USING MOBILE TECHNOLOGY TO ENGAGE MIDDLE SCHOOL STUDENTS IN THE SCIENTIFIC PRACTICE OF ARGUMENTATION VIA SCREENCASTING

by

Patricia Anne McGinnis

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education in Educational Technology

Boise State University

May 2016

BOISE STATE UNIVERSITY GRADUATE COLLEGE

DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the dissertation submitted by

Patricia Anne McGinnis

Dissertation Title: Using Mobile Technology to Engage Middle School Students in the Scientific Practice of Argumentation via Screencasting

Date of Final Oral Examination: 26 February 2016

The following individuals read and discussed the dissertation submitted by student Patricia Anne McGinnis, and they evaluated her presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

Yu-hui Ching, Ph.D.	Co-Chair, Supervisory Committee
Ross Perkins, Ph.D.	Co-Chair, Supervisory Committee
Yu-Chang Hsu, Ph.D.	Member, Supervisory Committee

The final reading approval of the dissertation was granted by Yu-hui Ching, Ph.D., Co-Chair of the Supervisory Committee, and Ross Perkins, Ph.D., Co-Chair of the Supervisory Committee. The dissertation was approved for the Graduate College by John R. Pelton, Ph.D., Dean of the Graduate College.

DEDICATION

This work is dedicated to my parents, Bob and Gerry Carius, who always encouraged me to follow my dreams.

ACKNOWLEDGEMENTS

This document represents my four-year journey towards accomplishing a goal that I have had for most of my adult life. It would not have been possible without the support of my family who exhibited enormous patience throughout the last four years. Thank you for listening to me when I was frustrated and for always asking how classes were progressing. I would also like to thank my advisor, Dr. Yu-hui Ching, for her advice while demonstrating enthusiasm for my project and patience with my numerous questions. Thank you, too, to Dr. Ross Perkins for his dedication and perseverance in guiding Boise State University's EDTECH online doctoral program and for serving as co-chair of my committee. Finally, I would like to thank Dr. Yu-Chang Hsu for providing valuable guidance and insight into the affordances of mobile technology.

Earning a doctorate via an online program can be a lonely process, but a fabulous cohort supported me through the process. A special thank you to Dwayne Ockel whose friendship and encouragement have been a constant source of inspiration for me. I also want to thank my colleague Glori Hinck with whom I have shared many heart-to-heart conversations over the last four years.

Finally, I would like to thank my teaching colleague who welcomed me into his classroom and gave me the freedom to create a unit of study that proved to be quite challenging at times. I am indeed fortunate to work in an environment with such supportive colleagues. Thank you, too, to the students who undertook many tasks with enthusiasm. Although there were times when things did not always go as planned, they

were always positive and did their personal best. I know they will grow into thoughtful and inquisitive people and I am pleased to have been part of their education.

ABSTRACT

This case study examined the use of mobile devices in supporting data collection and argumentation in the sixth grade science classroom. Mobile devices were used for data collection during laboratory activities and for constructing screencasts of science arguments. Findings revealed that students exhibit little planning when collecting digital data. Students used the digital data to add visual interest to their screencasts, support observations, and support inferences. Students who used the screencasting application's narration and annotating tools were more likely to create appropriate and sufficient science arguments than their peers. One of the low achieving students in this study was able to create a sophisticated scientific argument through the use of annotation and narration, indicating the potential for screencasting as a viable alternative for struggling students to convey their conceptual understanding of scientific principles. Both students and the classroom teacher viewed the use of mobile devices for creating screencasts of scientific arguments to be valuable. Other findings included that some students avoided narrating their screencast out of anxiety and that workflow issues arose due to the sharing of iPads.

Keywords: argumentation, NGSS, screencasts, mobile learning, science education, iPad

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADI	Argument-Driven Inquiry
APP	Application
CER	Claim-Evidence-Reasoning Framework
IRB	Internal Review Board
K-12	Kindergarten through 12^{th} grade
NCLB	No Child Left Behind
NGSS	Next Generation Science Standards
STEM	Science, Technology, Engineering, and Math
XPL	File format for Explain Everything Application

CHAPTER 1: INTRODUCTION

Recent advances in technology, coupled with an increasing understanding of how people learn and a need to bring education out of the industrial age and into a knowledge-based economy, have refocused attention on inquiry in the science classroom (Friesen & Scott, 2013). Recently, the United States has been criticized for its performance in the Trends in International Mathematics and Science Study (TIMSS), an international test in which the United States finds itself ranked seventh for grade four and ninth for grade eight (Tienkin, 2013). The concern over the state of science education in this country was the catalyst for the 2013 passage of the Next Generation Science Standards (NGSS). These standards, which are based on the *Framework for K-12 Science Education* (National Research Council, 2012), represent an updated version of the 1996 National Education Science Standards and will either be adopted outright by states or will be used to drive changes to state standards (National Association of State Boards of Education, 2013). Unlike the previous national standards, the NGSS are crafted as a three-dimensional approach to science composed of disciplinary core ideas, cross cutting concepts, and science practices.

> The framework is designed to help realize a vision for science education in the sciences and engineering in which students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields. The learning experiences provided for students should engage them with fundamental questions about the world and how scientists have investigated and found answers to these questions. (National Research Council, 2012, p. 8)

The NGSS portend that substantial changes will occur regarding the teaching and learning of science at the K-12 level. Educators will need to develop and implement activities that are strongly aligned to the standards (Bressler, 2014). Rather than science education being simply a body of knowledge to be transmitted to the learner, the standards place emphasis on science as a collection of well-defined practices (Coburn, Russell, Kaufman, & Stein, 2012). This is exemplified by the *Framework for K-12 Science Education* (National Research Council, 2012), which provides the evidence-based foundation for the NGSS. The framework outlines eight scientific practices crucial to the teaching of science. These practices are designed to support and extend inquiry activities in the classroom. The identified practices serve to articulate what inquiry should look like in the K-12 science classroom for the purpose of ensuring that students are actively engaged in experiencing the practices rather than merely learning about them (National Research Council, 2012). In addition to asking questions, carrying out investigations, interpreting data, using models, and applying computational thinking, there is an emphasis on constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information (Bybee, 2013).

In order to attain goals set forth by the NGSS, students need opportunities for reflection, discussion, discourse, and argumentation (Bybee, 2013). In science, argumentation refers to collaboration through critique, and is reminiscent of how scientists practice (Cavagnetto, 2010; Sampson, Grooms, & Walker, 2010). Argumentation is based on argumentation theory to which Toulmin (1958) made a seminal contribution through his book *The Uses of Argument*. Science educators have used Toulmin's model, which identifies specific components of an argument, as a framework for student arguments (Driver, Newton, & Osborne, 1998). Toulmin's argumentation theory has also been used as a basis for developing tools that can improve both written and oral argumentative discourse. For example, Keys, Hand, Prain, and Collins (1999) developed a science writing heuristic that guides the teacher in scaffolding argumentation and the student in crafting arguments. More recently, McNeill and Krajcik (2012) developed a framework for written science arguments and Furtak, Hardy, Beinbrech, Shavelson, and Shemwell (2008) are credited with developing a framework for analyzing reasoning in classroom discourse.

Personal experience and anecdotal evidence suggests that middle school students have difficulty composing written scientific arguments. When students are asked to write a concluding paragraph for laboratory activities, I have observed on numerous instances that students do not refer to their data when making claims despite being directed to do so. McNeill and Krajcik (2012) support these observations, stating, "Unfortunately, in science classrooms students often do not make use of evidence they collect. Conducting investigations can become more procedural and less focused on the use of evidence to answer a question or explain phenomena" (McNeill & Krajcik, 2012, p. 9). Scaffolding the process by exposing students to a claims-making framework pioneered by Krajcik and McNeill (2009) or by providing students with the science writing heuristic (Keys et al., 1999) may be pivotal to the student-created science arguments.

The passage of the NGSS reinforces the need to develop effective classroom activities that incorporate science practices as identified by the *Framework for K-12 Science Education*. One potential approach for improving science practices is through the infusion of technology into lessons that meet the three-dimensional approach of the

NGSS. The affordances of mobile technology, which include portability, computing power, and connectivity, translate into a potentially powerful tool for use in authentic learning environments (Hsu, Ching, & Snelson, 2014). This shift has profound implications for science education by changing teaching paradigms from teacher-delivered content to student-generated content in which students are actively engaged in a learner-centric environment that requires them to be producers of knowledge (Dyson, 2012). Activities such as documenting evidence, pooling and sharing data for analysis, and using applications for reflection and argumentation can be implemented for the purpose of creating a learning environment that involves students in the science practices outlined by the *Framework for K-12 Science Education*.

Science Education and Technology

Today's students can be thought of as 'prosumers,' individuals who both consume and produce content (Dyson, 2012). Educators can take advantage of this phenomenon by developing activities that result in authentic work by students who produce their own digital content to explain science concepts. Such technologies include podcasts, digital stories, animations, and video (Hoban, Nielson, & Shepherd, 2013). One relatively new technique for student-created digital content is that of screencasts. Originally restricted to capturing "a user's computer screen with accompanying audio" (Educause, 2006, p. 1), the definition of screencasts has been expanded to include creation on mobile devices via downloadable apps that enable the user to create voice-over narrations on a virtual whiteboard. Screencasting can provide insight into student thinking through verbal explanations and writing (Soto, 2014), making screencasting a potentially useful tool for capturing the argumentation process.

Since students are typically more fluent with making oral explanations than written explanations (Berland & McNeill, 2009), the use of screencasts in which students are expected to defend a claim with data and reasoning may be an important tool for successfully engaging students in the practice of argumentation. Simply providing a student with a device is not enough to ensure engagement or productivity, rather, teachers need to effectively incorporate the technology into the curriculum (Beach & O'Brien, 2015; Chou, Block, & Jesness, 2012; Deaton, Deaton, Ivankovic, & Norris, 2013). In the case of creating screencasts of scientific arguments, students need to be scaffolded through the process. It is anticipated that by blending the McNeill and Krajcik (2012) claim-evidence-reasoning (CER) framework with the science writing heuristic (Keys et al., 1999) that students will be properly scaffolded through the process of argumentation.

In addition to struggling with composing science arguments, personal experience also suggests that students struggle with documenting observational data when conducting laboratory work. For example, when describing the growth of a plant, students have difficulty conveying qualitative observations that would be considered adequate descriptors. Since one of the affordances of mobile devices is the ability to quickly capture and document events, their use can aid students in capturing qualitative data that they may otherwise have difficulty describing. No studies could be located that examined the use of technology to support the practices of data collecting in the K-12 science classroom; however, a study that involved pre-service teachers in an assignment related to forces and motion found that the teachers perceived mobile devices to be useful for data recording (Wilson, Goodman, Bradbury, & Gross, 2013). It is anticipated that by providing a mobile device to students during laboratory experiences that students will use the device to document observations and collect evidence.

Theoretical Underpinnings for the Study

This study is grounded in the theory of constructivism, a theory whose roots and relationship to science originated with John Dewey. Constructivists base their understanding of the world on observation and reflection of their experiences. Constructivism is the foundation of science inquiry, engaging the learner in making meaning through investigations. In the classroom, this often translates into a setting in which the teacher acts as a facilitator rather than as the purveyor of all knowledge, with students assimilating knowledge through activities such as explaining concepts in their own ideas (Berkeley, 2015).

Constructivism also serves as the foundation for my pedagogical beliefs. I have long been a proponent of inquiry teaching, for it has been my experience that students learn best when they are provided opportunities for exploring concepts rather than memorizing facts. As a constructivist, I structure lessons in such a way as to encourage students to develop deeper conceptual understanding of science topics through investigation, discussion, and reflection. The NGSS has resulted in a renewed focus on science education, and in doing so, has reinforced my own beliefs as they relate to the teaching of science. The ability to engage students in developing deeper conceptual understanding through technological tools, coupled with new standards that emphasize the practices that underscore the heart of science inquiry, make this a truly exciting time to be associated with science education at any level.

I approached this study much in the same way that I approach my teaching, by constructing my understanding of how students learn through triangulation of data sources such as observations, conversations with students, and performance on standards-based assessments. The underpinnings for the activities related to this study, including the structure of student assignments, my reflective analysis, and my resulting conclusions were founded upon my beliefs that the best way to teach science is through a constructivist approach.

Statement of the Problem

Little is known about how students learn with mobile devices or their impact on student learning (Sha, Looi, Chen, & Zhang, 2012). The utilization of mobile devices has the potential to positively impact science practices that occur in the K-12 classroom, but only if activities that incorporate technology are carefully integrated into the curriculum in a manner that supports science practices. Teachers are challenged to incorporate technology into the existing curriculum (Zhang et al., 2010), since the proliferation of mobile devices necessitates new pedagogy and techniques related to mobile learning (Hutchison, Beschorner, & Schmidt-Crawford, 2012).

The overarching goal of this case study was to examine the use of screencasting as a method for engaging middle school students in argumentation. A literature review revealed that although there are several studies involving the use of screencasts created by teachers for the purpose of delivering information to students, there are only a handful of studies that examine student-created screencasts, none of which involve the use of mobile technology by K-12 students in creating scientific arguments. This gap, coupled with a dearth of curriculum activities that address the three-dimensional intention of the

NGSS, mark this study as one that can have a substantial impact on how teachers can effectively incorporate argumentation into their classes.

Purpose of the Study

New national science standards, coupled with advances in technology, offer both challenges and opportunities for science educators to develop pedagogy related to improving the delivery of instruction in their classrooms. This study proposes using mobile technology as a tool for collecting digital evidence during lab work and for exposing student thinking through student-created screencasts. The central question that this study addressed is how student-created screencasts can be used to support students in argumentation. The following sub questions were used to guide the study:

1. What are the characteristics of student-collected evidence when using a mobile device during inquiry?
2. What are the characteristics of screencasts when using an app installed on a mobile device to create student arguments?
3. How do students utilize evidence collected via a mobile device to support their claims?
4. What are student and teacher perceptions of the value of using a mobile device to create science arguments?

Limitations

This study took place in a single sixth grade classroom composed of 25 learners of average ability. As such, the results of this study are not necessarily generalizable to other settings, since it is impossible to replicate the study exactly while controlling for all of the variables that impact learning. Among factors that could not be controlled were the participating teacher's pedagogical beliefs, his relationship with his students, and the intrinsic motivation the students possessed; all may have had an impact on the outcomes presented within this document. A variety of data-gathering techniques were utilized to increase this study's trustworthiness, including the use of an independent auditor, two raters of student work, and triangulation of results through multiple data sources.

