7sidX2nbDEXVvBjK_HW0P5


Khishfe, R. (2014). Explicit nature of science and argumentation instruction in the context of


doi:10.1002/tea.21017


## Appendix A

### Information Summary Table of Reviewed Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcomes Investigated</th>
<th>Nature of Intervention</th>
<th>SSI Topic</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felton, Garcia-Mila, &amp; Gilabert, 2009</td>
<td>Argumentative discourse goals</td>
<td>Comparison of dialogue instructions on argumentative discourse over eight fifty-minute sessions; Control/treatment group, quasi-experimental design, pretest/posttest</td>
<td>Greenhouse Effect</td>
<td>101 7th grade students; Five classes; Mean age: 12.2; Spain</td>
</tr>
<tr>
<td>Grace, 2009</td>
<td>Instruments to support students and teachers</td>
<td>Five 10-minute sessions to examine if group decision-making help develop students’ personal reasoning; pretest/posttest</td>
<td>Biological conservation</td>
<td>131 15-16-year-olds; Four classes; England</td>
</tr>
<tr>
<td>Molinatti, Girault, &amp; Hammond, 2010</td>
<td>Role of context on decision-making</td>
<td>Three successive one hour debate sessions. Last session students met with representative of association for patients suffering from disease to add context; Control and treatment groups; pretest/posttest</td>
<td>Embryonic stem cells and human brain repair</td>
<td>107 high school girls; 89 high school boys; Seven classes; Mean age: 16.4; England</td>
</tr>
<tr>
<td>Venville &amp; Dawson, 2010</td>
<td>Conceptual knowledge</td>
<td>One lesson on argumentation skills, 2 whole class argumentation sessions to determine if engagement in SSI improves conceptual understanding; quasi-experiment embedded within a case study; pretest/posttest</td>
<td>Genetics-Cystic fibrosis</td>
<td>Two classes of 46 10th grade students (14-15-year-olds); Australia</td>
</tr>
<tr>
<td>Arvola &amp; Lundegård, 2011</td>
<td>Conceptual knowledge</td>
<td>Tape recordings of 15 five minute student argumentation sessions in biology over one semester examining how socioscientific argumentation emerges in a classroom setting; qualitative study; analysis of value relations and DEQs</td>
<td>Abortion</td>
<td>15 9th grade students (age 15); Sweden</td>
</tr>
<tr>
<td>Nielsen, 2012</td>
<td>Conceptual knowledge</td>
<td>Eight 40-60 minute argumentation sessions to determine the extent students use factual science content when articulating the term ‘nature’; exploratory study</td>
<td>Should human gene therapy be allowed?</td>
<td>36 16-19-year-olds; Three classes Denmark</td>
</tr>
<tr>
<td>Albe &amp; Gombert, 2012</td>
<td>Instruments to support students and teachers</td>
<td>Five two-hour sessions over the second semester to identify argument content; coded for students’ communication, rhetorical processes; knowledge</td>
<td>Global warming</td>
<td>15 12th grade students (17-19-year-olds); Four classes France</td>
</tr>
</tbody>
</table>
### Appendix A

#### Information Summary Table

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcomes Investigated</th>
<th>Nature of Intervention</th>
<th>SSI Topic</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastwood et al, 2012</td>
<td>Nature of science (NOS)</td>
<td>Curriculum used over school year to determine if NOS contextualized in content driven curriculum versus a SSI learning environment leads to gains in NOS understanding; content and SSI groups; pretest/posttest on Views of Nature of Science</td>
<td>Stem cell research, euthanasia, safety of marijuana, fast food health</td>
<td>108-124 11th and 12th grade students; United States</td>
</tr>
<tr>
<td>Gilabert, Garcia-Mila, &amp; Felton, 2013</td>
<td>Argumentative discourse goals</td>
<td>Eight 50-minute sessions examined which task instruction (i.e., goal to reach consensus or persuade) would use the repetition strategy more frequently; between-groups design, utterances coded, types of argument structures repeated</td>
<td>Greenhouse effect</td>
<td>65 7th grade students</td>
</tr>
<tr>
<td>Khishfe, 2014</td>
<td>Nature of science</td>
<td>Eight week unit on NOS and argumentation in the context of SSI to investigate influence on argumentation skills and NOS understandings; mixed methods; pretest/posttest and interviews</td>
<td>Water usage and safety</td>
<td>121 7th grade students; 2 schools, 2 classes each school; Lebanon</td>
</tr>
<tr>
<td>Knight &amp; McNeill, 2015</td>
<td>Instruments to support students and teachers</td>
<td>Three lessons over three months examined the similarities and differences between oral collaboration and individual written socioscientific arguments; exploratory study, used argumentation learning progression to score arguments</td>
<td>Tap versus bottled water</td>
<td>17 7th grade students; United States</td>
</tr>
<tr>
<td>Rundgren, Eriksson, &amp; Rundgren, 2016</td>
<td>Instruments to support students and teachers</td>
<td>Four week study to explore students’ argumentation and decision-making relating to a SSI. Qualitative data collected included group discussion, individual written arguments and interviews. Exploratory study</td>
<td>Toxins in fish from the Baltic Sea</td>
<td>Seven 10th–12th graders; Sweden</td>
</tr>
<tr>
<td>Sadler, Romaine, &amp; Topçu, 2016</td>
<td>Conceptual knowledge</td>
<td>Three week study to explore the extent to which SSI-based instruction supports student learning of science content; proximal and distal gains assessed. Pretest/posttest, no control group</td>
<td>Sexually transmitted diseases</td>
<td>69 10th grade students; Three classes; United States</td>
</tr>
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</table>

**Note:** SSI = socioscientific issues
### OLD DOMINION UNIVERSITY
HUMAN SUBJECT RESEARCH AMENDMENT FORM

<table>
<thead>
<tr>
<th>Responsible Project Investigator (RPI)</th>
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<tbody>
<tr>
<td><strong>Responsible Project Investigator:</strong> The RPI must be a member of ODU faculty or staff who will serve as the project supervisor and be held accountable for all aspects of the project. Students cannot be listed as RPIs.</td>
</tr>
<tr>
<td><strong>First Name:</strong> Robert</td>
</tr>
<tr>
<td><strong>Telephone:</strong></td>
</tr>
<tr>
<td><strong>Office Address:</strong> 214 Lions Child Study Center</td>
</tr>
<tr>
<td><strong>City:</strong> Norfolk</td>
</tr>
<tr>
<td><strong>Department:</strong> Department of Communication disorders and Special Education</td>
</tr>
<tr>
<td><strong>Complete Title of Research Project:</strong> Examining the Development of Oral and Written Scientific Argumentation Among Secondary Students with Disabilities</td>
</tr>
</tbody>
</table>

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<tr>
<th>Type of Amendment Request (Check all changes that apply)</th>
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<tbody>
<tr>
<td>_ Study Design/Methodology</td>
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<tr>
<td>_ Data Collection Tools</td>
</tr>
<tr>
<td>_ Number of Subjects</td>
</tr>
<tr>
<td>_ Personnel Changes</td>
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</table>
Appendix B