Summary

Students must be supported in their learning if they are to grow into independent thinkers capable of supporting their thoughts with evidence and scientific reasoning. The passage of the NGSS has placed renewed emphasis on the science practices that support inquiry in the K-12 classroom. Among these practices is argumentation, a practice based on Toulmin's argumentation model. Argumentation, which can take both oral and written forms, often requires scaffolding by the teacher for successful implementation. The use of mobile devices may be a valuable tool capable of assisting students in developing science arguments; however, little is known about how students learn with mobile devices (Sha et al., 2012). One possible tool for engaging students in the argumentation process is that of screencasting, in which the user interacts with the device in a manner similar to that of an interactive whiteboard. Screencasts have the added advantage of being able to capture student thinking.

This study proposes using mobile technology as a tool for exposing student thinking through student-created screencasts. Chapters two through five and an appendix follow. Chapter two presents an overview of inquiry, following by a discussion of the practice of argumentation. A discussion of the argumentation framework used in this study and the rationale for scaffolding the practice of argumentation are also discussed.

This is followed by a description of screencasting and of the screencasting app that was used for this study. Chapter three consists of a detailed description of the various data-collecting tools and data analysis methods that were employed during this study. Chapter four presents the results of the study, using several data sources that include photographs, screen captures of student-created arguments, and quotations from participants. A discussion of the results and recommendations for further research are addressed in Chapter five.

CHAPTER 2: REVIEW OF THE LITERATURE

Science education is in a state of upheaval; the NGSS place emphasis on the scientific practice of argumentation, a practice few teachers incorporate into their classroom (Sampson & Blanchard, 2012; Sampson & Schleigh, 2013). In order to develop an understanding of the practice of argumentation and its role in inquiry, this literature review provides a brief history of inquiry and defines the various forms of inquiry as they occur in the science classroom. A brief discussion concerning the role of scaffolding during inquiry and assessing inquiry is included, followed by an overview of the scientific practice of argumentation, which includes scientific talk and scientific writing. The role of technology in supporting inquiry and the scientific practice of argumentation is also included before addressing how a relatively new technology, that of screencasting, can be utilized as a tool to develop evidence-based claims in the laboratory setting.

A Brief History of Inquiry

"Learning science is something students do, not something that is done to them" (National Research Council, 1996, p. 2). Studies indicate that conceptual understanding of science topics is best developed through active engagement in which the learner is actively thinking about the investigative process (Kahle, Meece, & Scantlebury, 2000; Minner, Levy, & Century, 2010). A research synthesis of 138 studies involving inquiry from the years 1984 to 2002 identified a "positive trend favoring inquiry-based instructional practices, particularly instruction that emphasizes student thinking and drawing conclusions from data" (Minner et al., 2010, p. 474). Other studies have found that inquiry can lead to an increase in reading and math scores (Nagle, Hariani, & Siegel, 2005) and can help to close the achievement gap between Spanish and English speaking students (Moreno & Tharp, 2006), as is exemplified by a study of the Detroit Public Schools that revealed significant increases in test scores among low achievers who participated in inquiry-based and technology-infused curriculum units (Marx et al., 2004).

Historically, inquiry's roots can be traced back to John Dewey, who advocated that students be actively engaged in their learning (Barrow, 2006). Dewey outlined the process of scientific inquiry as "presentation of the problem, formation of a hypothesis, collecting data during the experiment, and formulation of a conclusion" (Barrow, 2006, p. 266). Dewey's definition, along with policy documents such as the *National Science Education Standards* (National Research Council, 1996), have extolled a plethora of methods for defining inquiry which has led to confusion among educators (Barrow, 2006). Various viewpoints concerning inquiry led to the subsequent publication of *Inquiry and the National Science Education Standards* by the National Research Council (2000) in which five specific features of inquiry were identified. They include: (a) using questions to engage students, (b) involving students in collecting evidence, (c) using evidence to develop explanations, (d) evaluating explanations, and (e) communicating findings (National Research Council, 2000).

These defining features of inquiry help people to explain the natural world through the scientific process of argumentation. Argumentation is grounded in social constructivism (Sampson et al., 2010), a learning theory posited on the grounds that learning is an active process in which the learner creates knowledge via social interaction (Duffy & Cunningham, 1996). In science education, constructivism typically translates into an inquiry-based approach in which the learner is engaged in making meaning through investigations. In the authentic science world, scientists often work in teams to collaboratively construct knowledge and solve problems. “Science is fundamentally a social enterprise, and scientific knowledge advances through collaboration and in the context of a social system with well-developed norms” (National Research Council, 2012, p. 27).

Defining Inquiry

Reaching a consensus as to what constitutes inquiry and how to employ inquiry methods to promote student understanding of science content and science concepts remains highly contentious (Martin-Hauser, 2002; Minner et al., 2010), even among teachers of science (Banchi & Bell, 2008). Minner et al. (2010) developed a framework for describing inquiry-based instruction based on a literature review of information related to inquiry instruction over the last 30 years. Their framework consists of three components: (a) science content, (b) student engagement with science content, and (c) the responsibility placed on students to learn the content via questioning, designing, collecting data, creating conclusions, and communicating. The researchers further classified studies as inquiry-based if they contained science content, exposed students to scientific phenomena, involved students in an investigation, and incorporated active thinking or learning (Minner et al., 2010).

Banchi and Bell (2008) categorize inquiry along a four-level continuum that represents the level of support students receive from the teacher. Inquiry categories include confirmation, structured, guided, and open. During confirmation inquiry students are provided with both the question to be investigated and the procedure; the results are known in advance. This type of inquiry, often referred to as verification or cookbook labs (Barrow, 2006), does little to engage students in those science practices identified by the National Research Council (2000). A dependence on verification labs can be traced to science textbooks and their resources that fail to promote a more unstructured inquiry in which students can change variables or plan experiments (Chinn & Malhotra, 2002). In the second level of inquiry, structured inquiry, students receive the question and procedure but must create their own explanation using the data they collect (Banchi & Bell, 2008). During the third level of inquiry, guided inquiry, students are provided with the question to be explored but must design their own procedure. According to Banchi and Bell (2008), students need prior practice with planning experiments and recording data in order to be successful with guided inquiry. The last level of inquiry, open inquiry, is the most complex, as it most closely approximates the actual work of scientists (Banchi & Bell, 2008; Martin-Hauser, 2002; Zion & Mendelovici, 2012). In contrast to Banchi and Bell's (2008) categorization of inquiry levels, Minner et al. (2010) purport that inquiry is composed of three specific activities that include: (a) those activities that scientists are engaged in, such as conducting experiments, (b) the thinking process that students employ when learning science, and (c) the pedagogical approach teachers use when incorporating inquiry into their instruction.

Inquiry is in direct conflict with the traditional method of delivering science content information via a didactic approach (Friesen & Scott, 2013). Inquiry teaching involves a constructivist methodology in which students create their own learning with the teacher acting as facilitator (Zion & Slezak, 2005). Some teachers struggle with insecurity regarding classroom management in this environment (Johnson, Kahle, & Fargo, 2006; Welch, Klopfer, Aikenhead, & Robinson, 1981). Additionally, many teachers do not fully understand inquiry or the way scientists work, often relying on recalling of facts by students as a methodology (Fogelman, McNeill, & Krajcik, 2011), which is perceived as being easier to teach (Eltinge & Roberts, 1993; Welch et al., 1981). Studies have found that teachers who don't have a science background lack the ability to design activities that encompass higher levels of inquiry (Banchi & Bell, 2008; Coburn, 2000; Johnson et al., 2006; Trumbell, Scarano, & Bonney, 2006), which often results in an emphasis on verification labs (Waight & Khalick, 2010). Further, a dependence on textbook materials that emphasize content over process (Eltinge & Roberts, 1993) results in classes in which science is delivered as a body of knowledge, rather than a discipline (Barrow, 2006; Coburn, 2000; Eltinge & Roberts, 1993; Moreno & Tharp, 2006). Adding to the difficulty in understanding how to implement inquiry is the pressure many teachers feel to cover content required by No Child Left Behind (NCLB) mandated tests (Cavanagh, 2011; Hendrickson, 2006), particularly if student performance is linked to state tests that focus on facts (Neill & Medina, 1989). Teachers often sacrifice the time it takes to engage students in inquiry activities out of fear that students will be unable to successfully master tested concepts (Nagle et al., 2005; Rop, 2003; van Kampen, Banahan, Kelly, McLoughlin, & O'Leary, 2004).

The Role of Scaffolding

Smith and Ragan (2005) distinguish between expert and novice problem solvers; unlike novices, expert problem solvers possess domain-specific knowledge that is organized in their memory, allowing them to depend on schema-driven strategies. Since novices have no such pre-existing schema, problem solving results in a heavy cognitive load that can result in frustration and confusion (Kirschner, Sweller, & Clark, 2006). Students require assistance throughout the inquiry process because they are unable to develop conceptual understanding on their own (Olson, 2009). This is due to a lack of adequate background knowledge, the inability to manage extended experiments, and unfamiliarity with inquiry-dependent skills such as developing investigable questions, generating hypothesis, designing experiments, and collecting and analyzing data (de Jong & Joolingen, 1998; Kirschner et al., 2006; Thomas, 2000). The skills necessary for conducting inquiry place a large cognitive load on learners. This additional cognitive stress can be reduced through effective scaffolding (Hmelo-Silver, Duncan, & Chinn, 2007).

Scaffolding assists learners in mastering tasks within their zone of proximal development (Quintana et al., 2004), tasks that Vygotsky defines as those that can only be accomplished with the guidance of a more knowledgeable person such as a peer or teacher (Belland, Glazewski, & Richardson, 2008; Quintana et al., 2004). Scaffolding provides the assistance necessary to ensure learners are successful at accomplishing a difficult task (Quintana et al., 2004). Effective scaffolding requires that teachers know their students well enough to identify zones of proximal development to ensure all learners are challenged at an appropriate level (Brown & Campion, 1995); lower ability students and those with less prior knowledge will need more explicit scaffolds while accomplished students will need less (Belland et al., 2008; Cakir, 2011). Classroom supports that reduce cognitive load include breaking down tasks associated with inquiry into manageable pieces to reduce complexity (de Jong & Joolingen, 1998; Thomas, 2000), providing expert guidance by clarifying the scientific process, and eliminating tasks less central to the learning objective (Quintana, et al., 2004). For example, using a graphing program to visualize trends in data rather than taking the time to graph data by hand reduces cognitive load and is also a better utilization of class time. Simulations, concept maps, and worksheets can also be used to scaffold the learning process (Belland et al., 2008). Other examples of scaffolding include just-in-time-direct instruction such as mini-lectures that are given in response to an identified need (Edelson, 2001).

Assessing Inquiry

There has been a resurgence of attention placed on inquiry in the science classroom (Frieson & Scott, 2013), partially in response to concern over ensuring that the United States remains competitive, and partially as a result of confusion over how inquiry should be occurring in the classroom (National Research Council, 2012). The renewed interest in inquiry will demand assessments capable of evaluating student learning. The National Research Council (2000) defines assessment as understanding what students can do with what they know, making it crucial to develop assessments that parallel the learning that should be happening in inquiry-driven science classrooms (Harlan, 2013). The National Research Council (2000) does not recommend multiple-choice tests that focus on recall, although teachers often rely on such tests since they are easy to score and replicate state tests (National Research Council, 2000). Additionally, such tests do not adequately capture what is occurring in an inquiry environment (Stoddart, Abrams, Gasper, & Canaday, 2000). Rather, conceptual understanding is better measured through the use of diagrams, charts, or questions that require reflection (National Research

Council, 2000) or through open-ended assessments can include items such as performance tasks, student notebooks, open-ended questions, and portfolios (Kentucky Department of Education, 1996).

The *Framework for K-12 Science Education* (National Research Council, 2012) establishes learning progressions that develop student understanding over time, with the NGSS defining expected concepts and practices that students should know and be engaged in during specific grade bands (Lead States, 2013a; Pellegrino, 2013). Assessments need to reflect "evidence of students' ability to apply the practices and their understanding of cross-cutting concepts in the contexts of problems that also require them to draw on their understanding of specific disciplinary ideas" (Pellegrino, 2013, p. 321). Student understanding of science and the science practices that support inquiry is best accomplished via performance tasks in which the student creates claims supported by evidence (Pellegrino, 2013). As of yet, there is no comprehensive set of performance tasks matched to the NGSS performance expectations, making it crucial for the classroom teacher to develop what Harlan (2013) calls assessment literacy. Creating performance assessments that reveal the sophistication of student reasoning is challenging (Duncan & Rivet, 2013). When creating a performance assessment, the National Research Council (2014) recommends the use of a task-design approach. Students are given a specific task to perform that measures their performance of practices in the context of science content. In addition, the task should be written in such as way so as to locate the student's ability along a continuum that demonstrates a progressively sophisticated understanding (National Research Council, 2014). This can be accomplished through the use of rubrics or checklists that specify criteria for successful performance (National Research Council, 2000). These evaluation tools can also be utilized for self-assessment and peer assessment (National Research Council, 2000).

Argumentation

The *Framework for K-12 Science Education* states, “The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories” (National Research Council, 2012, p. 52). In order to attain goals set forth by the NGSS, science education must do a better job at paralleling the type of work performed by scientists. This will require a shift from a focus on content to a focus on developing conceptual understanding (Hutner & Sampson, 2015). Science-specific instructional practices based on what we know about how students learn science concepts will require curriculum that engages students in thoughtful discourse (Hutner & Sampson, 2015). Teachers also need to make thinking visible in order to address and correct misconceptions about the natural world (Hutner & Sampson, 2015). Developing conceptual understanding is best accomplished by providing students opportunities for reflection, discussion, discourse, and argumentation (Bybee, 2013).

The *Framework for K-12 Science Education* identifies eight science practices “to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice” (National Research Council, 2012, p. 30). These practices include constructing explanations and engaging in argument from evidence. Argumentation refers to collaboration through critique, and is reminiscent of how scientists practice (Cavagnetto, 2010). Differentiating between the practice of creating explanations and the practice of argumentation is often confusing, in part because "arguments are essential to the process of justifying the validity of any explanation" (Osborne & Patterson, 2010, p. 629). Adding to this confusion is the fact that several researchers fuse the two practices, treating them as a single practice (Osborne & Patterson, 2010). There are notable differences between constructing explanations and argumentation. Explanations act to clarify a phenomenon and are often an answer to the question 'Why?' (Osborne & Patterson, 2010). In most classrooms, explanations are causal, answering questions such as why things fall, why matter is conserved, or how photosynthesis occurs (Salmon, 1998). Explanations should include a claim that "relates how a variable or variables relate to another variable or set of variables" (Lead States, 2013b, p. 60). Explanations attempt to explain a phenomenon based on facts; the phenomenon itself is one that has been accepted by science (Obsorne & Patterson, 2010). Despite the importance of constructing explanations, a study by Ruiz-Primo, Li, Tsai, and Schneider (2010) found that in an analysis of eight middle school classrooms across five states, "constructing explanations was not widely implanted in the classrooms despite its significance in the context of inquiry-based science instruction" (Ruiz-Primo et al., 2010, p. 583). According to the *Framework for K-12 Science Education*, middle school students are expected to construct explanations "supported by multiple sources of evidence consistent with scientific ideas, principles, and theories (Lead States, 2013b, p. 61).

In comparison, argumentation "is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community" (Lead States, 2013b, p. 63). While an explanation attempts to elucidate the reason behind a specific phenomenon, an argument "examines the question of whether the explanation is valid" (Osborne &

Patterson, 2010, p. 629). Argumentation in science is different from argument in everyday language (Sampson & Schleigh, 2013); argumentation in science is a knowledge-building process (Goss & Brodsky, 2014). Sampson and Schleigh (2013) define a scientific argument as “an attempt to validate or refute a claim on the basis of reasons” (Sampson & Schleigh, 2013, p. ix). A science argument consists of a claim that needs to be justified, is used to persuade others (Osborne & Patterson, 2010), and typically answers the question ‘How do you know?’ (Mayes, n.d.). Arguments are supported with both evidence and scientific reasoning; the *Framework for K-12 Science Education* states that students in grades 6-8 should be able to “construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation” (Lead States, 2013b, p. 63).

A scientific argument can be considered both process and product; when working in groups, students engage in the process of argumentation through the creation of an argument, whereas construction of a written argument results in a product (McNeill & Gonzalez-Howard, n.d.). Argumentation is critical to understanding science because the process develops communication and reasoning skills, supports student understanding of scientific practice, and fosters science literacy (Jimenez-Aleixandre & Erduran, 2007; McNeill & Krajcik, 2012). In a study of 54 articles that examined the effectiveness of argumentation, Cavagnetto (2010) concluded that argumentation that occurs within the context of student investigations of science principles appears to be optimal for improving science literacy.

A framework developed by McNeill and Krajick (2012) for constructing arguments can be utilized to develop performance assessments in which students are expected to explain phenomena (McNeill & Krajcik, 2012). The incorporation of argumentation into the performance task assists students in creating evidence-based explanations and in critiquing "alternative explanations as part of a knowledge-building community with agreed-upon epistemological norms akin to those used by scientists" (Duncan & Rivet, 2013, p. 397). The shift to assessing students via evidence-centered performance tasks will necessitate new strategies in order to ensure that classroom discourse is utilized as a methodology for exposing student thinking (National Research Council, 2014).

Scaffolding the Argumentation Process

The incorporation of argumentation is not a typical practice of most science teachers (Sampson & Blanchard, 2012), although it has been more than fifteen years since the development of a heuristic designed to scaffold science arguments (Keys et al., 1999). The heuristic, which is composed of a set of teacher and student prompts, is a guideline for laboratory activities and is designed to promote conceptual understanding via talk and writing (Wallace, 2004). The heuristic requires students to justify their claims based on evidence and scientific principles. Students are provided with the following prompts to guide their writing:

- Beginning ideas: What are my questions?
- Tests: What did I do?
- Observations: What did I see?
- Claims: What can I claim?
- Evidence: How do I know? Why am I making these claims?
- Reading: How do my ideas compare with other ideas?

- Reflection: How have my ideas changed?

Addus, Gunel, and Hand (2007) found that students who followed the heuristic's prescribed format exhibited a greater understanding of science inquiry and performed better than students who crafted a traditional lab report. A subsequent study found that ninth grade students who composed reports using the science writing heuristic performed better on conceptual questions than peers who had written conventional lab reports (Hohenshell & Hand, 2006). Studies have found that in order for students to successfully follow the heuristic, the teacher needs to carefully scaffold the process (Hand, Wallace, & Yang, 2004). Keys (1999) reported that students who are unsupported in their writing generally write a list of observations instead interpreting data. More recently, an analysis of 72 notebooks from middle school students revealed that only 18% provided explanations that included the three components of claim, evidence, and reasoning (Ruiz-Primo et al., 2010).

Similarly, students must be scaffolded through classroom discussion when participating in exploratory talks that develop scientific reasoning (Pendrill et al., 2014). Even when supported through the process, many students do not make high-level explanations. A study by Laru, Jarvela, and Clariana (2012) found that 58% of middle school students made low-level knowledge claims, consisting of observations rather than higher-level theoretical explanations or inferences, during a field trip where they received scaffolding prompts via mobile phones. In a related study, Ruiz-Primo et al. (2010) found that middle school students involved in inquiry activities did not support their claims with data or that they simply provided data without reasoning. Anecdotal evidence and conversations with colleagues have led me to believe that students frequently omit referencing their data when writing a conclusion to a lab report, an observation supported by McNeill and Krajcik (2012) who note that "students often do not make use of evidence they collect" (McNeill & Krajcik, 2012, p. 9). Making sense of information is challenging (Quintana et al., 2004) since many students lack practice with gathering and synthesizing evidence or do not connect evidence to their conclusions (Belland et al., 2008).

These observations are not surprising, given that middle school students struggle with the process of argumentation (Jonassen & Kim, 2010). Arguments are constructed when students make conclusions using inferences from evidence (Brodsky, Falk, & Beals, 2013). In order to fully engage in the argumentation process, students need to understand the difference between evidence, which consists of observations either gathered using the senses or using tools, versus inferences, or explanations formed from evidence (Rau, 2009). An observation can be defined as a "descriptive statement about natural phenomena that is directly accessible to the senses, whereas inferences "are statements about phenomena that are not directly accessible to the senses" (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002, p. 500). Inferences are made based on observations and can be thought of as predictions about "what is happening, what is going to happen, or what has just happened" (Grossman, 2013). Scientists use both observations and inferences when constructing explanations (Hanuscin & Rogers, 2008).

Argumentation Frameworks

There has been a considerable interest among researchers who have embraced the idea that argumentation is a core scientific practice (Kuhn, 2010). Among the more notable recent contributions has been the development of the Claim, Evidence and

Reasoning (CER) Framework by Krajcik and McNeill (2009). The CER Framework "helps students see how to justify claims in science" (McNeill & Krajcik, 2012, p. 21).

CER Framework

Krajcik and McNeill (2009) developed a framework for argumentation in which students are scaffolded through the argumentation process (Figure 2.1). Since the framework was developed for K-12 classrooms the researchers chose to substitute the words scientific explanation for the word argument (Krajcik & McNeill, 2009). The framework developed by Krajick and McNeill (2009) is based on Toulmin's (1958) model of argumentation, which specifies how reasoning from data occurs to support a claim (Driver et al., 1998). Science educators have adopted Toulmin's model as a template for organizing argumentation in the classroom (Driver et al., 1998). Toulmin's model consists of four essential components: (a) data, or facts that support a claim, (b) a claim, or a conclusion based on facts, (c) warrants, or principles that connect the data to the claim, and (d) backing, or commonly agreed upon assumptions that act to justify a warrant (Driver et al., 1998). Krajcik and McNeill (2009) modified Toulmin's model, condensing it to three major components: (a) a claim that answers a question, (b) evidence, in the form of observations, reading, or archived data, that support the claim, and (c) the reasoning or justification that links the claim to the evidence through scientific principles. A fourth element of the framework, rebuttal, provides alternative explanations and counter evidence. This fourth element is introduced once students are proficient at creating scientific explanations consisting of a claim, evidence, and reasoning (Krajcik & McNeill, 2009). Krajcik and McNeill (2009) refer to their model, which contains all the components of an argument, as a scientific explanation. Their use of the term scientific explanation in lieu of the term argumentation contributes to the confusion between the practices of scientific explanation and argumentation (Osborne & Patterson, 2010). Osborne and Patterson (2010) encourage teachers to use the term argument with their students, rather than scientific explanation. Accordingly, this study will use the term argumentation to refer to the claims-making process in which a claim is supported by evidence and explained using reasoning.

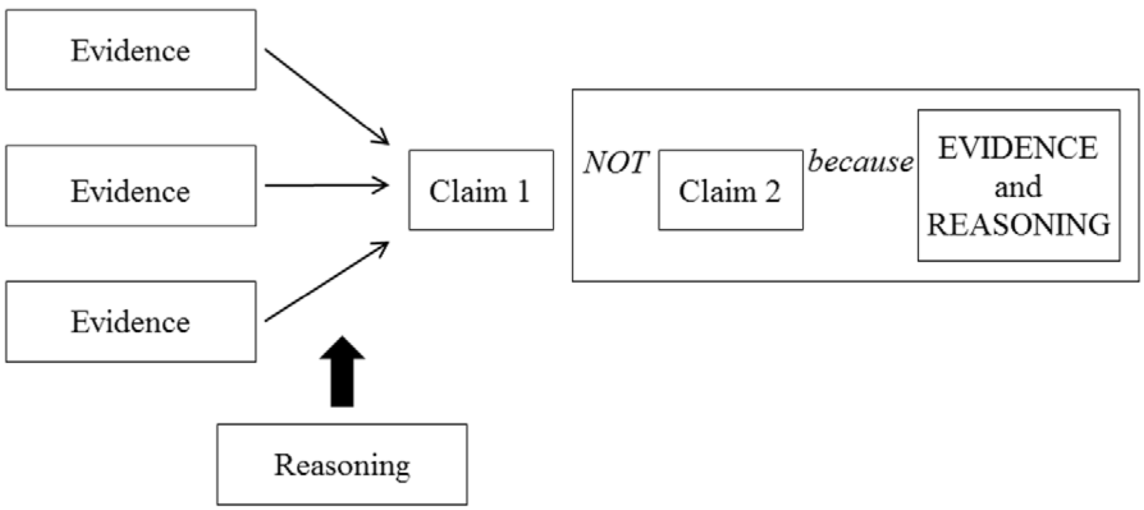


Figure 2.1. CER Framework (Krajcik & McNeill, 2009)

Students are expected to apply the CER Framework to learning tasks that "include the use of data and scientific principles" (McNeill & Krajcik, 2012, p. 54). McNeill and Krajcik (2012) encourage teachers to identify those places in the curriculum where incorporating scientific explanations logically fit. They recommend that, depending on the individual student or the grade level involved, teachers consider limiting the openness of the question being investigated and the amount of data generated, with increasing complexity over time. McNeill and Krajcik (2012) recommend several different teaching strategies when implementing the framework. These strategies include: (a) discuss the framework, (b) connect to everyday examples, (c) provide a rationale, (d) connect to other content areas, (e) model and critique examples, (f) provide students with feedback, (g) have students engage in peer review, and (h) debate student examples. To date, two books, one aimed at K-5 teachers and the other at middle school teachers, have been developed using the CER Framework.

ADI Instructional Model

In comparison, Sampson and Gleim (2009) developed an instructional model called Argument-Driven Inquiry (ADI). ADI focuses on the development of science specific literacy skills through argumentation that occur as part of guided inquiry laboratory activities to “give students an opportunity to learn science by doing science” (Argument-Driven Inquiry, 2014). The argumentation process depicted by the ADI Instructional Model differs slightly from the CER Framework. Authors of the ADI Instructional Model use the term justification rather than reasoning. In addition, rebuttals are not part of the model; rather, there is a greater focus afforded to the actual writing process.

The ADI Instructional Model was developed with the goal of engaging students in the science practices as defined by the NGSS (Sampson et al., 2015). ADI, which consists of eight stages, involves students in creating oral and written arguments (see Figure 2.2). Unlike the CER Framework which focuses primarily on the science practice of argumentation, the ADI Instructional Model was developed to address all the science practices outlined in the NGSS through the use of school science laboratories (Sampson et al., 2015). Another notable difference is that the research conducted for the ADI Instructional Model has been conducted at the middle school, high school, and college level, resulting in several practical lab books aimed at both middle school and high school instructors. The ADI Instructional Model recommends that the teacher become a facilitator throughout the process, allowing students to "learn from their mistakes with guidance from teachers" (Sampson et al., 2015, p 14).

Stage 1	• Identification of the task and the guiding question
Stage 2	• Design a method and collect data
Stage 3	• Analyze data and develop a tentative argument
Stage 4	• Analyze data and develop a tentative argument
Stage 5	• Explicit and reflective discussion
Stage 6	• Write an investigative report
Stage 7	• Double --blind peer review
Stage 8	• Revise and submit report

Figure 2.2. The stages of the ADI Instructional Model (Enderle, Grooms, Campbell, & Bicket, 2013)

Stages one through five of the ADI Instructional Model are group-oriented in structure. During stage one, students are provided with background information about the science concept being investigated, key terms, the guiding question, and materials available for developing procedures aimed toward answering the guiding question. In the second stage, student groups consisting of three to four students develop procedures for collecting data; stage 3 involves data analysis and creation of a scientific argument. The ADI Instructional Model uses the term justification to refer to the application of science concepts and theories that explain how student-collected evidence supports a claim. The authors of the ADI Instructional Model recommend having student groups write their claim, evidence, and justification on a large whiteboard or poster board, with data presented in graphical form (Enderle et al., 2013). An argumentation session occurs next, with individual group members defending their argument to peers that circulate the classroom; peers are expected to assess and critique the arguments. Groups are then given an opportunity to reconvene and make modifications to their argument based on input gleaned from the argumentation session. A whole class discussion is also led at this time to allow teachers to connect the science concepts to the investigation (Enderle et al., 2013).

During stages six through eight, each student writes a laboratory report, which is subjected to a double-blind peer review and revised prior to submission. Students are expected to address the guiding question and its importance, to describe the methodology used to collect and analyze data, and to include the group's scientific argument (Enderle et al., 2013).

Assessing Argumentation

Argumentation is an important skill (Lu & Zhang, 2013), yet assessing argumentation can be challenging (Knight & Gyrmonpré, 2013). Knight and Grymonpré (2013) demonstrate a continuum of student abilities that illustrates student mastery of the argumentation process (Figure 2.3). At the lowest level of the pathway, a student fails to create an argument by either omitting a claim or failing to justify a claim. At the intermediate level, students justify their claim using evidence that is either conceptually inaccurate or irrelevant; this is an important distinction because irrelevant data weakens an argument (Barber, Pearson, & McNeill, n.d.). Students who demonstrate mastery of the practice of argumentation do so by supporting their claim using only appropriate justification.