Institutional Review Board Application

Investigator Risk/Benefit Assessment

<table>
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<tr>
<th><strong>Will there be a change to the risks or benefits to the subjects? Explain.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to the addition of 12th grade participants, thus another classroom, the research design has been changed to a multiple probe design replicate across three classes. This design will examine the effects of explicit instruction in scientific argumentatin (SA) on students’ engagement during group SA episodes. The multiple probe design requires planned intermittent data collection prior to the introduction of the intervention. Horner and Bear (1978) recommend intermittent probe data be collected rather than collecting “unnecessary” baseline measures, making multiple probe a practical alternative for research conducted in a classroom setting. In order for multiple probe to be considered an appropriate research design, there must be a strong a priori assumption that behaviors will not be learned outside the instructional session, as is the case with many academic skills. The multiple probe design (a) is rigorous in the evaluation of threats to internal validity, (b) assists in determining the efficacy of an intervention, (c) has no withdrawal of intervention requirements to demonstrate experimental control, (d) requires the collection of data during the same time period of behaviors in the natural environment (thus providing a close approximation of goals of most classroom teachers), (e) is a useful method to evaluate effects of an independent variable that is irreversible, such as an academic skill, and (f) provides a means for evaluating behavior over time (Gast &amp; Ledford, 2014). In contrast to multiple baseline designs, multiple probe designs must meet additional criteria to Meet What Works Clearinghouse Pilot Singles-Case Design Standards without Reservations due to the intentional omission of baseline data points. In addition to the three consecutive probe points included at the beginning of each baseline and prior to introduction of the intervention across classes, each case (i.e., class) not receiving the intervention must have a probe point in a session where another case receives the intervention. This probe point must be consistent in level and trend with the case’s previous data points (What Works Clearinghouse [WWC], 2017). For example, when Class 2 receives the intervention, there must be one probe point in Class 1 and one probe point in Class 3 during the intervention period. The probe points for Class 1 and Class 2 must be consistent with their previous data points, meaning the new data point should continue to indicate that the data remain stable. The proposed study is designed to meet WWC Pilot Singles-Case Design Standards without Reservations, as well as the Council for Exceptional Children Standards for Evidence Based Practices in Special Education. An additional change from the original IRB is that upon return of consent forms (i.e., Assent Form, Informed Consent signed by parent, Informed Consent for use of Photo/Video Materials) students will be given a $10 Visa gift card. All students who return the paperwork will receive the gift card, regardless of whether they choose to participate in the study.</td>
</tr>
</tbody>
</table>
Appendix B

Institutional Review Board Application

**PLEASE NOTE:**

- You may implement the requested modifications when the University Institutional Review Board gives you final WRITTEN notice of their approval.
- You MUST inform the committee of ANY adverse event, changes in the method, personnel, funding, or procedure.
- At any time the committee reserves the right to re-review a research project, to request additional information, to monitor the research for compliance, to inspect the data and consent forms, to interview subjects that have participated in the research, and if necessary to terminate a research investigation.
Appendix C

Institutional Review Board Approval Letter

OFFICE OF THE VICE PRESIDENT FOR RESEARCH
Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone (757) 683-3460
Fax (757) 683-0902

DATE: November 8, 2018
TO: Robert Gable, PhD
FROM: Old Dominion University Institutional Review Board
PROJECT TITLE: [1257115-3] Examining the Development of Oral and Written Scientific Argumentation Among Secondary Students with Disabilities
REFERENCE #: 18-127
SUBMISSION TYPE: Amendment/Modification
ACTION: APPROVED
APPROVAL DATE: November 8, 2018
EXPIRATION DATE: June 20, 2019
REVIEW TYPE: Expedited Review

Thank you for your submission of Amendment/Modification materials for this project. The Old Dominion University Institutional Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UP/RSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this committee. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLA/INTS regarding this project must be reported promptly to this committee.
Appendix D

Letter of Support from Private Day School

June 5, 2018,

Institutional Review Board
Old Dominion University
Darden College of Education
Department of Communication Disorders & Special Education
225 Child Research and Learning Center
Norfolk, VA 23529-0135

To Whom it May Concern:

As the leader of Chesapeake Bay Academy, a school for exceptional learners grade K through 12, I appreciate the need for young researchers to take the lead and explore new interventions for our students with learning differences. It is therefore my pleasure to express my support for the research of Mindy Gumpert, doctoral candidate.

Chesapeake Bay Academy stands ready to assist Ms. Gumpert in partnering with her to execute her doctoral study related to scientific argumentation.

Please let me know if you have questions or concerns. I look forward to our work together in support of Ms. Gumpert and our community of exceptional learners.

Best Regards,

[Signature]

Judy, Jankowski, Ed.D.
Head of School
PROJECT TITLE: Examining Oral Scientific Argumentation Engagement Among Secondary Students with Learning Disabilities and Learning Differences

INTRODUCTION
The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. The title of the research is Examining Oral Scientific Argumentation Engagement Among Secondary Students with Learning Disabilities and Learning Differences. The proposed study will take place at Chesapeake Bay Academy in two ninth grade Life Science classrooms and one 12th grade Physics classroom.

RESEARCHERS:

Robert Gable, PhD.
Associate Professor of Special Education
Responsible Project Investigator
Darden College of Education
Department of Communication Disorders and Special Education
Old Dominion University
Principal Investigator

Mindy Gumpert, M.S. Ed.
Doctoral Student
Darden College of Education
Department of Communication Disorders and Special Education
Old Dominion University
Investigator

DESCRIPTION OF RESEARCH STUDY
Several studies have been conducted looking into the subject of the scientific argumentation ability of typically developing students. However, little research has been conducted looking into the scientific argumentation abilities of students with learning differences. Research suggests that teaching students how to engage in scientific argumentation will enable students to argue like a scientist to solve a problem. The scientific argumentation sessions are a way for students to work together to solve a problem in science and improve their science knowledge. During science class, students will be presented with a problem in science and will collaborate to find a solution to the problem. Students will take turns discussing ideas and offering suggestions or solutions to the issue during the scientific argumentation session.
Appendix E

Informed Consent Document

If you decide to allow your child to participate, then he/she will join a study involving research of the scientific argumentation abilities of ninth and 12th-grade students with learning differences. During their regularly scheduled science instruction, students will have three opportunities a week (20 minutes each) to engage in a scientific argumentation session. The argument sessions will be recorded and reviewed at a later time in order to identify skills and strategies students use during the scientific argumentation sessions.

If you say YES, then your child’s participation will last for approximately 25 sessions, and will include three 20-minute scientific argumentation sessions a week. The study will take place in your child’s science classroom during their regularly scheduled science period at Chesapeake Bay Academy. Approximately 15-20 students will be participating in this study.

EXCLUSIONARY CRITERIA
Your child must be a ninth or 12th-grade student taking a Science class at Chesapeake Bay Academy to participate in this study.

RISKS AND BENEFITS
RISKS: If you decide your child can participate in this study, then he/she may face a risk of fatigue. The researcher tried to reduce these risks by making the scientific argumentation sessions short in duration (20 minutes). Breaks will be provided to students should they need them. And, as with any research, there is some possibility that your child may be subject to risks that have not yet been identified.

All data information collected in this study will be stored securely to protect student confidentiality unless disclosure is required by law. The data and video will be stored in a secure server (in a password protected computer at ODU) accessible to only the study investigators and data collectors at the Child Study Center, office 225. The identifiers will be removed after completing data analysis and publishing research results in academic journals or conferences. Each child will be given a pseudonym for confidentiality purposes.

BENEFITS: The main benefit to your child for participating in this study is the opportunity to engage in scientific argumentation and the opportunity to potentially improve his/her science knowledge.

COSTS AND PAYMENTS
The researchers are unable to give your child any payment for participating in this study.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.
Appendix E

Informed Consent Document

CONFIDENTIALITY

Participants will be assigned a pseudonym so that your child's name will not be attached to his/her responses. Only researchers involved in the study or in a professional review of the study will have access to the data sheets. The researchers will take reasonable steps to keep private information, such as data and video recordings confidential. The data and video will be stored in a secure server (in a password protected computer at ODU) accessible to only to the study investigators and data collectors at the child Study Center, office 225. The identifiers will be removed after completing data analysis. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify your child. Of course, the records may be subpoenaed by court order or inspected by government bodies with oversight authority.

WITHDRAWAL PRIVILEGE

Your child’s participation in this study is completely voluntary. It is OK for you to say NO to your child’s participation. Even if you say YES now, you are free to say NO later, and your child can withdraw from the study -- at any time. The researchers reserve the right to withdraw your child’s participation in this study, at any time, if they observe potential problems with his/her continued participation.