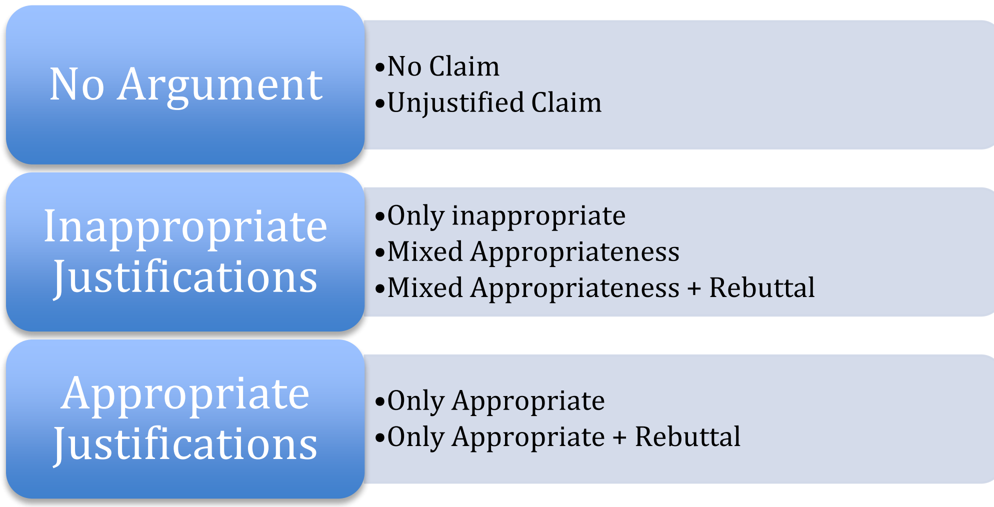


Figure 2.3. Pathway to Mastery: Assessing the Quality of Students' Arguments (From Knight & Grymonpré, 2013)

One method of assessing student work is through the use of a rubric such as the base rubric developed by McNeill and Krajcik (2012) for evaluating student claims, evidence, and reasoning (see Figure 2.4). Well-developed arguments contain accurate and complete claims, appropriate and sufficient data, and appropriate and sufficient reasoning that supports the claim. The last aspect of arguments, rebuttals, is made up of alternative explanations that may explain a phenomenon (McNeill & Krajcik, 2012).

Score	Claim	Evidence	Reasoning	Rebuttal
0	Does not make a claim, or makes an inaccurate claim	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support the claim)	Does not provide reasoning, or only provides inappropriate reasoning	Does not recognize that an alternative explanation exists and does not provide a rebuttal or make an inaccurate rebuttal
1	Makes an accurate but incomplete claim	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence	Provides reasoning that connects the evidence to the claim. May include some scientific principles or justifications for why the evidence supports the claim, but not sufficiently	Recognizes alternative explanations and provides appropriate but insufficient counter evidence and reasoning in making a rebuttal
2	Makes and accurate and complete claim	Provides appropriate and sufficient evidence to support claim	Provides reasoning that connects the evidence to the claim. Includes appropriate and sufficient scientific principles to explain why the evidence supports the claim	Recognizes alternative explanations and provides appropriate and sufficient counter evidence and reasoning when making rebuttals

Figure 2.4. Base Rubric for Scientific Explanations (McNeill & Krajcik, 2012)

The authors of the ADI Instructional Model include downloadable instructional materials on their website (www.argumentdriveninquiry.com). Among these is an ADI investigation report peer review guide that is used by both peers and instructor to evaluate student investigative reports. Peer evaluation has proven effective; a study of 131 middle school students revealed that the quality of written arguments improved when assessing peers' arguments using a teacher-provided rubric (Lu & Zhang, 2013). The scoring used by the authors of the ADI Instructional Model, shown in Figure 2.5, is similar to that of the McNeill and Krajcik (2012) base rubric, with values of zero, one, and two being used to indicate the competency level for various components of the report. These components include the introduction and guiding question, the methods, the argument, and the mechanics.

Section 3: The Argument	Reviewer Rating			Instructor Score
1. Did the author provide a ***clear and complete claim*** that answers the guiding question?	☐ No	☐ Partially	☐ Yes	0 1 2
2. Did the author use **evidence** to support his or her claim? Evidence is an analysis of data and an explanation of what the analysis means.	☐ No	☐ Partially	☐ Yes	0 1 2
3. Did the author ***present the evidence*** in an appropriate manner by ▪ including a correctly formatted and labeled graph (or table);	☐ No	☐ Partially	☐ Yes	0 1 2
▪ using correct metric units (e.g., m/s, g, ml); and	☐ No	☐ Partially	☐ Yes	0 1 2
▪ referencing the graph or table in the body of the text?	☐ No	☐ Partially	☐ Yes	0 1 2
4. Does the ***evidence support the author's claim***?	☐ No	☐ Partially	☐ Yes	0 1 2
5. Did the author use a scientific concept to ***justify the evidence***? The justification of the evidence explains why the evidence matters.	☐ No	☐ Partially	☐ Yes	0 1 2
6. Is the ***justification of the evidence*** acceptable?	☐ No	☐ Partially	☐ Yes	0 1 2
7. Did the author **use scientific terms correctly** (e.g., *hypothesis* vs. *prediction, data* vs. *evidence*) and **reference the evidence in an appropriate manner** (e.g., *supports* or *suggests* vs. *proves*)?	☐ No	☐ Partially	☐ Yes	0 1 2
Reviewers: If your group made any "No" or "Partially" marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.			

Figure 2.5. Middle School Version of Peer Review Guide for the Argumentative Section of ADI Investigation (Argument-Driven Inquiry, 2014)

Using the framework developed by McNeill and Krajick (2012), Knight and Grymonpré (2013) developed a checklist to assist in assessing both written and oral arguments (Figure 2.6). The checklist assists teachers to "quickly and accurately decide where their students' arguments fall" (Knight & Grymonpré, 2013, p. 54). Their checklist, which can be utilized for a peer review process, helps both students and teacher look for the presence or absence of a claim, evaluate the appropriate justification (evidence and reasoning) of the claim, and critique the justifications for a rebuttal (Knight & Grymonpré, 2013).

Checklist to Assess the Quality of Arguments

- ☐ Student (s) provide a claim

- ☐ Student (s) provide inappropriate justification (s)
  - ☐ Inaccurate/Implausible, or
  - ☐ Irrelevant to the claim, or
  - ☐ Does not support the claim

- ☐ Student (s) provide appropriate justification (s)
  - ☐ Accurate/Plausible, or
  - ☐ Relevant to the claim, or
  - ☐ Supports the claim

- ☐ Student (s) provided a rebuttal
  - ☐ Critiqued the accuracy of the justification (s), or
  - ☐ Critiqued the relevancy of the justification (s), or
  - ☐ Critiqued whether the justification (s) support the claim

Figure 2.6. Checklist to Assess Quality of Arguments (Knight & Grymonpré, 2013)

Using Technology to Promote Science Understanding

Technology is viewed as a tool capable of surmounting some of the issues related to the integration and support of inquiry in the classroom (Kim, Hannafin, & Bryan, 2007). In a study involving K-12 STEM teachers, Hu and Garimella (2014) found that iPads both stimulated and sustained learner interest and offered participants opportunities for collaborative discussion and interaction, which supported the practices of argumentation and collaborative science inquiry. Very little is known about how students learn with mobile devices or their impact on student learning (Sha et al., 2012). Some studies indicated that K-12 science students who were taught with mobile applications learn more than their traditionally taught peers. A study by Huang, Lin, and Cheng (2010) found that students who were equipped with personal digital assistants that contained information about plants stimulated learning interest and resulted in a gain in knowledge as measured by pre and posttests. A similar activity involving personal digital assistants in which elementary students answered questions related to cultural studies found that the use of prompts resulted in higher knowledge gains than students who were not provided with prompts on the mobile device (Hwang & Chang, 2011).

Few studies have examined how mobile devices can support the argumentation process. Laru et al. (2012) investigated the use of scaffolds designed to promote collaborative inquiry within an authentic context. The study involved 22 12-year old students who participated in a one-day field trip to a nature center for the purpose of exploring how teams of students construct arguments when provided with procedural support and scaffolding for claim, ground, and warrant production. This case study attempted to answer several research questions that included determining differences between low and top performing groups of students when engaged in collaborative inquiry, comparing the quality of claims between low and top performing student groups, and measuring knowledge growth of biology concepts between low and top performing student groups. The researchers found that high performing groups made more knowledge claims than low performing groups (Laru et al., 2012).

Researchers cannot assume that activities that occur in an authentic setting will result in student learning. For example, Dunleavy, Dede, and Mitchell (2009) found that students who rushed through a highly engaging augmented reality scenario in a competitive manner failed to read critical text-based information and at times were unaware of their physical surroundings, leading the researchers to conclude that students require opportunities to discuss their findings. A study by Lai et al. (2007) revealed similar findings; researchers found that students immersed themselves in the act of taking photographs with mobile devices, but that they tended to be disinterested in their immediate physical surroundings. Likewise, Laru et al. (2012) concluded that, based on the data for elicitation and quick consensus building, students may have been more focused on completing the activity than in participating in the inquiry process.

Mobile Devices

Although few studies could be located that address the utilization of mobile devices in the laboratory setting, tablets can be employed to document lab set-ups, capture an image for importing into an electronic notebook, draw sketches, and record data (Hesser & Schwartz, 2013). The use of drawing tools can lend insight into student thinking; individual images can be compiled to construct a video that, along with narration, can create a product that demonstrates student understanding of complex phenomenon (Lehtinen & Viiri, 2014). Within the field setting, mobile devices can be used to collect visual data, making the devices pivotal to earth and environmental science studies (Wallace & Witus, 2013), while apps such as Leaf Snap and Project NOAH can aid in biological and ecological studies (Merrill, 2012). In a study of a high school physics class that utilized iPads, researchers found that

> By facilitating data collection, analysis, and collaboration, the iPads allowed students to draw their own conclusions based on evidence, rather than relying on the book or the teacher to provide solutions. The shift of authority from the teacher and textbook to evidence was most apparent during labs (Van Dusen & Otero, 2012, p. 411).

Simply providing a student with a device is not enough to ensure engagement or productivity, rather, teachers need to effectively incorporate the technology into the curriculum (Beach & O’Brien, 2015; Chou et al., 2012; Deaton et al., 2013). Mobile learning tools need to be used in a purposeful manner (Soto, 2014). Further, when integrating mobile devices into the curriculum, the device needs to be used in a deliberate manner with the chosen apps used to meet specific learning objectives (Pepperdine University, 2010).

Studies that utilize technology to support inquiry typically involve a scaffolding element. For example, a study by Laru et al. (2012) compared the quality of knowledge message claims between low and top performing student groups. Student groups, each of which was outfitted with a mobile phone and a lapel microphone recorder, were tasked with creating claims based on ill-structured problems presented to them by a fictional scientist. A prototype peer-to-peer messaging application called *Flyer*, which utilized a mobile encounter network (MEN), allowed participants to connect to each other without a network. Students received Flyers that scaffolded the claims-making process via sentence starters, edited the Flyers, and used the MEN to send Flyers to peers. Additional scaffolding was provided by a nature guide and by tutors who asked questions throughout the activity to prompt knowledge claim making.

Student-Created Content

It has been argued that user-generated content, in which the student generates content rather than the teacher, is pivotal to fully engaging today's students (Dyson, 2012); 'prosumers' who act as both producers and consumers of content (Mundy, Stephens, & Dykes, 2010). Hoban et al. (2013) assert that digital technologies can provide students the opportunity to create their own digital content to explain science concepts. These technologies include: (a) podcasts, short audio recordings that explain a concept; (b) digital stories, or narrated slide shows that consist of static images; (c) animations, which are useful for showing changes at microscopic levels; and (d) video, which combines images and narration.

This shift has profound implications for science education by changing teaching paradigms from teacher-delivered content to student-generated content in which students are actively engaged in a learner-centric environment that requires them to be producers of knowledge (Dyson, 2012). Pena (2011) found that state science assessment scores were higher among middle school students who had created podcasts, screencasts, and vodcasts, compared to students who had not created digital media products. Further, the act of organizing information in order to communicate effectively encourages critical thinking and problem solving (Deaton et al., 2013), perhaps because students are encouraged to think deeply about their topic prior to creating their digital media product (Sadik, 2008). A study involving middle school students found that storytelling through video resulted in products where most students used narration rather than text to convey their connection to a literature topic. The author concluded “students were encouraged to think more deeply about the meaning of the topic or story and personalize their experience and also clarify what they knew about the topic before and during the process of developing and communicating their stories” (Sadik, 2008, p. 502).

The affordances of mobile devices, which include portability, connectivity, affordability, and the ability to record photographs, sound, and video (Dyson, 2012), have enabled the shift from consumer to prosumer. A study of sixth graders who used an app called VoiceThread in which they created an interactive presentation that provided an explanation of photosynthesis, made use of the affordances of mobile technology (Beach & O’Brien, 2015). These affordances include: (a) multimodality, or combining images and video with sound and text; (b) collaboration, which allows joint responses to be made on the same text; (c) interactivity, or the ability for the audience to provide feedback on an author's work; and (d) connectivity, using apps to make connections between written text, images, and video segments (Beach & O'Brien, 2015). Such affordances allow students to become producers rather than consumers of information that may "develop meaning and in the process generate informative discussions" (Hoban & Nielson, 2014, p. 69).

In the science classroom one of the most useful affordances of mobile technology is the ability to capture video of lab activities that can be later analyzed to promote argumentation and sense making (Pendrill et al., 2014). Relatively inexpensive editing tools and the ubiquitous nature of the Internet allows video production to be a project educators can incorporate into their classrooms (Gold et al., 2015). Video production can lead to in-depth understanding of science content while providing an opportunity for students to work in collaborative groups (Gold et al., 2015). Students are often highly motivated by the opportunity to create their videos, as Gold et al. (2015) found in a study involving high school students who produced their own videos about climate change.

Each form of digital media has its own affordances, requiring students to select the most appropriate form for the purpose (Hoban et al., 2013). For example, a study of pre-service teachers took advantage of merging photos together to create a stop-motion animation to explain the phases of the moon (Hoban & Nielson, 2010). In a similar study in which college students created stop-motion videos of cell processes and provided feedback to each other's work, test scores indicated an increased understanding of mitosis (Deaton et al., 2013). Regardless of the digital media chosen, students should be encouraged to write out their explanation to explain the scientific phenomenon (Hoban & Nielsen, 2010; Hoban et al., 2013), a finding supported by a study in which middle school students created a storyboard to organize their work prior to completing a digital documentary (Hofer & Swan, 2006).

Another primary affordance of digital media is the ease with which it can be shared with others; digital explanations can be uploaded to YouTube, a blog, or to a shared folder for access. File sharing allows students to learn from each other's explanations (Hoban et al., 2013). Students are often motivated by an external audience such as sharing with peers via social media (Gold et al., 2015; Green, Chassereau, Kennedy, & Schriver, 2013; Green, Inan, & Maushak, 2014). This can arguably result in better work as students engage with content in a deeper manner (Hofer & Swan, 2006).

Screencasting

One relatively new technique for student-created content is the use of screencasts. Screencasts can be defined as "a screen capture of the actions on a user's computer screen, typically with accompanying audio," (Educause, 2006, p. 1). Screencast tools, such as Jing and Screencast-o-Matic, were created to capture a user's computer or laptop screen. Today, the ability to screencast has been extended to mobile devices via downloadable apps that enable the user to create voice-over narrations on a virtual whiteboard. Screencasts have primarily been utilized to create tutorials for students (Educause, 2006), although some educators are exploring their application for student use (Soto, 2014). Screencasts created by instructors typically are composed of demonstrations or tutorials that provide scaffolding for complex processes such as coding (Lee, Pradhan, & Dalgarno, 2008). In a study that compared college students in an entry-level nutrition class who watched instructor-created screencasts to students who did not watch screencasts, the screencasts were found to increase knowledge acquisition (Morris & Chikwa, 2014).

When created by students, screencasting apps can provide insight into student thinking through the verbal explanations and writing that can capture the argumentation process. Argumentation is a socially situated process (Driver et al., 1998), therefore, creating screencasts in a small group may foster argumentation skills within students. Affordances of screencast apps that are beneficial to students include their playback functionality, the ability to record explanations, and the ability to be corrected after watching (Soto, 2014). For teachers, screencasts provide a record of student explanations, have the ability to be re-watched, are easily accessible for viewing, and can easily be disseminated (Soto, 2014).

There are a number of screencasting applications, or apps, that combine an interactive whiteboard with a screencasting tool. Among them is Explain Everything, an app that allows users to create tutorials on mobile devices (Figure 2.7). Explain Everything's authoring tools personalize the screencast-making process for the student; personalization has been earmarked as one of mobile technology's major advantages (Song, Wong, & Looi, 2012). The Explain Everything app affords the user the ability to change the color of the text, utilize a laser pointer, insert pictures and documents, create new pages to show different ideas, and annotate pictures and images.

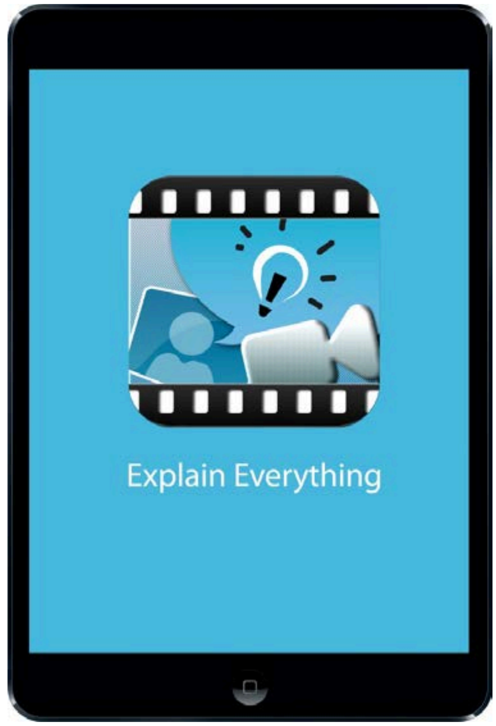


Figure 2.7. Explain Everything App

Explain Everything is advertised as “the #1 app for every teacher” (Explain Everything, 2015), indicating that the makers of the app have targeted teachers as their audience. Although there are several studies involving the use of screencasting created by teachers for the purpose of delivering information to students, a review of the literature indicates that few studies have been conducted that examine student-created screencasts (Stucky, 2012). Soto (2014) studied screencasts made by elementary students who were tasked with solving mathematical problems, finding that screencasting provided insight into student thinking and encouraged students to reflect on their thinking.

Screencasts as a Tool for Supporting Science Practices

Screencasting can be utilized to create oral science arguments, a task that may allow students to demonstrate their thinking in a manner superior to written scientific arguments. Krajcik and McNeill’s 2009 CER Framework was created to assist teachers in scaffolding both written and oral scientific explanations, since both forms of communication are important and “can help all students achieve greater success in science as well as develop a deeper understanding of explanations and arguments that they encounter in their daily lives” (McNeill & Krajick, 2012, p. 39). Studies have found that writing in science can enhance student comprehension of content and process (Keys, 1999; Keys et al., 1999; Rivard & Straw, 2000), while talking with others helps students to develop conceptual understanding as they evaluate scientific arguments (Enderle et al., 2013). Conflicting studies have been found, however, when comparing science talk to written explanations. Seddon and Pedrosa (1988) found no difference in student achievement between the quality of written versus oral explanations of chemistry concepts at the university level. A quasi-experimental study by Rivard and Straw (2000) found that scientific writing improved when conducted within a social context associated with questioning, interpreting, defending claims, and focusing on evidence. Their study examined 43 eighth grade students who were randomly assigned to one of the following groups: (a) a writing only group, (b) a talk only group, (c) a writing and talk group, or (d) a control group, with each group being asked to explain a key concept in ecology. All of the groups received the same instruction over the course of a six-week unit and were administered a pretest, a posttest, and a delayed posttest given six weeks after the unit ended. Results indicated that the writing and talk group performed best, with students who discussed the concept exhibiting longer retention than those who had simply written their explanation. The researchers concluded “peer discussion combined with writing appeared to enhance the retention of science knowledge over time,” (Rivard & Straw, 2000, p. 583). A separate study reached similar conclusions. A study of college students enrolled in an introductory biology course compared students who rotated through three treatments that included writing, discussion, and discussion combined with writing. Student exam scores on essay questions were highest when the treatment consisted of writing and discussion, suggesting that discussion should be part of active learning (Linton, Pangle, Wyatt, Powell, & Sherwood, 2014).

Authors Sampson et al. (2015) argue that students should write their arguments, an act that may be difficult for some students due to the complexity of the writing process; “unskilled writers are nearly always more proficient at oral than written communication” (Stay, 1985, p. 250). In a study of four classes ranging from fifth grade to twelfth grade, Berland and McNeill (2009) found that verbal argumentation was more complex than written argumentation, stating, “written products may under-represent their abilities and may not afford the students opportunities to push on their thinking” (Berland & McNeill, 2009, p. 27). The authors further suggest that the discrepancy between the two modes was due to: (a) underdeveloped writing skills that could not support the creation of complex arguments, and (b) to an absence of an audience that serves to provide a purpose for writing.

Screencasting may be an option for allowing students to create scientific arguments. A review of the literature unveiled only two studies related to screencasting and science practices. Stucky’s (2012) quasi-experimental design involved middle school students in utilizing an interactive simulation in which the learners were tasked with a challenge that required them to adjust abiotic factors within the simulation. Each group received the same challenge, with some students writing scientific arguments and others utilizing screencast technology to create their scientific arguments. Results indicated that students who created screencasts spent more time, used more words, and provided more references to the cause of a phenomenon than students who composed written arguments (Stucky, 2012). In a separate study, high school physics students utilized the online simulation software InquirySpace (The Concord Consortium, 2016) to conduct activities involving data collection via virtual sensors (Hazzard, 2014). Screencast software was used to capture graphical data and student discussions of results. The screencasts themselves were used as an alternative to the traditional lab report. Students were scaffolded through the process with prompts similar to the Keys et al. (1999) science writing heuristic. The prompts included:

- State your question
- Explain your procedure for collecting data
- Identify the variables and describe how you measured them
- Describe the pattern you identified
- Explain why you think this pattern exists
- Describe any problems you had collecting data and how you overcame them

The author concluded that screencasts were effective due to the pride students took in producing a screencast for an audience. Additionally, the lack of editing afforded by the screencast software resulted in students spending “more time thinking about science and less time perfecting their final presentation” (Hazzard, 2014, p. 59).

Both Stucky (2012) and Hazzard (2014) used computers to capture student thinking via screencasts; neither study used mobile devices, nor did the authors examine the quality of the student-created product. Additionally, both studies involved students in capturing components of online simulations rather than authentic student-collected data. Only one study could be located that used mobile devices in the K-12 science classroom for creating screencasts. A study of an AP high school physics classroom determined that students who created screencasts with iPads assisted students in creating “their own conclusions based on evidence, rather than relying on the book or the teacher to provide solutions” (Van Dusen & Otero, 2012, p. 411). The study also determined that students tended to use teacher input to guide their lab reports but used themselves to guide their screencasts (Van Dusen & Otero, 2012). Other findings included an increase in student play in which students performed off-task behaviors with non-related apps, an increase in student agency in which students were more likely to take responsibility for their learning, and an increase in perceived student social status due to iPad ownership.

Summary

The affordances of mobile devices, combined with free or inexpensive screencasting apps, can result in student-created content that shifts the responsibility for learning to the student. The ability to combine text, images, and narration via screencasting for generating science arguments can result in student-created products that lend insight into student thinking. Few studies have examined how screencasts can be used to support argumentation in the classroom, and there are no known studies that examine the type of data students collect to support their arguments nor how that data is used in student-created screencasts to support the argumentation process. This study aims to contribute to the body of literature regarding how students utilize screencasts to support their scientific arguments. The following chapters will discuss the methodology of the research design, present results, and analyze the findings.

CHAPTER 3: METHODOLGY

The framework for the NGSS outlines science practices that are crucial for K-12 learners and are intended to engage students with experiencing science from a hands-on approach that replicates the type of work done by scientists (National Research Council, 2012). In addition to practices related to laboratory activities, such as data collection and measurement, is the practice of argumentation. Argumentation is critical to understanding science because it develops communication and reasoning skills, supports student understanding of scientific practice, and fosters science literacy (Jimenez-Aleixandre & Erduran, 2007; McNeill & Krajcik, 2012). When constructing scientific arguments, students are expected to state a claim that “includes qualitative or quantitative relationships between variables that predict and/or describe phenomena” (Lead States, 2013b, p. 61). Student claims use evidence in the form of data or observations that are supported via a justification that links the evidence to a scientific concept, principle, or underlying assumption, much in the way that “scientists generate and evaluate scientific knowledge” (Sampson & Schleigh, 2013, p. xv).

This study explored the use of technology as a vehicle for engaging students in the science practices related to carrying out a science investigation and developing a scientific argument. Specifically, the use of mobile devices for collecting digital evidence and for creating screencasts of science arguments was explored via a case study approach. Case studies are a type of qualitative methodology that is appropriate for naturalistic environments such as the K-12 classroom. Creswell (2012) defines a case study as a form of ethnography, while Yin (2009) defines a case study as one that uses a real-life situation or context as its setting. Case studies lend themselves to the collection of data within a real-world setting and are useful for addressing both descriptive and explanatory questions, or those questions that typically begin with ‘what’ or ‘how’ (Yin, 2012). Case studies are constructivist in their approach (Baxter & Jack, 2008), seeking to determine meaning through the in-depth study of a bounded system (Creswell, 2013). Creswell (2012) suggests that case studies be bounded in terms of time, place, or other boundary of a physical nature. The case itself, which can either consist of a single-case design or a multiple-case design, serves as the major unit of analysis, but can contain subunits or subcases (Yin, 2012).

According to Merriam (1988), there is no standard format for writing a case study. This case study followed Yin’s (2009) recommended linear-analytic approach in which the problem, a literature review, methods, results, and conclusions are discussed. A single-case design consisting of a sixth grade science class was used for analysis. Additionally, subcases consisting of individual students were explored to determine the perceived value of creating screencasts to support argumentation in science.

Research Questions

This study examined student use of mobile devices for collecting digital evidence and explored how that evidence was used to support claims. The following research questions were used to guide this study:

1. What are the characteristics of student-collected evidence when using a mobile device during inquiry?

2. What are the characteristics of screencasts when using an app to create scientific arguments?
3. How do students utilize evidence collected via the mobile device to support their claims?
4. What are the students' and teacher's perceptions of the value of using a mobile device to form science arguments?

Demographics of School

The study took place in a suburban public school located approximately twenty miles outside of Philadelphia, Pennsylvania. The school district is made up of approximately 5,000 students and 800 educators and support staff. The sixth grade class is housed in an upper elementary building consisting of grades five and six. More than 82% of the sixth grade students performed at proficiency or above for reading and 56.7% were proficient in mathematics on the 2014 Pennsylvania State Assessments. In the spring of 2015, the school was named a National School of Character based on a positive impact on academics, school behavior, and climate (Character.org, n.d.). The school contains 783 students, 74.3% of which are Caucasian. Ten percent of the student body qualifies for free or reduced lunch.

Available Technology

The school is a Google Apps school, which means that the students have access to a district-provided Google account, which includes Google Drive. The school district adopted Google Classroom in the fall of 2014, which has enabled the teacher to establish an online class in Google Classroom. Google Classroom is a closed platform that allows students to safely and privately share products with the teacher. The participating teacher has daily access to six iPads for classroom use that he obtained through his participation in iPad training offered by the district. In addition, a cart of 30 iPads is available by reservation. Although this study could be conducted with any mobile technology, iPads were employed due to their accessibility. Prior to conducting the study, the school's technology integrator downloaded the Explain Everything app onto each iPad. Since the school district has a site license for Explain Everything, the app was able to be loaded on every iPad without an associated cost.

Access and Recruitment

IRB approval, approval from the participating teacher, and approval from the district's superintendent were obtained prior to beginning the study. All participants, both students and the classroom teacher, were informed that they would be able to withdraw from the study at any time if they wished. All adult participants and parents of participating minors signed a consent form prior to commencing the study; participating students signed assent forms. Additionally, procedures such as the use of pseudonyms were utilized to ensure that participants remained anonymous.

Student Participants

Purposeful sampling was used to ensure that a heterogeneous group of students was selected for the study. The unit for this case study was composed of a single class of 25 sixth-grade science students, 10 boys and 15 girls. Three of the students in the classroom were of Asian descent; the remaining students were Caucasian. The school principal develops classes based on tracking which results in groups that are either predominantly special education, predominantly gifted, or heterogeneous in nature. All of the students who participated in this study were regular education students; special education students and gifted students did not participate. One of the male students suffered a concussion at the beginning of the study and was unable to use the iPad as a result (limitations were placed on using any kind of technology due to the issues that technology can have on a concussed brain). Among the students in the class are three target learners; one of whom possessed a 504 plan that incorporated modifications to better help her succeed (she is diagnosed with Attention Deficit Disorder). The target learners were students who had been identified by their fifth grade teachers as students who exhibit weak performance on classroom assessments and assignments. These students meet with an instructional support teacher twice a month for the purpose of organizing notebooks and to work on study skills.

Participating Teacher

The participating instructor is a 36 year-old male in his sixth year of teaching. Previous to teaching, he worked as an auto mechanic, which allows him to bring a real-world perspective to his classroom. He entered the teaching profession in order to have an influence in the community and to work in a creative field. He strongly feels that by providing positive educational experiences that his students will leave his classroom with a positive attitude toward learning in general. He also feels that such an environment will contribute to his students becoming lifelong learners and foster their development as contributing members of the community. The teacher enjoys the freedom to choose methods to help his students meet the class's learning objectives; he also enjoys the challenge of developing differentiated techniques to help individual students.