COMPENSATION FOR ILLNESS AND INJURY

Agreeing to your child’s participation does not waive any of your legal rights. However, in the event of harm, arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that your child suffers harm as a result of participation in any research project, you may contact Dr. Robert Gable, Responsible Project Investigator, at 757-683-3157 or Mindy Gumpert, Investigator, at 757-630-2826, Dr. Tancy Vandecar-Burdin the current IRB chair at 757-683-3802 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT

By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits to your child. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them. Feel free to contact Dr. Robert Gable, Responsible Project Investigator, at 757-683-3157 or Mindy Gumpert, Investigator, at 757-630-2826.
Appendix E
Informed Consent Document

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. Tancy Vandecar-Burdin, the current IRB chair, at 757-683-3802, or the Old Dominion University Office of Research, at 757-683-3460. **Note: By signing below you are telling researchers YES, that you will allow your child to participate in this study. Please keep a copy of this form for your records.**

Your child’s name (please print):

__________________________________________

Your name (please print):

___________________________________________________

<table>
<thead>
<tr>
<th>Subject’s Signature</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Parent / Legally Authorized Representative’s Signature</td>
<td>Date</td>
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</table>

**INVESTIGATOR’S STATEMENT**

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject’s questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

| Investigator’s Printed Name & Signature | Date |
Appendix F

ASSENT FORM

My name is Mindy Gumpert. I am a student at Old Dominion University (ODU). Dr. Gable is a professor at ODU. We are asking you to take part in a research study because we want to teach you about how to argue in science using real world issues. You might think arguing is bad, but scientists do it all the time with each other when they discover new things. Arguing is good in science, and we would like to teach you how to argue like scientist do to gain new knowledge.

If you agree to participate, you and up to 15 other students will participate in scientific argumentation sessions during your science classes. You will work with a group of your peers to learn how to argue to answer a question or solve a problem in science.

You do not have to participate; no one will be mad at you if you choose not to. Even if you start, you can stop later if you want. If you decide to be in the study, we will not tell anyone else what you say or do if you do not want us to. We will need to videotape you and the other students as part of our research. We need signatures from you and your parent/guardian on three forms. If you return the signed forms to Mr. Foss, you will receive a $10 Visa gift card. Even if you and your parents decide you do not want to participate in the study, if your parent/guardian writes a statement saying you will not participate on one of the forms and you return them unsigned, you will still receive a $10 Visa gift card. Do you have any questions?

Sincerely,
Robert Gable
Associate Professor of Special Education
Responsible Project Investigator
Child Study Center Room 111A
Norfolk, VA 23529
(757) 683-3157
rgable@odu.edu

Mindy Gumpert
Doctoral Candidate
Child Study Center Room 125
Norfolk VA 32529
mgump001@odu.edu
757-630-2826

Signing here means that I have read the information in this form to you and that you are willing to be in this study and be videotaped.

Signature of participant____________________________________
Subject’s printed name _____________________________________________
Signature of investigator____________________________________________
Date___________________________
Appendix G

INFORMED CONSENT DOCUMENT
FOR USE OF PHOTO/VIDEO MATERIALS

STUDY TITLE: Examining the Impact of Two Interventions During Oral Scientific Argumentation Episodes Among Secondary Students with Disabilities

DESCRIPTION:
The researchers would like to take photographs or videotapes of your child during scientific argumentation episodes in order to illustrate the research in teaching, presentations, and/or publications.

CONFIDENTIALITY:
The photos and videotapes will be stored in a locked file cabinet at Old Dominion University in the Child Care Center, Office 111A. Your child would not be identified by name in any use of the photographs or videotapes. Even if you agree for your child to be in the study, no photographs or videotapes will be taken of him or her unless you specifically agree to this. After five years, all data will be destroyed.

VOLUNTARY CONSENT
By signing below, you are granting to the researchers the right to use your child’s likeness, image, appearance and performance - whether recorded on or transferred to videotape, film, slides, photographs - for presenting or publishing this research. No use of photos or video images will be made other than for professional presentations or publications. The researchers are unable to provide any monetary compensation for use of these materials. You can withdraw your voluntary consent at any time.

If you have any questions later on, then the researchers should be able to answer them: Dr. Robert Gable, 757-683-3157; Mindy Gumpert, 757-630-2826. If at any time you feel pressured to have your child participate, or if you have any questions about your child’s rights or this form, then you should call Dr. Tancy Vandecar-Burdin, the current IRB chair, at 757-683-3802, or the Old Dominion University Office of Research, at 757-683-3460.
**Appendix H**

Socioscientific Issues used in Argument Sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Should a zoo be built in your city? (Simon, Erduran, &amp; Osborne, 2006)</td>
</tr>
<tr>
<td>2</td>
<td>Why should we use bottled water instead of tap water? (Knight &amp; McNeil, 2015)</td>
</tr>
<tr>
<td>3</td>
<td>How does killing the wolves in Yellowstone justify the benefits to the ecosystem? (Evagorou, Jimenez-Aleixandre, &amp; Osborne, 2012)</td>
</tr>
<tr>
<td>4</td>
<td>Why should parents be forced to vaccinate their children?</td>
</tr>
<tr>
<td>5</td>
<td>Why should we use wind power (i.e., turbines) instead of coal for electricity? (Dawson &amp; Carson, 2017)</td>
</tr>
<tr>
<td>6</td>
<td>How do we know global warming is a fact not fiction? (Walker &amp; Zeidler, 2007)</td>
</tr>
<tr>
<td>7</td>
<td>Why should we use genome editing, such as CRISPR-Cas 9, to alter human genomes? (Sadler &amp; Zeidler, 2003)</td>
</tr>
<tr>
<td>8</td>
<td>Why should plastic straws not be banned?</td>
</tr>
<tr>
<td>9</td>
<td>Why should neighborhood speed limits be reduced in half? Will that safeguard children? (Dolan, Nichols, &amp; Zeidler, 2009)</td>
</tr>
<tr>
<td>10</td>
<td>Why should the Tidewater area plan for structural adaptations instead of strategic retreat as a response to sea-level rise?</td>
</tr>
<tr>
<td>11</td>
<td>Why shouldn’t we conduct research on animals? (Zeidler, Walker, Ackett, &amp; Simmons, 2002)</td>
</tr>
</tbody>
</table>
### Socioscientific Issues used in Argument Sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Should the US Ban Genetically Modified Organisms (GMOs), allow GMOs with product labeling, or allow GMOs with no restrictions on labeling?</td>
</tr>
<tr>
<td>13</td>
<td>If you had $5 to spend on research, how should the amount of money spent on cell phone research compare to the allocation of funds for some of the other topics you have argued (e.g., plastic straws, research on animals, coastal flooding)?</td>
</tr>
<tr>
<td>14</td>
<td>Why should counties in Florida use crushed glass as a new alternative to slowing erosion rather than continuing to purchase beach sand to fix the beaches? (Dolan, Nichols, &amp; Zeidler, 2009)</td>
</tr>
<tr>
<td>15</td>
<td>Why should the Canadian harp seal hunt be continued? (Dolan, Nichols, &amp; Zeidler, 2009)</td>
</tr>
<tr>
<td>16</td>
<td>How were the fines levied against BP sufficient to compensate for the impact the oil spill had on the environment and the economy?</td>
</tr>
<tr>
<td>17</td>
<td>Why should individuals have the right to claim space, celestial bodies, and natural resources on the moon?</td>
</tr>
<tr>
<td>18</td>
<td>You have limited funding but want to start a small furniture building business. You want to convert the existing building into a green building, but it will cost twice as much money as you have. How do you justify spending the extra money to your business partner?</td>
</tr>
</tbody>
</table>
Appendix H

Socioscientific Issues used in Argument Sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Why should the US follow China’s lead in its plan to cut meat consumption by 50% to reduce greenhouse gas emissions?</td>
</tr>
</tbody>
</table>
Appendix I

Views of Nature of Science Elementary Questionnaire Protocol

Name_______________________________________

Date _______________________________________

Instructions

• Please answer each of the following questions. You can use all the space provided and
  the backs of the pages to answer a question.
• Some questions have more than one part. Please make sure you put answers for each part.
• This is not a test and will not be graded. There are no “right” or “wrong” answers to the
  following questions. I am only interested in your ideas related to the following questions.
• If you need, you can draw pictures to explain your ideas.