The participating teacher enjoys incorporating technology into his classes and was selected for a prestigious summer technology workshop offered through the Pennsylvania

Department of Education during the summer of 2015. The teacher is an advocate for inquiry-based instruction and has explored the flipped classroom and project-based learning within the last school year. He is committed to improving student learning and is open to new ideas related to pedagogy, technology, and science instruction.

Classroom Setting

Students receive 45 minutes of science instruction each day in sixth grade, which focuses on the scientific method and includes an introduction to chemistry, physics, and watersheds. At present, argumentation is not a standard practice, nor is the use of the CER Framework. There are four sixth-grade science teachers at the school, each of whom has their own classroom that holds approximately 25 student desks suitable for seatwork, lectures, small group work, and testing. In addition, each teacher shares a laboratory room with one other sixth grade science teacher. The laboratory room, which is only six years old, has seven lab stations along the perimeter of two sides of the room; each station can contain up to four students. The center of the room has 30 individual student seats that face forward. The room is outfitted with an overhead mounted projector, a pull-down screen, an eyewash station, an emergency shower, and numerous lab materials that provide hands-on experiences for students.

Researcher as Research Instrument

All researchers bring philosophical assumptions to their work (Creswell, 2013). Acknowledging these assumptions is important, as they can influence the problems identified, the questions being asked, and the type of data collected (Creswell, 2013). This study was grounded in a postpositivist interpretive framework to understand how mobile devices can support science practices. As someone with an advanced degree in a scientific field, I gravitate towards a scientific approach to research in which I examine evidence for the presence of patterns. A postpositivist approach led me to identifying the research problem through reflective analysis of my own classroom. This study demonstrates a number of techniques typical of postpositivist research, including utilizing a variety of data sources, taking steps to ensure trustworthiness, and using a scientific reporting approach to present and analyze data.

This case study was guided by my two decades of experience as a middle school science instructor. I acted as a participant observer throughout the study and at times acted as a co-instructor. As such, it is important to note that I brought with me my own set of experiences and biases. As a constructivist, I construct my understanding of how students learn by triangulating data from sources such as observations, conversations with students, and test scores. Similarly, in this study I used a variety of sources to triangulate findings with the goal of achieving objectivity. The biases I possess were minimized through strategies such as the use of multiple data sources, an independent auditor, member checking, and analysis of student artifacts by two raters. These strategies served to depict an in-depth portrait of a middle school science classroom whose students were engaged in creating screencasts of scientific arguments. Interpretation of student screencasts was strengthened through the inclusion of student and teacher voice.

Description of the Unit of Study

The sixth grade curriculum includes a six-week unit on the topic of chemistry during which students study physical and chemical properties of matter. The activities described in this study, which occurred during the fall of 2015, served to introduce students to the chemical and physical properties of matter. The concept of physical and chemical properties was chosen as the topic of exploration because matter and energy has been identified as being one of the seven crosscutting concepts that “that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering” (Lead States, 2013b, p. 79).

The NGSS represent science instruction as a three dimensional approach consisting of disciplinary core ideas, science and engineering practices, and crosscutting concepts. The following physical science disciplinary core idea from the NGSS was addressed: PS1.A: “Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it” (Lead States, 2013a, p. 56). The study involved the following science and engineering practices: (a) analyzing and interpreting data, (b) constructing explanations, (c) engaging in argument from evidence, and (d) obtaining, evaluating, and communicating information. The crosscutting concepts of cause and effect and structure and function were also addressed.

The participating teacher and I worked together to plan the unit of study. Topics included properties of matter, physical and chemical change, and identification of an unknown substance. The activities were arranged in a sequential manner that scaffolded the students through the screencasting process while introducing skills necessary for argumentation (Appendix A).

Researchers Sampson et al. (2015) recommended that students work in small groups, with the optimum number of three students per group, in order to obtain the greatest amount of engagement among students when creating a scientific argument. Throughout the unit of study, students worked in groups of three to four individuals, completing several introductory lessons and three laboratory activities. The number of laboratory tables drove the number of students assigned to each group. The sixth grade science laboratory contains seven laboratory stations, necessitating the creation of four groups that contained four students and three groups composed of three students.

Activities Conducted Prior to Data Collection

Table 3.1 details the activities that occurred over the course of this research study. Several activities, including an introduction to the CER Framework, practice with writing a scientific argument, two laboratory exercises, and the creation of two screencasts of scientific arguments, were conducted to scaffold the students through the process of learning how to use the Explain Everything app for writing a scientific argument. Data on a third laboratory activity, the Mystery Powders Lab, was analyzed for this study.

Table 3.1.

Outline of Activities

Week	Activity*
1	Introduced project, answered questions about the project, and handed out assent and consent forms (1) Classroom observations (4)
2	Classroom observations (4)
3	CER Framework introduced with "Do you need a cell phone?" (1) Groups constructed an argument for "What happened to the cat?" Peer review of arguments using checklist (1) Teacher introduced Explain Everything app. Students created a screencast on a topic of their choice. Teacher showed screencasts from two volunteers to discuss guidelines for creating a quality screencast (1) Students conducted Penny Lab (1)
4	Groups created a group screencast of Penny Lab. Teacher showed one screencast to class to analyze the quality of the argument (3) Students conducted Chemical and Physical Properties Lab (1)
5	Each student created an individual screencast of the Chemical and Physical Properties Lab and provided peer review to two peers. Exit slip administered at conclusion of class (3) Researcher and teacher evaluate screencasts of Chemical and Physical Properties Lab**
6	Students conducted Mystery Powders Lab (1) Each student created an individual screencast of the Mystery Powders Lab Students provide peer feedback and fill out an exit slip (3)
7	Researcher and teacher evaluate Mystery Powders Lab screencasts. Teacher interview conducted** Focus groups interviews conducted (2)

*The number of class sessions that the activity took is found in parenthesis. Activities did not occur every day due to events such as researcher unavailability, field trips, and student holidays.
**Occurred outside school hours

Introduction to CER Framework

Prior to creating a scientific argument, students were introduced to the CER Framework over a two-day period. The introductory activities followed McNeill and Krajick's (2012) recommended teaching strategies for implementing the framework. These include (a) discuss the framework, (b) connect to everyday examples, (c) provide a rationale, (d) connect to other content areas, (e) model and critique examples, (f) provide students with feedback, (g) have students engage in peer review, and (h) debate student examples.

After explaining the CER Framework, the participating teacher connected the framework to an everyday example by asking the students to create an argument for the question "Do you need a cell phone?" The use of this example provided students with a strong rationale for mastering the CER Framework. Students worked in groups of three to four individuals to write an argument on a large (24" x 32") whiteboard. For scaffolding purposes, students were provided with a suggested layout of an argument when using a whiteboard (Appendix B). Student groups presented and defended their arguments to the class as a method of gaining experience with constructing and defending arguments. This process allowed the teacher to critique examples of argumentation and to provide feedback, which McNeill and Krajcik (2012) recommend when introducing the CER Framework. Most groups only used inferences, rather than inferences based on observations, which prompted the teacher to lead a discussion reinforcing the differences between observation and inference (terms that had been introduced at the start of the school year). In order to assist students with understanding the CER Framework, the teacher made the analogy that writing a scientific argument was similar to the type of work students conduct when writing a text-dependent analysis in their English class. Text-dependent analysis writing, which is required as part of the Common Core State Standards, requires students to analyze readings and to cite information from the readings when composing their writing (Brown & Kappes, 2012).

Next, students were shown a short video, the *Doritos Super Bowl Commercial Dead Cat Bribe* (CommercialsAtMost, 2012), which depicts a dog burying a collar identical to one featured in a poster about a missing cat. Since there are many subtle clues in the video, the participating teacher showed the video four times in a row to the class, asking them to watch carefully for all of the clues.

Students, working in groups of three or four, were than asked to construct an argument for the guiding question “What happened to the cat?” Students used observations gleaned from the commercial, made inferences, and documented their claim, evidence, and reasoning on a large (24” x 36”) whiteboard. For scaffolding purposes, students were provided with a suggested layout of an argument when composed on a whiteboard (Appendix B). Student groups presented and defended their arguments to the class as a method of gaining experience with argumentation. This was accomplished by having two members from each group visit other student groups, while one to two members of the original group explained and defended their group’s argument to their visiting peers. The visiting students completed a peer review using a checklist modified from Knight and Grymonpré (2013) (Appendix C) to determine if the arguments contained the necessary components. Following this, the original student groups reconvened to examine the checklists and to discuss possible revisions to their original argument. The process of engaging in peer review and debating student examples are teaching strategies that McNeill and Krajcik (2012) recommend when implementing the CER Framework.

Introduction of Explain Everything App

Students were introduced to the Explain Everything app using a methodology that the participating teacher has successfully employed for introducing iPad apps in the past. The teacher gave the students one day to explore the Explain Everything app and to create an individual screencast on a topic of his or her choice. Throughout the class period, students were able to ask the teacher questions and to use their peers as resources for better understanding the app's mechanics. Two student-created screencasts were solicited from student volunteers and shown to the class. This was accomplished by connecting the individual student iPads to the teacher's computer, which allowed the screencasts to be projected onto the interactive whiteboard at the front of the classroom. The class participated in a teacher-led peer review of the two student-created screencasts for the purpose of eliciting guidelines when creating a screencast. This procedure ensured that each student was familiar with the Explain Everything app and was able to view examples of screencasts created by peers.

Laboratory Activities

The introduction to argumentation was followed by two laboratory activities, the Penny Lab and the Physical and Chemical Changes Lab. The resulting screencast arguments for the lab activities were scaffolded with increasing task complexity as shown in Table 3.2. Data on the third laboratory activity, the Mystery Powders Lab, was analyzed for this study.

Table 3.2.

End Products for Laboratory Activities

Laboratory Activity	**End Product**
Penny Lab	Group Screencast
Physical and Chemical Changes Lab	Individual Screencast
Mystery Powders Lab	Individual Screencast

<u>Penny Lab</u>

During the Penny Lab activity students investigated the guiding question 'How does soap affect the number of drops of water that can fit on a penny?' The lab, which is part of the current sixth grade curriculum, engaged students in determining how the surface tension of water is impacted by soap. Students were assigned to groups of three or four individuals; each student group was provided with one iPad for the purpose of collecting data. One student from each group was assigned to the role of videographer and instructed to capture digital evidence in the form of photographs or videos. The videographer was told to navigate to his or her Google Drive and to take pictures or video from within their Google Drive. At the close of class, the participating teacher met with the videographers for the purpose of copying the evidence into a class folder that resided in his Google Drive; within the class folder were separate folders for each lab group. The teacher shared the link to the class folder with the class, thus ensuring that each student had access to their group's data.

Students worked in their lab teams to co-construct an argument that answered the guiding question. Each group of students was provided with one iPad for the purpose of constructing a screencast of their scientific argument. Since the lab was the first science activity in which students applied the CER Framework, students were provided with several possible claims and reasoning statements for the purpose of scaffolding their science argument (Appendix D). In keeping with best practices when using digital media as recommended by Hoban and Nielson (2010) and Hoban et al. (2013), students began their work by developing a storyboard for their screencast, which aided them in organizing their thoughts prior to screencast construction. Students were provided with a storyboard template to assist them in this process (Appendix E). The template was based on the science writing heuristic prompts developed by Keys et al. (1999). The participating teacher and I checked each group's storyboard for completion and provided any necessary scaffolding prior to the group creating their screencast.

Students were able to access their group's evidence via Google Drive. This required that they had to open their Google Drive and then navigate to a shared folder via a link that the teacher had provided. Students added the shared folder to their Google Drive, which enabled them to access and add any desired digital evidence to their screencast. At the end of the work session, the participating teacher showed one screencast to the class by connecting the iPad to his computer, which allowed the screencast to be projected onto an interactive whiteboard. A class discussion concerning the claim, evidence, and reasoning present in the screencast was held. During the discussion, the participating teacher reinforced that the purpose of creating a screencast was to develop a scientific argument.

Physical and Chemical Changes Lab

The next introductory activity was the Physical and Chemical Changes Lab, in which students rotated between seven laboratory stations to conduct simple lab activities representing examples of physical and chemical change. The teacher, who creates new lab groups for each lab activity, assigned students to a group containing three or four individuals. Students worked in their teams to assign each group member to one of the following roles: (a) the experimenter, whose job it was to perform the experiment; (b) the materials manager, who was responsible for cleaning up; (c) the captain, whose responsibility was to read the directions; and (d) the videographer, who was responsible for using the iPad to collect scientific evidence via pictures and/or video. For teams consisting of three students, one person served as both the captain and the materials manager.

Each student group was provided with one iPad for the purpose of collecting data as the group carried out the lab activities. The videographer was responsible for using the iPad to collect scientific evidence via pictures and/or video. Teams were encouraged to work together to determine the type of evidence that should be captured via the iPad. The videographer was instructed to navigate to his or her Google Drive and to take pictures and video from within their Google Drive. At the close of class, the participating teacher met with the videographers for the purpose of copying the evidence into a class folder in his Google Drive; within the class folder were separate folders for each lab group. The teacher shared the link to the class folder with the class, thus ensuring that each student had access to their group’s data.

Following the lab activity, each student created an individual screencast of his or her scientific argument using evidence collected by the group's videographer. Students were able to access their group's evidence via Google Drive. This required that they had to open to their Google Drive and then navigate to a shared folder via a link that the teacher had provided. Students added the folder to their Google Drive, which enabled them to access and add any desired evidence to their screencast.

The creation of an individual screencast ensured that each student had been through the process of screencasting a scientific argument. Similar to the previous laboratory activity, students were scaffolded through the argumentation process with a storyboard template (Appendix E). Prior to the creation of individual screencasts, the participating teacher and I reviewed each student's storyboard for completion and provided scaffolding as necessary.

Addressing Workflow Issues

Unlike the group screencast in which only a handful of iPads were utilized, several problems arose that were directly attributable to the necessity of sharing devices. The participating teacher had decided early in the study that he wanted to involve his class of gifted learners in the same activities that were being conducted with the class that was part of the research study. Since there were not enough devices for each student in both classes to be assigned to an iPad for their use, devices were used by more than one student to create screencasts. Although the iPads were used in only two of the teacher's classes, a number of issues arose related to workflow. For example, when students opened the Explain Everything app, some of the iPads opened to a screencast belonging to a student who had not exited out of the application, requiring students to save the screencast prior to working on their own project. This proved problematic because some students chose to exit the screencast without saving it, which resulted in the loss of data or even entire projects. Another issue related to sharing iPads emerged as students attempted to locate and use the same iPad each day. The teacher had given instructions for students to use the same iPad each day (each iPad is numbered). This strategy created problems because some of the iPads contained screencasts belonging to more than one student in the class. This resulted because students who had missed class for music lessons constructed their screencast at a later time in the day, and in doing so, utilized an iPad that another student had used during class time. A work-around was eventually developed that involved students in exporting their project to their Google Drive, thus allowing an Explain Everything project to be downloaded onto any iPad.

Once the issues to workflow were addressed, each screencast was peer reviewed by two peers using a checklist modified from Knight and Grymonpré (2013) (Appendix C) to determine if the screencast contained the necessary components of an argument. Following the peer review, students were instructed to submit their screencast as an attachment to an assignment that the teacher had created in Google Classroom.

The participating teacher and I evaluated all screencasts in order to gain practice in using the base rubric with the goal of achieving consistency between raters. Screencasts were evaluated for the appropriateness and sufficiency of their claim, evidence, and reasoning using a base rubric (Appendix F) from McNeill and Krajcik (2012). Given the fact that creating scientific arguments was a newly introduced skill, students were not expected to incorporate a rebuttal in their scientific argument. This is in keeping with McNeill and Krajcik's (2012) recommendation that rebuttals be introduced after students are proficient with the CER Framework.

There were some issues related to submission of the screencasts to Google Classroom. One student was unable to create a screencast due to restrictions placed on him after he suffered a concussion. Of the remaining 24 students who created a screencast, two submitted the assignment but did not include the screencast file as an attachment. An additional three students did not turn in the assignment due to issues with properly saving and exporting their file. Since the assignment was not graded, students were not penalized if they were unable to correctly attach and submit a file containing their screencast. The inability of some students to properly attach a screencast to a file in Google Classroom was noted; I helped the same students upload their next screencast.

Of the 19 pilot screencasts that were submitted to the teacher, only three featured narration. In addition, eight of the 19 screencasts contained no digital evidence. Although students had been given a class period to explore Explain Everything and had used the app in a small group setting to create a screencast of a science argument, the results of the individual screencasts created for the Physical and Chemical Changes Lab were unexpected; the majority of students had not taken advantage of the voice-recording feature, nor had they incorporated evidence into their screencast. As a result of this outcome, it was decided that the students would be encouraged to use Explain Everything's narration tool and to clarify the expectations regarding the incorporation of evidence into their next scientific argument.

Activities Conducted During Data Collection

As part of the chemistry unit, students conducted a guided inquiry lab called the Mystery Powders Lab. Students spent one day in the laboratory room conducting tests on unidentified powders. A specific letter was assigned to each of the powders: (a) baking soda was labeled A, (b) baking powder was labeled B, (c) cream of tartar was labeled C, and (d) cornstarch was labeled D. A fifth cup, which was labeled 'unknown powder,' contained baking powder. Students tested each of the powders with the following liquids: (a) water, (b) vinegar, (c) diluted iodine, and (d) a pH indicator made from red cabbage (Appendix G shows a picture of the set up for the lab).

The teacher created new student groups for the Mystery Powders Lab activity. Each group consisted of three to four students. The teacher assigned one student in each group to the role of videographer, basing his selection on students whom he felt were the most tech-savvy. The remaining students self-selected for one of the following roles: (a) the experimenter, whose job was to perform the experiment; (b) the materials manager, who was responsible for cleaning up; and (c) the captain, who was responsible for reading the directions. For teams consisting of three students, one person served as both the captain and the materials manager. The class was informed that each student was expected to write their observations on their individual data table. Similar to the Physical and Chemical Changes Lab, students were given no direction regarding the type of evidence that they were to collect with the iPad. Students were instructed to work as a team to help the videographer determine the type of evidence that he or she should collect using the iPad. This approach was chosen for the purpose of determining the characteristics of student-collected evidence when using a mobile device during inquiry.

Videographers were instructed to navigate to their Google Drive when taking photographs and video. This method resulted in the photographs and video being placed directly into the student's Google Drive, thus eliminating the need to upload the digital evidence into Google Drive from the iPad camera roll. At the close of class, the participating teacher met with the videographers for the purpose of copying the evidence into a class folder in his Google Drive; within the class folder were separate folders for each lab group. The teacher shared the link to the class folder with the other students, thus ensuring that each student had access to their group's data.

The methodology for screencast creation closely followed the procedures conducted during the Chemical and Physical Changes Lab activity; students were scaffolded through the creation of individual student screencasts in which each student was expected to apply the CER Framework. Students were supplied with a storyboard template (Appendix E) to assist them in the process of developing their scientific argument. The storyboard template was based on the science writing heuristic prompts developed by Keys et al. (1999). The participating teacher and I checked each storyboard for completion prior to students creating their individual screencasts, providing scaffolding as necessary.

Based on the outcome of the previous screencasts, the participating teacher reminded students that they could use Explain Everything's narration tool and that they needed to incorporate evidence into their screencast. Students were able to access their group's evidence via Google Drive. This required that they had to open their Google Drive and then navigate to a shared folder via a link that the teacher had provided.

Students added the folder to their Google Drive, which enabled them to access and add any desired evidence to their screencast.

Each student's screencast was peer reviewed by two peers from other student groups who used a checklist modified from Knight and Grymonpré (2013) (Appendix C) to determine if the screencast contained the necessary components of an argument. The participating teacher created an assignment in Google Classroom that required students to turn in the screencast as an attachment. Students were able to revise their screencast based on the peer review process before uploading their screencasts to Google Classroom. The majority of the students were successfully able to attach their Explain Everything file to Google Classroom; assistance was provided to any student who was unsure of the process.

Data Sources

Multiple sources of data were used for triangulation. The data corpus for this study consisted of the following: (a) observations via an observation protocol, (b) digital evidence collected by students, (c) student-created screencasts of a science argument, (d) a teacher interview, (e) two student focus groups, (f) exit slips, (g) field notes, and (h) photographs. Each of these data sources will be discussed in detail in the following section.

Observations

An observation protocol adapted from the Reformed Teaching Observation Protocol (Pilburn et al., 2000) was used for the purpose of observing students as they worked as a group during laboratory activities (Appendix H). The Reformed Teaching Observation Protocol (RTOP) was developed as an observational tool as a means to measure how teachers incorporate inquiry into their classes. Although the protocol was written prior to the NGSS, it captures the activities that support inquiry in science classes. Among those activities are active engagement by students, concentrating on collecting and using evidence, orchestrating discourse among students about scientific ideas, encouraging all students to participate in science learning, and challenging students to accept and share responsibility for their own learning.

The protocol developed for this study was utilized to organize and collect data relevant to group activity, recording observable actions such as on-task and off-task behaviors, discussions, asking questions, and using the iPad to collect data. Group activities were documented as being conducted by either all members of the group, the majority of the members of the group, half of the members of the group, a minority of the members of the group, or no members of the group. Prior to using the observation protocol with the Mystery Powders Lab, the school technology integrator and I field-tested the observation protocol to determine its reliability for documenting student behavior. The protocol was initially utilized to observe students every five minutes as they used iPads in a science classroom; a comparison of the observation results was made. A high level of consistency between raters was achieved. The field test did reveal that it was too difficult to monitor lab groups every five minutes, necessitating a change in the protocol so that groups were monitored every ten minutes.

The school technology integrator and I used the protocol to observe student groups during the Mystery Powders Lab, with observations documented approximately every ten minutes. In addition to capturing specific within-group interactions, the observations provided insight into student decision-making regarding the type of evidence collected with the iPad. These observations were explored during the student focus groups.

Digital Evidence Collected by Students

After the Mystery Powders Lab, the participating teacher met with each videographer and copied the evidence from their iPad into a class folder in his Google Drive. The teacher also created separate folders for each lab group within the class folder, this ensuring that students could access their group's data. After the teacher shared the link to the folder with me, I made a copy of the folder's contents and placed the student-collected evidence in a folder in my personal Google Drive account. This prevented the digital evidence from being accidentally altered or deleted by a student.

Screencasts

Student artifacts consisted of student-created Explain Everything project files that were in the form of XPL files. An XPL file is one that can be edited using a mobile device that contains the Explain Everything app. XPL files contain the raw material for a completed screencast such as video, audio, pictures, and annotations. Once the user has completed the screencast to his or her satisfaction, it can be saved as an MP4 file, which makes it accessible for viewing on a variety of devices. During this study, students did not convert their XPL file into an MP4 file, which allowed the participating teacher and I to assess screencasts on a much more granular level. These individual XPL files served to clarify student thinking, which is in keeping researcher recommendations for having students demonstrate their understanding through the writing process (Sampson et al., 2015). The XPL files for 24 screencasts of the Mystery Powders Lab were analyzed for the purpose of characterizing the screencasts and for determining how students utilized evidence collected via a mobile device to support their claims.

Teacher Interview

A semi-structured interview was conducted with the participating teacher for the purpose of determining his perception of the value of using iPads to form science explanations (Appendix I). The 30-minute interview explored perceived issues related to pedagogy when using iPads as a technology for creating science arguments and explored the potential of using the screencasting technique for struggling writers. I used an iPad mini to capture the interview and to ensure that all information was accurately recorded. The interview was transcribed within 24 hours and typed into a document using word processing software.

Student Focus Groups

Two focus groups, which occurred after the Mystery Powders Lab, were held for the purpose of exploring student opinion of the use of screencasting to report science explanations (Appendix J). Focus group number one consisted of three girls and focus group number two consisted of three boys. Groups were divided by gender because it has been my experience as a veteran middle school teacher that children of this age tend to feel more comfortable in same-sex groups. Each focus group contained students representing a range of ability levels to ensure optimum diversity. A criterion strategy was used to determine the student interview sample (Miles & Huberman, 1994) and ensured that diversity in gender and ability levels were represented. This was achieved by having the teacher identify three girls of varying ability levels and three boys of varying ability levels for participation in the focus groups. Interviews were held in a quiet classroom during the school day, with the first focus group interview taking 30 minutes and the second focus group interview taking 25 minutes. An iPad mini was used to capture the focus group interviews and to ensure that all information was accurately recorded.

During the focus groups, a semi-structured interview was held which explored the perceived value of using iPads to screencast scientific arguments, the perceived impact that iPad had on learning, and the perceived benefits and drawbacks to the use of the iPad in creating screencasts of science arguments. In order to ensure honesty, the students were encouraged to be honest and were assured that their grades would in no way be impacted by what they said. The students were also informed that participation in the focus group was strictly optional.

Field Notes

The intent of this descriptive case study was to understand how student-created screencasts could be used to support argumentation in the middle school science classroom. As a participant researcher, I interacted with the participants in the study and collected observations via field notes, paying particular attention to documenting student use of the iPad as a data-collecting tool. I also kept field notes that included information about student-student interactions, teacher-student interactions, student-technology interactions, and researcher impressions regarding student progress in creating screencasts. Information related to interaction with the iPad and any unusual events was also documented.

<u>Photographs</u>

I took photographs of students as they were working in their lab groups and as they created their individual screencasts. The photographs were used to supplement observations and field notes.

<u>Exit Slips</u>

Exit slips were used twice during the study as a method for understanding student perceptions of using iPads during laboratory activities. The use of exit slips, a strategy that requires students to write an answer to one or more questions at the end of class, was used to supplement observations and field notes. In the interest of ensuring that students provided honest feedback, all exit slips were anonymous. The first exit slip was administered after students created their screencast of the Physical and Chemical Changes Lab. Students were given a 3 x 5 card and asked to write down one thing that they liked about creating a screencast and one thing that they did not like about creating a screencast. The second exit slip was administered at the conclusion of the creation of the screencast for the Mystery Powders Lab. Students were asked to respond to the following questions

- How did your team decide what type of evidence to collect with the iPad?
- What kind of evidence did your team collect?
- What challenges did you encounter when using the iPad to collect evidence during the lab?
- What would you do differently the next time you are allowed to use an iPad to collect evidence during lab?

Data Analysis

Multiple data sources were utilized for the purpose of triangulating findings to support identified findings (Creswell, 2013; Morrow, 2005). Analysis and coding of the data sources was undertaken using qualitative content analysis in which data sources were systematically examined and reexamined for their placement into a coding frame (Schreier, 2014). Data sources included: (a) digital evidence collected by students, (b) screencasts, (c) interviews and student focus groups, (d) exit slips, (e) field notes, and (f) photographs. A description of the data analysis and coding that occurred is addressed in the next part of this chapter.

Coding the Digital Evidence Collected by Students

The student-collected photos and videos from each group's iPad were examined, categorized, and represented using a comparison table as recommended by Creswell (2013). After making a copy of all of the evidence, I used the computer to create a spreadsheet in which I recorded each piece of evidence as either a photograph or a video. I also documented the number of the lab group that had recorded the digital evidence. If the evidence was a photograph, I wrote a description of the photograph, stating if it was a picture of the lab materials, of a powder or the powder's reaction to a liquid, or of a data table. I grouped the pictures by the following categories: (a) materials, (b) procedure, (c) reactions of powders, (d) data table of the powders' reactions, and (e) written data table. In order to analyze the videos, I watched each video at least twice and recorded the total amount of time for each video. I also transcribed any talking that I could hear in the video and wrote a brief description of the events occurring in the video. I did not categorize the videos, since all of the videos depicted a powder interacting with a liquid. Some of the talking heard on the videos became part of the data corpus.

Screencasts

The participating teacher and I evaluated all screencasts for the appropriateness and sufficiency of their claim, evidence, and reasoning using a base rubric from McNeill and Krajcik (2012) (Appendix F). Given the fact that creating scientific arguments was still a relatively new skill, students were not expected to incorporate a rebuttal in their scientific argument. Prior to evaluating the Mystery Powders Lab screencasts, the participating teacher and I used the base rubric to evaluate the Chemical and Physical Changes screencasts. This allowed us to obtain proficiency with the rubric.

I made two copies of the base rubric for each screencast, one for the participating teacher and one for myself. We used these copies to evaluate and take notes on the individual screencasts. The evaluation process, which took place over a two-day time period, was conducted in the participating teacher's classroom after school hours. Each evaluation period took approximately two hours. Since the participating teacher had given me rights as a co-teacher in Google Classroom, I was able to access all the XPL screencast files from his Google Classroom account. In order to view the files as an Explain Everything file, I first had to navigate to Google Classroom, click on the Explain Everything XPL file, and add the file to my Google Drive. Next, I opened Explain Everything on my iPad mini and navigated to my Google Drive, then downloaded the screencast files into the Explain Everything application.

The participating teacher and I completed the base rubric as we viewed each individual screencast slide. This was accomplished by first connecting my iPad mini to the teacher's computer so that the screencast could be viewed on the interactive whiteboard. We then discussed our findings and observations; any differences in ratings were resolved via discussion so that we were able to achieve a 100% inter-rater agreement.