1. What is science?

2. (a) What are some of the other subjects you are learning?

   (b) How is science different from these other subjects?

3. Scientists are always trying to learn more about our world. Do you think what
   scientists know will change the future?

4. (a) How do scientists know that dinosaurs once lived on the earth?

   (b) How sure are scientists about the way dinosaurs looked? Why?
Appendix I

Views of Nature of Science Elementary Questionnaire Protocol

5. A long time ago all the dinosaurs died. Scientists have different ideas about why and how they died. If scientists all have the same facts about dinosaurs, then why do you think they disagree about this?

6. TV weather people show pictures of how they think the weather will be for the next day. They use lots of scientific facts to help them make these pictures.

How sure do you think the weather people are about these pictures? Why?

7. (a) Do you think scientists use their imaginations when they do their work?

Yes  No

(b) If NO, explain why.

(c) If yes, then when do you think they use their imaginations?
Appendix J
Assessment of Scientific Argumentation in Classrooms Observation Protocol

Group 1 2 3  Date _____________________
Coder _________________________________________ ASAC Percentage __________

THESE ITEMS TARGET HOW THE GROUP ATTEMPTS TO MAKE SENSE OF WHAT IS GOING ON

<table>
<thead>
<tr>
<th>Item</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The talk of the group was focused on solving a problem or advancing understanding.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>Description: Groups that score high on this item maintain the focus of their talk and efforts on understanding or solving the problem rather than the best way to finish their work quickly or with the least amount of effort. Note: Groups that stay on topic but never engage in an in-depth discussion about what is happening should score low on this item.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The participants modified their explanation or claim when they noticed an inconsistency or discovered unusual data.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>Description: A group that modified their claim or explanation when they noticed inconsistencies would not ignore “things that do not fit” or attempt to discount them once they are noticed by one of the participants. Groups that score high on this item try to modify their claim or explanation (not just their reasons) in order to account for an inconsistency rather than attempting to “explain them away”.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The participants were skeptical of ideas and information.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>Description: During scientific argumentation, allowing a variety of ideas to be presented, but insisting that challenge and negotiation also occur would indicate that group members were skeptical. Accepting ideas without accompanying reasons would result in a low score because it is a sign of “gullible” thinking. In other words, students must be willing to ask, “How do you know?” or “Are you sure?” Groups that respond to the ideas of others with comments such as “ok”, “that sounds good to me”, or “whatever you think is right” would score low on this item.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The participants provided reasons when supporting or challenging an idea.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>Description: Providing reasons to support or challenge a claim, conclusion, or explanation is a crucial characteristic of argumentation. Claims must have some support provided for them beyond simply restating the claim itself. Making claims without support would result in a low score on this item and including any reason like “that’s what I think”, “it doesn’t make sense”, “the data suggests...” or “but that doesn’t fit with...” would result in a higher score. Note: Personal or past experiences count as a reason for this item.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix J

Assessment of Scientific Argumentation in Classrooms Observation Protocol

**THESE ITEMS TARGET HOW THE GROUP DETERMINES WHAT COUNTS AS VALID OR ACCEPTABLE**

<table>
<thead>
<tr>
<th>5. Participants used evidence to support and challenge ideas or to make sense of the phenomenon under investigation.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
<td></td>
</tr>
</tbody>
</table>

*Description:* Students must include data (e.g., numbers, measurements, observations, facts). Statements like “That’s what I think.” or “It doesn’t make sense.” would result in a low score. Statements like “the data we found suggests that...” or “our evidence indicates...” would result in a higher score.

<table>
<thead>
<tr>
<th>6. The participants examined the relevance, coherence, and sufficiency of the evidence.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
<td></td>
</tr>
</tbody>
</table>

*Description:* This item draws attention to the amount and kinds of evidence used to support a claim or explanation. Groups that attempt to (a) determine the value of a piece of evidence (e.g., “Does that matter?”), (b) look at the links or the relationship between multiple pieces of evidence (e.g., “This supports X and Y but this only supports X.”), or (c) attempt to determine if there is enough evidence to support an idea (e.g., We do not have any evidence to support that.”) would score higher on this item.

<table>
<thead>
<tr>
<th>7. The participants evaluated how the available data was interpreted or the method used to gather the data.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
<td></td>
</tr>
</tbody>
</table>

*Description:* The evidence evaluated for a claim or explanation should be evaluated on how well the data was gathered and interpreted. A question such as “Why is that evidence included?” or “How did they gather their data?” or “Where did that data come from?” indicates that the participants are assessing methods or an interpretation of data and would result in a higher score.
## Appendix J

Assessment of Scientific Argumentation in Classrooms Observation Protocol

### THESE ITEMS TARGET GROUP DYNAMICS

<table>
<thead>
<tr>
<th>Item</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. The participants were reflective about what they know and how they know.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Description: It is important for members of the group to agree on what they know and to be specific about how they know. Statements such as, “Do we all agree?” or “Is there anything else we need to figure out?” or “Can we be sure?” indicate that participants are monitoring their progress and have an end goal in mind.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>9. The participants respected what each other had to say.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Description: Respecting what each other had to say is more than listening politely. Respect also indicates that what others had to say was actually heard and considered (e.g., That is a good point.” Or “Interesting idea.” Or I hadn’t thought of that.” A group that scored high on this would allow everyone to present their ideas and express their opinions without censure or ridicule.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>10. The participants discussed an idea when it was introduced into the conversation.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Description: To be a participating and contributing member of the group, it is important to feel valued. Ideas and opinions need to be acknowledged. This means they are considered and given weight by the group. Groups that ignore ideas when they are proposed (results in the same idea being mentioned over and over) would earn a low score on this item.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>11. The participants encouraged or invited others to share or critique ideas.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Description: Groups that consist of individuals that invite others to share (e.g., “What do you think?”), critique (e.g., “Do you agree?” or “It’s okay to disagree with me”) or discuss an idea (e.g., “Let’s talk about this one some more.”) would score higher than a group with an alienating leader that dominates the conversation and the work of the group.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
<tr>
<td>12. The participants restated or summarized comments and asked each other to clarify or elaborate on their comments.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Description: The depth of discussion will be enhanced not by making assumptions about another person’s ideas or views, and it demonstrates that their point of view is valued and is furthering the discussion. Communication provides students with opportunities to identify the strengths and weaknesses of their understanding.</td>
<td>Not at all</td>
<td>Once or twice</td>
<td>3-4 times</td>
<td>5 or more</td>
</tr>
</tbody>
</table>
### Assessment of Scientific Argumentation in Classrooms Observation Protocol

#### STUDENTS MAKE CONNECTIONS BETWEEN THE SCIENCE CONTENT IN THE CURRENT LESSON AND PRIOR EXPERIENCES IN AND OUT OF SCHOOL

<table>
<thead>
<tr>
<th>13. Students use unrelated concepts to explain socioscientific issues.</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Students give specific examples of unrelated concepts to explain the issue.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14. Students make connections to what they already know or to applications in real world contexts.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15. Students describe the controversy in terms of possible consequences.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Possible consequences would include not knowing how to take action or determining that there is no known or possible solution.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16. Students describe the controversy as a series of trade-offs between personal comfort (morals, ethics) and political or economic change.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>17. Students exhibit skepticism when presented potentially biased information.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Twitter, Facebook, and Instagram information would be potentially biased. Students should acknowledge each bias if presented with information from social media. Someone’s personal opinion would be potentially biased.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix J

Assessment of Scientific Argumentation in Classrooms Observation Protocol

Scoring

Number of items scored a one or higher  = ________ = ________%

Inter-observer Agreement = Number of Agreements  x 100 = ________ x 100 = ________

Number of Agreements + Disagreements

(Note: If IOA is not 85% or better, coders must negotiate differences and reach consensus)
### Appendix K

**Individual Coding Protocol**

<table>
<thead>
<tr>
<th>Name __________________________________________________</th>
<th>Date ____________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom: Physics Earth Science 1 Earth Science 2</td>
<td></td>
</tr>
<tr>
<td>Start Time ______________ Stop Time _______________ Length of Session ______________</td>
<td></td>
</tr>
</tbody>
</table>

**Directions:** Tally number of occurrences

<table>
<thead>
<tr>
<th>Claim</th>
<th>Evidence</th>
<th>Reasoning</th>
<th>Group Interactions (GI)</th>
<th>Additional Information (AI)</th>
<th>Barely Substantive (BS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total: ______</th>
<th>Total: ______</th>
<th>Total: ______</th>
<th>Total: ______</th>
<th>Total: ______</th>
<th>Total: ______</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>C + E + R</th>
<th>GI</th>
<th>AI</th>
<th>BS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total number of occurrences</th>
<th>Length of Session</th>
<th>Reliability Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(# occurrences ÷ length of session)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rater ______________________________</th>
<th>Interobserver Agreement ______ %</th>
</tr>
</thead>
</table>

**Coding Key**

**Claim**
Student makes a statement that answers the Guiding Question (e.g., Should parents vaccinate their children? Claim: I claim parents should vaccinate their children). Student does not need to use the word claim in his/her statement to get a tally mark. “Yes, I think that...” or “No, I do not think that...” would also be acceptable as a claim.

**Evidence**
Student provides data (numbers, measurements, observations, facts) as evidence to support the claim. (e.g., 4000 new measles cases have been reported this year.). A student may use a phrase such as “The data we found suggests that...” or “Our evidence indicates...” but they do not have to use those phrases to get a tally mark.

**Reasoning**
Statement of why the evidence supports the claim. Student should offer examples.

**Group Interactions**
Students interact appropriately with each other. Any of the following statements would demonstrate appropriate group interactions: “Do we all agree?” “Is there anything else we need to know?” “Interesting idea, I hadn’t thought of that.” “What do you think?” “Do you agree?” Note negative behaviors in the Comments section below.

**Additional Information (AI)**
Student added additional information based on background knowledge or prior experience that relates to the Guiding Question. This must be information (evidence) other than information presented in class.

**Barely Substantive (BS)**
Students included information that is unrelated to the Guiding Question OR information that is clearly untrue or made up.

**Other**
One word answers such as “Yes” would not count as an occurrence. “Yes, I think that....” would count.
Appendix L

Procedural Fidelity Checklist for Baseline and Probe Conditions

Date: 

Time: 

Condition:  Baseline  Probe

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Not Observed 0</th>
<th>Observed 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher greets students and sets timer for 20 minutes.</td>
<td>(a) _____</td>
<td>(a) ______</td>
</tr>
<tr>
<td></td>
<td>(b) _____</td>
<td>(b) ______</td>
</tr>
<tr>
<td>Researcher tells students they will have an opportunity to address a moral or social dilemma about a current science problem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher hands students a written scenario and reads the scenario aloud.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher tells students they will have approximately 15 minutes to consider different courses of action related to the complex socioscientific problem just read aloud.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher tells students to get started.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If students ask what consider different courses of action related to the complex socioscientific problem means, researcher will respond, “Just do your best.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When the tier rings, researcher tells students time is up.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher collects papers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher tells students thank you for working hard.</td>
<td></td>
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</tr>
</tbody>
</table>
Appendix M

Sample Socioscientific Issue for Argument

Guiding Question: Should we ban plastic straws? You must pick a side and defend it. There must be two points of view represented in the argument.

The Environmental Impact of Plastic Straws – Facts, Statistics, and Infographic

When its usage is added up, plastic straws create a big problem for the environment.

- the USA using 500 million straws every day (enough straws to circle around the Earth 2.5 times!), that’s a lot of trash and potential litter.
- Updated Statistic: Last year, Americans used about 390 million plastic straws every day. This statistic comes from the market research firm Freedonia Group.
- The excessive use of plastic straws is doing great damage to the environment, and specifically the oceans.
- Water is being polluted and aquatic life is being injured and killed off on a huge scale due to the volume of plastic in the ocean, which straws contribute to in enormous numbers
- Straws are difficult to recycle because they are so light and small that they drop out of sorting machines and mix with other materials.
- They are technically recyclable, but in practice this does not happen nearly as much as it should. Straws are used in such vast quantities across the globe that they end up in the oceans simply through human error.
- They are littered, left on beaches, blown into the ocean by the wind, or they find their way into the sea through plugholes and drains.
- Plastic does not biodegrade, it breaks down into smaller pieces called ‘microplastics’ which are even more dangerous for marine life.
Appendix M

Sample Socioscientific Issue for Argument

Plastic Straws

ENVIRONMENTAL IMPACT & FACTS

It’s no secret that plastic straws and plastic in general are bad for the environment (especially marine life). Here are some facts and statistics about the environmental impact of plastic straws.

500 Million

...The number of straws used by Americans daily. That’s enough straws to circle around the Earth 2.5 times!

Plastic straws are the 11th most found ocean trash (2017).

It takes up to 200 years for a plastic straw to decompose, and they can’t be recycled in most places.

Each year, 1 million seabirds and 100,000 marine animals die from ingesting plastic.
Appendix M

Sample Socioscientific Issue for Argument

- Due to their small size, straws are often mistaken for food by animals and because of their cylindrical shape, straws can cause suffocation and death to the animal.
- In at least one instance, the stomach of a penguin was perforated by a plastic straw.
- In another, in a video seen around the world, a sea turtle’s nostril bled as a plastic straw was removed.
- About 1,400 people visit the emergency room every year due to injuries from drinking straws. The majority of incidents involve young children and lacerations to the mouth, abrasions to the cornea, or insertions into the ear and nose. A common scenario involves a child falling with a straw or poking a sibling.
- Whether made of stainless steel, glass, paper, or bamboo, there is no question that reusable or compostable paper straws are better for the environment than plastic. More than 500 million plastic straws are used every day in the U.S., typically enjoyed for minutes before being discarded.
- Too small to be recycled, plastic straws will persist in the environment well past our future generations lifetimes, breaking into tiny pieces over time.
- We ALL can do something to help. When out at a restaurant, simply say “no straw please” to your server.
- Around 71% of seabirds and 30% of turtles have been found with plastic in their stomachs and if plastic is ingested, marine life has just a 50% chance of survival.
- Every year about 8 million metric tons of plastic end up in our oceans and in 2025, the annual input is estimated to be about twice that.
- Straws contribute a lot to that figure, and feature in the top 10 items found in coastal clean-ups.

Why People With Disabilities Want Starbucks to Keep Offering Plastic Straws

Meg Dowell
July 9, 2018
Sample Socioscientific Issue for Argument

Despite the positive environmental implications, some individuals and groups are fighting back, upset that “eliminating” plastic straws puts certain people with disabilities at a major disadvantage.

One article in The Guardian featured the distressed thoughts of a woman who has been disabled since she was 14. She’s aware of the environmental dangers of the plastic straw, but has no other option. She wrote:

- “I need straws that bend, ones that can handle all drinks, including medication, and all temperatures.
- I need straws that aren’t too fat, that won’t cause me to choke or be difficult for me to keep in my mouth.”
- Many biodegradable straw options don’t work when used with drinks at high temperatures.
- Some argue that new Starbucks straws are meant to replace the ones used in cold drinks. But some conditions such as cerebral palsy make drinking without a straw and lid — regardless of temperature — impossible.
- So why not use paper straws? Some individuals with learning or developmental disabilities take longer to finish their drinks. Paper straws go soggy when they’re left in liquid for too long.
- Straws made with metal or bamboo are often dangerous for people with Parkinson’s: They’re too strong.
- Stainless-steel straws conduct heat (and cold). And you don’t want someone who might chew on their straw to do so when it’s made of glass.
- Some also argue that reusable straws are either too expensive or need washing. This makes them a luxury item many with disabilities can’t afford.

Stores won’t offer straws automatically, but they aren’t getting rid of them altogether. Starbucks clarified that anyone who wants or needs a straw with their drink can have as many as they want, but only when they request it. If paper straws aren’t an option for some people, it’s very likely single-use straws will still be. But they’ll be made from alternative materials, not traditional plastic. Still eco-friendly, but hopefully more accommodating.

Those living with disabilities are simply frustrated by the lack of sustainable options that are both safe and suitable on an individual basis.
Straws are important tools

Utensils such as plastic straws serve an essential role in the daily lives of some people with physical disabilities, helping them with to eat and drink.

- They are also used as tools to exercise the lungs.
- Plastic straws are particularly important for disabled people because they are flexible, cheap and widely accessible.
- Alternatives such as metal or glass straws do not offer the same degree of flexibility.

Despite the availability of more environmentally friendly biodegradable straws, many of these products are not suitable to be used for liquids above 40 degrees Celsius, making them impractical for the consumption of soup or hot beverages — the average cup of coffee is served at about 70C.

- Chief executive of ConnectAbility Australia David Carey says that although alternative materials for straws do exist in the market, they do not measure up in either convenience or safety.

Disability rights advocate Michaela Hollywood from Muscular Dystrophy UK says protecting the environment and supporting people with disabilities do not have to be incongruous.

"As a disabled person I am deeply concerned about the environment. There is no doubt that our society needs to change our ways and reduce or eliminate single use plastic from our lives," she says.

Appendix N

Procedural Fidelity Checklist for Intervention Argument Sessions

Date: 

Time:
<table>
<thead>
<tr>
<th>Procedures</th>
<th>Not Observed 0</th>
<th>Observed 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher thanks students for working with her and sets timer for 20 minutes.</td>
<td>(a) _____</td>
<td>(a) _____</td>
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<tr>
<td></td>
<td>(b) _____</td>
<td>(b) _____</td>
</tr>
<tr>
<td>Researcher tells students they will <em>have an opportunity to address a moral or social dilemma about a current science problem.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher reminds students of behaviors that are used in scientific argumentation:</td>
<td>(a) _____</td>
<td>(a) _____</td>
</tr>
<tr>
<td>(a) making a claim that answers the guiding question</td>
<td>(b) _____</td>
<td>(b) _____</td>
</tr>
<tr>
<td>(b) providing evidence for the claim (observations or measurements)</td>
<td>(c) _____</td>
<td>(c) _____</td>
</tr>
<tr>
<td>(c) using reasoning to link evidence to the claim tying it back to science</td>
<td>(d) _____</td>
<td>(d) _____</td>
</tr>
<tr>
<td>(d) demonstrating appropriate group interactions (everyone gets a chance to speak, use inside voices)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher sets the goal for the group: to defend a point of view or to reach consensus.</td>
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<tr>
<td>Researcher hands students a written scenario and reads the scenario aloud.</td>
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<tr>
<td>Researcher asks if there are any questions and answers questions.</td>
<td>(a) _____</td>
<td>(a) _____</td>
</tr>
<tr>
<td></td>
<td>(b) _____</td>
<td>(b) _____</td>
</tr>
<tr>
<td>Researcher tells students to USE any scaffolds they want during the session.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix N

Procedural Fidelity Checklist for Intervention Argument Sessions continued

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Not Observed 0</th>
<th>Observed 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher tells students they will have approximately 15 minutes to consider different courses of action related to the complex socioscientific problem just read aloud.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher tells students to get started.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When the timer rings, researcher tells students time is up and debriefs students about the process.</td>
<td>(a) _____</td>
<td>(a) _____</td>
</tr>
<tr>
<td></td>
<td>(b) _____</td>
<td>(b) _____</td>
</tr>
<tr>
<td>Researcher thanks students for working so hard.</td>
<td></td>
<td></td>
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<tr>
<td>Researcher provides timely, correctional feedback using cues and prompts throughout the SA episode.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher provides reteaching when necessary.</td>
<td></td>
<td></td>
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</tbody>
</table>
Appendix O

Social Validity Survey

Name ____________________________________ Date ______________________

Directions: Use the number lines below to show how much you agree or disagree with each of the statements. Circle a number that best shows your opinion.

1. I liked arguing about socioscientific issues.

1 2 3 4 5
No! I strongly disagree! I guess so. . . Yes! I strongly agree!

2. Participating in group arguments on socioscientific issues helped me relate to current science issues better.

1 2 3 4 5
No! I strongly disagree! I guess so. . . Yes! I strongly agree!
Appendix O

Social Validity Survey

3. It was difficult for me to remember the parts of argumentation (e.g., making a claim, providing credible evidence, using reasoning to link the evidence to the claim, tying it all back to science).

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No! I strongly disagree!</td>
<td>I guess so. . .</td>
<td>Yes! I strongly agree!</td>
<td></td>
<td></td>
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</table>

4. I learned how to argue without getting mad.

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No! I strongly disagree!</td>
<td>I guess so. . .</td>
<td>Yes! I strongly agree!</td>
<td></td>
<td></td>
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</table>

5. I am comfortable when my peers disagree with me.

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<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No! I strongly disagree!</td>
<td>I guess so. . .</td>
<td>Yes! I strongly agree!</td>
<td></td>
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</table>
Appendix O

Social Validity Survey

6. I learned how to really listen to what people are saying.

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<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No! I strongly disagree!</td>
<td>I guess so...</td>
<td>Yes! I strongly agree!</td>
<td></td>
<td></td>
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</tbody>
</table>

7. I learned to make strong arguments by using credible evidence.

<table>
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<tr>
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<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No! I strongly disagree!</td>
<td>I guess so...</td>
<td>Yes! I strongly agree!</td>
<td></td>
<td></td>
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</tbody>
</table>

8. I think discussing socioscientific issues with my peers influenced my learning.

<table>
<thead>
<tr>
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<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No! I strongly disagree!</td>
<td>I guess so...</td>
<td>Yes! I strongly agree!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix O

Social Validity Survey

Turn your paper over and write at least one paragraph (5 sentences) about how you have changed in the way you engage in argument from the beginning of the study to the end (e.g., what you learned, how that may impact you in the future).
Mindy Gumpert

EDUCATION

PhD (projected graduation Fall, 2019), Old Dominion University, Norfolk, VA
Dissertation Title: An Examination of Oral Argumentation Using Socioscientific Issues Among Secondary Students with Disabilities

M.S., Education, Old Dominion University, Norfolk, VA, 2015
B.S., Special Education, University of West Florida, Pensacola, FL, 1986

Certifications
- Special Education, Specific Learning Disabilities • K-12
- Master of Science in Education • K-6

INSTRUCTION

VIRGINIA WESLEYAN UNIVERSITY • Adjunct Instructor • Fall 2019, Spring 2020

INST 482: Issues in Education
- This course provides a better understanding of how education research reveals and helps to address contemporary issues in education. Through this course, students will develop a comprehensive literature review of an issue in education. Students will gain an appreciation for the process of education research and a better understanding of its power as a resource for classroom teachers.
- Face-to-face instructional delivery

OLD DOMINION UNIVERSITY • Adjunct Instructor • 2018 - present

SPED 486/586: Teacher Candidate Internship for Special Endorsement
- Teacher candidates will complete seven weeks at the elementary level and seven weeks at the middle/secondary level. Students enrolled at the graduate level complete 9 credit hours. Prerequisites: admission to ODU Teacher Education Program; completion of the approved teacher education program in the specific endorsement area; completion of SPED 483; departmental approval; passing scores on Praxis Core Academic Skills for Educator Tests (or equivalent as prescribed by the Virginia Board of Education); passing scores on Virginia Communication and Literacy Assessment (VCLA), the Virginia Reading Assessment (VRA)/Reading for Virginia Educators (RVE), the appropriate Praxis II content examination and endorsement program exit exam.
- Spring 2020

SPED 403/503: Directed Field Experience in Special Education
- This course provides variable hours of direct participation in a community or educational setting with individuals with special needs. The course includes specific skills of program planning, implementation, evaluation and classroom management. Practicum of 45 hours required.
- Asynchronous instructional delivery, Fall 2019, Spring 2020

SPED 400/500: Foundations of Special Education: Legal Aspects and Characteristics
- This course provides an introduction and overview of the field of special education including legal aspects, regulatory requirements, and critical analyses of research. The course also offers a broad overview of the expectations associated with the identification, characteristics, and education of students with disabilities.
- Face-to-face instructional delivery
- Spring 2019, Summer 2019, Summer 2020

SPED 313: Fundamentals of Human Growth and Development: Birth through Adolescence
- This course provides an understanding of the physical, social, emotional, and intellectual development of children and adolescents and the ability to use this understanding in guiding learning experiences.
Developmental issues related to giftedness or disability and the impact of family disruptions, child abuse and substance abuse are addressed.

- Synchronous instructional delivery
- Fall 2018, Fall 2019

**Graduate Assistant Instructor** • 2016 - 2018

**SPED 313: Fundamentals of Human Growth and Development: Birth through Adolescence**
- Synchronous instructional delivery
- Fall 2016, Spring 2017, Fall 2017

**SPED 400/500: Foundations of Special Education: Legal Aspects and Characteristics**
- Face-to-face instructional delivery
- Summer, 2018

**PROFESSIONAL EXPERIENCE** • Chesapeake Public Schools • 2001 - 2016

**Equity Tutor** • 2016
Part-time instructor responsible for providing remediation to Title 1 elementary students in reading and math to prepare them for the state standardized tests. Designed lessons and assessments for a students with a wide range of educational needs.

**Special Education Co-Teacher** • 2008 - 2015
- Developed outstanding working relationships with co-teachers through shared attitudes, beliefs, and perceptions of co-teaching.
- Shared instructional responsibilities and planning time to design and implement hands on, activity-based lesson plans appropriate for students with disabilities and general education students.
- Served as motivator and positive role model for students.
- With co-teachers developed effective instructional skills including classroom management.
- With co-teachers addressed individual student performance and differentiated instruction.
- With co-teachers continually modified presentations based on the curriculum guidelines.
- Shared responsibilities with co-teachers for content area instruction.
- Attended all parent conferences, assisted with grading and report card comments.

**Child Study Team Chairperson** • 2010 - 2015
Facilitated weekly Child Study meetings and ensured that the sessions adhered to all federal and state guidelines. Designed a Child Study packet for teachers to complete to ensure ample documentation of student data.

**Elementary Special Education Teacher** • 2002 - 2008

**EARLY CAREER HISTORY**

**Early Childhood Special Education Teacher** • Greenbrier Primary School • Chesapeake, VA • 2001 - 2002

**Early Childhood Education Teacher** • Great Bridge Preschool and Kindergarten • Chesapeake, VA • 1998 - 2001

**High School Special Education Teacher** • Bayview Behavioral Hospital • Corpus Christi, TX • 1988 - 1989

**Elementary Special Education Teacher** • Blanche Moore Elementary School • Corpus Christi, TX • 1986 – 1988

**SUMMER PROGRAM LEADERSHIP EXPERIENCE**

**Program Developer and Co-Instructor** • Enviro Camp • Summer 2018
One of three members of the program staff for a weeklong camp in a housing project in South Chesapeake. The camp was co-sponsored by the non-profit organization, Reading Enriches All Children (REACH), and
Tidewater Writing Project (TWP). Responsibilities included co-authoring the grant application, designing the curriculum to incorporate writing activities into an environmental theme, teaching writing lessons, supervising students, and assisting in activities throughout the week (e.g., planting container gardens, field trip to the Learning Barge). The goal of the camp was to cultivate awareness of environmental stewardship to children ages seven to 12.

Program Developer and Co-Instructor ● Speed Academy ● 2017
One of two members of the program staff for weeklong camp integrating engineering and science content through the use of remote control vehicles for Portsmouth Public Schools secondary students. Assisted in curriculum design and implementation, collected evaluation data to be used for subsequent grant proposals to support the camp.

Program Developer for Tidewater Writing Project Youth Writing Camps ● 2014 - present
Responsibilities include collaborating annually with Old Dominion University’s (ODU) Big Blue Camp director to plan four to five one week summer writing camps for youth ages five to 12 and serving as a liaison between TWP and the Big Blue Camp at ODU. Other responsibilities include identifying themes for camps, writing camp descriptions for advertisement, hiring and supervising instructors, arranging access to technology, and buying supplies.

Program Developer and Co-Instructor ● Outdoor Adventures Camp ● 2017
One of two members of the program staff for a weeklong camp that featured traditional and contemporary poetry writing using the flora and fauna of the ODU campus as inspiration. This camp served children ages seven to 12. Responsibilities included designing the curriculum to incorporate several types of poetry writing into a nature theme, teaching writing lessons, supervising students, and planning and implementing other activities throughout the week.

Program Developer and Co-Instructor ● Cinematic Adventures Camp ● 2016
One of two members of the program staff for a weeklong camp that featured digital storytelling. Children wrote a script then produced a video based on their script. Responsibilities included designing the curriculum to incorporate writing through digital storytelling, teaching first and second grade students how to use digital storytelling, assisting students with script writing, making a movie to present at the end of camp talent show, and planning and implementing other activities throughout the week.

Program Developer and Co-Instructor ● FUNctional Writing Camp ● 2014
One of two members of the program staff that established the first one-week TWP summer writing camp for youth ages 7-12 at ODU. Developed an innovative curriculum that included functional writing skills such as creating a map for a scavenger hunt throughout the ODU campus, writing directions for a STEM activity to design a car, and the creation of a cookbook. Responsibilities included designing the curriculum to incorporate functional writing activities, marketing the camp and enrolling students, teaching writing lessons, supervising students, and planning and implementing other activities throughout the week. This camp was the foundation for establishing future collaboration between ODU’s Big Blue Camp and TWP.

SCHOLARSHIP

EXTERNAL FUNDED GRANT EXPERIENCE


INTERNAL FUNDED GRANT EXPERIENCE


PUBLICATIONS


MANUSCRIPTS UNDER REVIEW, IN PREPARATION, OR IN REVISION


PROFESSIONAL PRESENTATIONS


PROFESSIONAL DEVELOPMENT PRESENTATIONS


HONORS AND AWARDS
Graduate Teaching Assistantship  •  Old Dominion University  •  2016 - 2018
Three Minute Thesis Runner-Up  •  Old Dominion University  •  2017
Three Minute Thesis is an internationally recognized competition that challenges PhD students to present compelling oration on their thesis and its significance in three minutes.
Old Dominion University Graduate Travel Award  •  2017
Council for Learning Disabilities Leadership Academy  •  2016 - 2018
Selected for a cohort of six emerging leaders who demonstrated potential through service on a CLD committee and a passion for leadership in CLD. The cohort presented several roundtable sessions to new Leadership Academy applicants as well as one collaborative group session. Served as Technology Chair for the 2017 Annual CLD Conference.
Outstanding Elementary Teacher  •  Virginia Association of Science Teachers  •  2014
Butts Road Intermediate Reading Teacher of the Year • 2008

S E R V I C E

PROFESSIONAL DEVELOPMENT - Chesapeake Public Schools and Old Dominion University Collaboration • 2018 - present
- Initiated contact with Chesapeake Public Schools superintendent to offer opportunities for CPS and ODU to collaborate.
- Created and administered a Needs Assessment to CPS assistant principals to identify professional development needs.
- Co-planned and facilitated meeting with CPS Director of Exceptional Learning and Old Dominion University faculty to discuss Needs Assessment and make a plan moving forward with professional development initiative.
- Collaborated with CPS Director of Exceptional Learning to plan and facilitate a meeting with CPS Director of Assessment and Accountability, Director of Professional and Organizational Development, Director of Strategic Initiatives, and special education administrators to discuss professional development needs.
- Currently developing Needs Assessment for two special education administrators for teachers of students with emotional/behavioral disorders to identify professional development needs.

PROFESSIONAL DEVELOPMENT - Tidewater Writing Project and Barry Art Museum Collaboration • Fall 2019
- Designed a one day professional development program based on the children’s book *The Dot*.
- 10 educators from Title 1 and non-Title 1 schools participated in professional development at the Barry Art Museum
- In Spring 2020, teachers will share *The Dot* lessons with each other and collaborate to develop an annual event for the Barry Art Museum.

Open Institute Coordinator • 2017
- Coordinated and implemented a two-day professional development for educators that focused on technology-based instructional tools for writing. Responsibilities included:
  - Developing course curriculum and institute schedule
  - Scheduling presenters
  - Facilitating discussions

Co-Assistant Director • 2014 - 2016
- Coordinated TWP professional development meetings and trained TWP teacher consultants. Acted as a liaison between the ODU community and local community-based organizations.

Advanced Summer Institute Facilitator • Summer 2014
- Coordinated and implemented a two week, 60 hour professional development institute for teachers to improve their personal and professional writing skills. Responsibilities included:
  - Developing course curriculum and course schedule
  - Grading electronic writing portfolios
  - Scheduling presenters
  - Facilitating reading/writing groups, and discussions

Co-Director of The John Tyler Project • 2014 - 2015
- Co-designed and implemented a one-year, 60 hour writing program for 19 elementary teachers at a Title 1 school in Portsmouth, VA. Responsibilities included:
  - Co-writing grant proposal
  - Developing course curriculum and course schedule
  - Scheduling presenters
  - Reviewing videotaped lessons and offering critique
- Reading teacher reflection logs
- Facilitating an open forum discussion of teachers’ lessons
- Data collection

**UNIVERSITY SERVICE**

- Invited as a special education expert for New Student Orientation.
- Invited committee member to revise interview questions for teacher candidates.
- Invited as a featured presenter at the President’s Administrative Retreat for all university administrative personnel. Presented Three Minute Thesis on An Examination of Scientific Argumentation in an Inclusive Classroom.
- Invited reviewer for Department of Teaching and Learning lesson plans. Assisted in revising a rubric that included CAEP Standard 1 components and common items to be included in all program lesson plans.
- Interviewed undergraduate teacher candidates and provided feedback to the Office of Clinical Experiences on prospective teacher dispositions.
- Invited panel member at the Welcome Back Orientation for new doctoral students and the New Graduate and International Student Orientation.
- Invited member to the Graduate Student Advisory Board.
- Represented graduate students at O’Connor Brewing Company by presenting a five-minute talk on pilot research as a part of Old Dominion University’s Lightning Talks.
- Invited special education expert for STEM 434: Developing Instructional Strategies for Teaching Elementary Science. Critiqued presentations and offered lesson modifications to meet the needs of students with disabilities.
- Presented This Girl is on Fire at the Girl Power Big Blue Camp, which focused on improving self-esteem in elementary and middle school girls.
- Three Minute Thesis preliminary judge.

**University Supervisor for the Office of Clinical Experiences**

- Observed special education teacher candidates.
- Provided oral and written constructive feedback on classroom instruction.
- Directed monthly seminar meetings to address the specific needs of teacher candidates.
- Reviewed digital portfolios that addressed teacher competencies.
- Reviewed teaching philosophy essays and resumes.

**SERVICE FOR PROFESSIONAL ORGANIZATIONS**

**President** • Virginia Council for Learning Disabilities • 2019-2020

**Virginia Council for Learning Disabilities Symposium Chairperson** • 2019-2020

Coordinator for the one day professional development symposium for over 350 educators throughout the state of Virginia.

**Special Needs Advisory Board Member** • National Science Teachers Association • 2019-2021

**ExploraVision Virtual Judge** for national STEM competitions • National Science Teachers Association • 2019

**Conference Activities Co-Chair** • Council for Learning Disabilities • 2018 - 2021

**President Elect** • Virginia Council for Learning Disabilities • 2018 - 2019

**Annual State Symposium Coordinator** • Virginia Council for Learning Disabilities • 2018 - 2019

**Vice President** • Virginia Council for Learning Disabilities • 2017 - 2018

**Regional Representative** • Virginia Council for Learning Disabilities • 2016 - 2017

**Division K Conference Paper and Poster Proposal Reviewer** • Teacher Learning and Professional Development • American Educational Research Association • 2015-present

**SIG-Special Education Research Conference Paper and Poster Proposal Reviewer** • American Educational Research Association • 2015-present • SIG-Special Education Research
Conference Paper and Poster Proposal Reviewer • Council for Learning Disabilities • 2017 - present
Conference Paper and Poster Proposal Reviewer • Virginia Council for Learning Disabilities • 2017 - present
Peer Reviewer for Professional Journals
- Journal for Virginia Science Education • 2019 - present
- LD Forum • 2018 - present
- Science and Children • 2017 - present
- The Teacher Educators’ Journal • 2017 - present
- TEACHING Exceptional Children • 2019 - present

COMMUNITY SERVICE
Volunteer Special Olympics Basketball • Old Dominion University • 2019
Invited Guest Reader • George Washington Carver Elementary • 2019
Invited Reviewer • Virginia Wesleyan Teacher Education Program • 2018
Reviewer and member of the reaccreditation team assisting with the governance and guidance of Virginia Wesleyan University’s education program.
Invited Member/Secretary • Virginia Wesleyan University Elementary Education Advisory Board • 2017 – present.
The advisory board discusses the relationship between higher education and K-6 instruction, current needs of classroom teachers, and specific initiatives of Virginia Wesleyan University.
Developer and Coordinator • Solar System Day and SOLympics • 2016 – present
Each November, two fourth grade classrooms participate in designing three dimensional models of the solar system. Each April over two hundred fourth graders participate in the math SOLympics. The annual outdoor event is designed as an engaging, interactive review for the math Standards of Learning test. Students rotate through ten stations completing math activities and physical challenges.
Invited Speaker • EDUC366: Classroom Management and Teaching • 2017
Presentation on classroom management in inclusive classrooms at Virginia Wesleyan University.
Invited Speaker • Blair Middle School for CARE Now • 2016
Provided writing activities for Set Sail into Science after school program.

Current Memberships and Professional Affiliations
- American Education Research Association
- American Association for the Advancement of Science
- Council for Exceptional Children
- Council for Learning Disabilities
- International Association of Special Education
- International Literacy Association
- National Association for Research in Science Teaching
- National Association of Special Education Teachers
- National Science Teachers Association
- Virginia Association of Science Teachers
- Virginia Council for Learning Disabilities