The claim portion of the screencast was evaluated in the following manner: claims were coded as a 0 if missing, as a 1 if the claim was inappropriate or incomplete, and as a 2 if the claim was appropriate and complete. Claims had to relate to the investigation in order to be considered appropriate and accurate. An accurate and complete claim was one that fully answered the guiding question, "How can physical and chemical properties be used to identify an unknown substance?" Failure to link the identity of the unknown powder to chemical and physical properties was interpreted as an incomplete claim, which resulted in a score of 1.

The base rubric by McNeill and Krajick (2012) (Appendix F) was also used to evaluate evidence present in each screencast. Evidence was coded as a 0 if inappropriate or missing and as a 1 if appropriate but insufficient. In order to receive a score of 2, students were required to provide both appropriate and sufficient evidence to support their claim. Appropriate evidence was data that related to and supported the claim.

Similarly, the base rubric by McNeill and Krajick (2012) was used to evaluate the reasoning portion of the screencast. When composing their reasoning, students were expected to link their evidence to physical and chemical properties. Reasoning was coded as a 0 if inappropriate or missing, as a 1 if appropriate and insufficient, and as a 2 if sufficient and appropriate. Students who received a score of 1 for the reasoning portion of their scientific argument failed to connect their evidence to physical and chemical changes.

Analyzing the Screencasts

After the teacher and I scored the screencasts with the base rubric, I assigned each student an identification code. I use the letter B to designate boys and the letter G to designate girls. Each boy was assigned to a number, so that I had boys one through ten, or B1 through B10. Boy number one, the boy who had a concussion, did not complete the assignment and therefore, was not part of the data set. I repeated this process for the 15 girls in the class, creating an identification code that ranged from G1 to G15.

After this, I created a coding frame by using a computer to generate a spreadsheet with the following column headers: (a) student identification code, (b) claim score, (c) evidence score, (d) reasoning score, (e) use of data as being either observational or inferential, (f) length of time for any screencast that was read or narrated, and (g) use of annotations. I filled in the identification code for each student and their claim score, evidence score, and reasoning score using the scores that had been generated from the evaluation session. I also was able to identify the evidence as either observational or inferential using notes taken when the participating teacher and I had evaluated the screencasts. Finally, I was able to record the length of time for spoken and narrated screencasts by simply looking at the screencast file in Explain Everything, since the file indicated the length of spoken screencasts.

Next, I created a data table with four columns for each screencast (Appendix K). The columns included: (a) slide number, (b) what was said, (c) notes, and (d) screenshot. I listened to each screencast at least three times again, this time looking at each individual slide for the purpose of transcribing any talking or narration that the student had included. I also took a screenshot of each slide and placed it into the corresponding cell in the data table. In the notes column I recorded information such as whether or not the student provided a partial or complete claim. I also recorded any annotations that the student had used in their screencast into the spreadsheet in the notes column. Using both the spreadsheet and the information present in the data tables, I explored the data for potential relationships that existed between variables, such as student approaches to screencasting, the use of annotating tools, and how students used their evidence to support their claims. In order to better visualize screencast characteristics and discern any patterns that existed between the variables, I created additional data tables for the purpose of clearly visualizing patterns. Finally, I spent time dissecting the screencast of student G13, whose screencast was unique due to her sophisticated use of the Explain Everything app and the inclusion of a rebuttal in her science argument.

Use of Digital Evidence

Evidence from the individual screencasts was analyzed and categorized by the participating teacher and I as being an observation or an inference. These two categories are based on the idea that scientists use both observations and inferences when construction explanations (Hanuscin & Rogers, 2008). An observation can be defined as “descriptive statement about natural phenomena that are directly accessible to the senses,” whereas “inferences are statements about phenomena that are not directly accessible to the senses” (Lederman et al., 2002, p. 500).

In order to classify the use of evidence as being observational or inferential, the participating teacher and I examined how each student used the evidence in their screencast. We first looked at screencasts of the Physical and Chemical Changes Lab in order to gain practice with evaluating the use of data and for achieving high inter-rater agreement. Next, as each screencast for the Mystery Powders Lab was evaluated, the participating teacher and I individually assessed the students' use of the data. In order for a student to have used data to support inferences, students needed to clearly link the reactions of the unknown powder to the reactions of one of the known powders to water, vinegar, iodine, and a pH indicator. After our individual assessment, we discussed our findings. In most cases, we were in agreement; differences were resolved via discussion that allowed us to reach 100% agreement.

Analyzing the Use of Digital Evidence

After the digital evidence had initially been classified as being used in an observational or inferential manner, I recorded the use of evidence into the same spreadsheet that I had constructed for analyzing the screencasts. I read and re-read the text that students had written and any narration I had transcribed in order to look for patterns related to the use of evidence. Next, I created additional data tables for the purpose of comparing the use of evidence to the quality of the student claim and to the use of annotations in order to determine if a relationship existed. The information was presented with frequency counts. The presentation of data via frequency counts is a technique typical in qualitative content analysis (Schreier, 2014).

Interviews and Focus Groups

The teacher interview and the student focus groups were recorded using an iPad mini to ensure trustworthiness of the data. Interview data was transcribed within 24 hours of the interview and summaries of the interviews were composed and typed into a document using a word processing program; all summaries were validated using member checking (Creswell, 2013). The teacher and students who participated in the focus groups were provided with a transcript of the recorded interview and were asked to assess it for accuracy; all interviewees confirmed that the transcripts correctly conveyed their opinions. This member checking process added credibility to the study and ensured that the statements included in the results section were accurate.

Since the database was small (a total of 33 single-spaced pages in length), this work was conducted by hand. I constructed the coding frame based on categories developed from the interview questions. The use of previously acquired knowledge, in this case the interview questions, meant that I worked in a concept-driven manner to segment and code responses (Schreier, 2014). I highlighted the corresponding segments of each category in a specific color. All sentences and phrases from the category were copied into a document using word processing software; this was repeated until documents of each category were created. Although this process may have been more labor intensive than using qualitative analysis software, it enabled me to interact more intimately with the data. Newly coded items were compared to previously coded items, with previously coded passages being reexamined to ensure consistency.

Field Notes

Field notes were typed up each night following classroom observations. The field notes also contained my reflections for the purpose of evaluating the effectiveness of techniques utilized throughout the study. The field notes assisted in establishing reflexivity and served to capture my thoughts from both an etic and emic perspective.

The field notes also served to document all data collecting and analysis decisions throughout the study, thereby establishing an audit trail.

Photographs

A total of 54 photographs were taken during the activities related to the Mystery Powders Lab; 24 of the photographs documented laboratory activities and 30 photographs showed students constructing their individual screencasts. Photographs were examined and classified by the specific activity depicted in the picture. Photographs served to illustrate findings that had been identified through analysis of interviews, observations, exit slips, and field notes.

Exit Slips

Exit slip responses represented segments that were coded using the exit slip question as a main category. Responses to exit slips were then compared to the responses from the student focus groups, observations, field notes, and photographs. Since exit slips are a formative assessment strategy administered at the end of class, students generally wrote short responses. For example, when asked to write what they liked about using Explain Everything, typical responses included “I had the freedom to make something on my own,” “It was fun doing a presentation,” and “I liked the lasers and writing.” The exit slips yielded valuable insight into student thinking and assisted in triangulating the data.

Trustworthiness

This study employed several validation strategies, which is in keeping with Creswell’s (2013) recommendation for qualitative research. The data corpus included classroom observations, interviews, student-collected digital evidence, and screencasts, all of which were used to triangulate the findings.

Credibility

The study's credibility was achieved through a variety of techniques, including prolonged field experience in which I observed in the classroom on a daily basis over a period of six weeks. This aided in the development of a relationship of trust between the students, the participating teacher, and myself. In addition, triangulation of research methods using observation, interviews, and screencast analysis were used to explain teacher and student perception of using the iPad to create science arguments. During the interviews, tactics for ensuring honesty of informants (Shenton, 2004) were utilized. These tactics included: (a) encouraging participants to be honest, (b) allowing participants the opportunity to refuse to be interviewed, and (c) assuring the participants that the research in no way reflected on participant grades and/or employment. Iterative questioning was used during both teacher interview and student focus groups for the purpose of eliciting additional data from the participants and/or exploring contradictions as recommended by Shenton (2004). I conducted member checks with the participating teacher throughout the data collection process for the purpose of verifying patterns. Member checks were also conducted after interviews had been recorded and transcribed.

Confirmability

Confirmability refers to the objectivity of the study (Shenton, 2004). A number of precautions were taken to reduce researcher bias. An independent observer utilized the classroom observation protocol to observe students as they used the iPads to collect data during the Mystery Powders Lab. The results were compared to my results to ensure consistency. The participating teacher and I classified evidence from individual screencasts and used a rubric to evaluate the individual screencasts. In order to achieve high inter-rater reliability, we practiced categorizing how students use evidence in their screencasts. Similarly, the practicing teacher and I practiced applying the base rubric to evaluating screencasts. These practice sessions increased consistency between the raters; all differences were resolved via discussion to achieve 100% inter-rater agreement. I also employed a reflective commentary throughout the data reporting, which yielded insight into thinking and decision-making for the creation of an audit trail. The results of data analysis were shared with the participating teacher for the purpose of identifying any perceived discrepancies. Peer consultation, in which the data and data analysis was shared with an individual who possesses a science education background, was also used to establish validity through feedback on the data analysis.

Transferability

This study's small sample size and purposeful sampling makes it difficult to achieve transferability. The thick description used to depict the classroom setting and student involvement in screencast creation will assist readers in transferring insights from this study to their own classroom. It is hoped that practitioners who read this study can modify and utilize some of strategies described.

Dependability

The ability to recreate this study for the purpose of achieving similar results is difficult to achieve, given the unique nature of the classroom and the many variables that impact student learning. The use of thick description will help readers develop a thorough understanding of procedures conducted throughout the study. Additionally, a practicing optometrist who acted as an independent auditor examined the data and findings to ensure that my conclusions were sound and clearly conveyed. The auditor, who is a second-career science teacher, is familiar with pedagogy related to teaching science at the middle school level, having completed a semester-long student teaching assignment in a middle school.

Summary

This study addressed how mobile devices can be utilized to support science inquiry, specifically the science practice of constructing scientific arguments from evidence. A sixth grade science class containing 25 students participated in a guided lab in which they used iPads to document the results of chemical reactions to identify an unknown powder. Students applied the CER Framework to create a science argument designed to answer the guiding question “How can physical and chemical properties be used to identify an unknown substance?” Students constructed their science arguments using iPads and a screencasting application called Explain Everything. Several data sources were utilized for the purpose of triangulating findings. These sources included daily classroom observations over a six-week period, student-collected digital evidence in the form of photographs and video, student-created screencasts, interviews, field notes, exit slips, and photographs.

A base rubric by McNeill and Krajcik (2012) was used to evaluate the quality of the science argument present in the screencasts with student-collected evidence categorized by formal criteria. Screencasts were also analyzed using qualitative content analysis for the purpose of characterizing the science arguments and understanding how students used digital evidence to support their claim. Interviews with the participating teacher and student focus groups were held for the purpose of yielding understanding into their opinion regarding the use of mobile devices for creating screencasts.

CHAPTER 4: RESEARCH FINDINGS

The passage of the NGSS calls for embedding science practices into the K-12 science classroom. While some practices, such as data collecting, are often incorporated into classrooms, the practice of argumentation is not a typical practice of most science teachers (Sampson & Blanchard, 2012; Sampson & Schleigh, 2013). The affordances of mobile technology, which includes the ability to quickly capture laboratory data and create narrated screencasts, make mobile devices a potential tool for engaging students in inquiry and the practices that support inquiry. This study was conducted to understand how iPads could be used to support science practices in the middle school classroom. Specifically, this study aimed to characterize the digital data captured by students during a laboratory activity and to understand how students used the data to support a science argument. Analysis of students' approach to data collecting, how they used the digital evidence to support their science arguments, the response to a potential audience, and the impact that workflow had on the use of iPads to create screencasts are addressed in the remainder of this chapter.

Organization of Data Analysis

This chapter presents the findings related to the research questions. The results for each research question are discussed in detail and are supported with multiple data sources that were used to triangulate findings related to the four research questions. The data related to each research question is presented in order, beginning with categorizing the data students collected using the iPads and student approach to data collection. Next, a summary of the characteristics of student screencasts is presented via a review of the rubric scores screencasts received and a discussion of findings related to the use of digital evidence and student approach to screencasts. The screencast of one individual learner is discussed in depth, while the voices of other students and the teacher are employed to illustrate their opinion of the screencasting process for creating science arguments. Research questions are discussed in the following order

1. What are the characteristics of student-collected evidence when using a mobile device during inquiry?
2. What are the characteristics of screencasts when using an app installed on a mobile device to create student arguments?
3. How do students utilize evidence collected via a mobile device to support their claims?
4. What are student and teacher perceptions of the value of using a mobile device to create science arguments?

Research Question Number 1: What Are the Characteristics of Student-Collected Evidence When Using a Mobile Device During Inquiry?

Students spent one class period in the laboratory room performing the Mystery Powders Lab, which involved conducting tests on common powders used in cooking. The lab activities were designed to reinforce physical and chemical properties of matter. A specific letter was assigned to each of the powders: (a) baking soda was labeled A, (b) baking powder was labeled B, (c) cream of tartar was labeled C, and (d) cornstarch was labeled D. A fifth cup, which was labeled ‘unknown powder,’ contained baking powder.

Students tested each of the powders with the following liquids: (a) water, (b) vinegar, (c) diluted iodine, and (d) a pH indicator made from red cabbage.

Digital Evidence Collected by Students

The teacher provided one student in each of the seven lab groups with an iPad for the purpose of documenting evidence. Students were given no direction regarding the type of evidence that they were to collect with the iPad. Analysis of each group's iPad camera roll revealed that a total of 141 pictures and 68 videos were collected during the 45-minute class period (see Table 4.1).

Table 4.1.

Total Numbers of Picture and Video Evidence Collected by Students Via the iPad

Group	Total Pictures	Total Videos	Length of Videos (min.)
1	34	8	2:22
2	7	4	1:01
3	31	10	2:40
4	15	10	2:29
5	17	19	4:20
6	20	6	1:27
7	17	11	2:23
Total	141	68	16:42
Average	20.1	9.7	2:31

As depicted in Table 4.2, the majority of photographs were of reactions of unidentified powders with unidentified liquids. Although it was evident that students were attempting to capture the reaction that a particular liquid had on a powder, few pictures contained any type of identifying titles, making it difficult to identify the actual experiment being conducted (an example of such a picture is shown in Table 4.3).

Table 4.2.

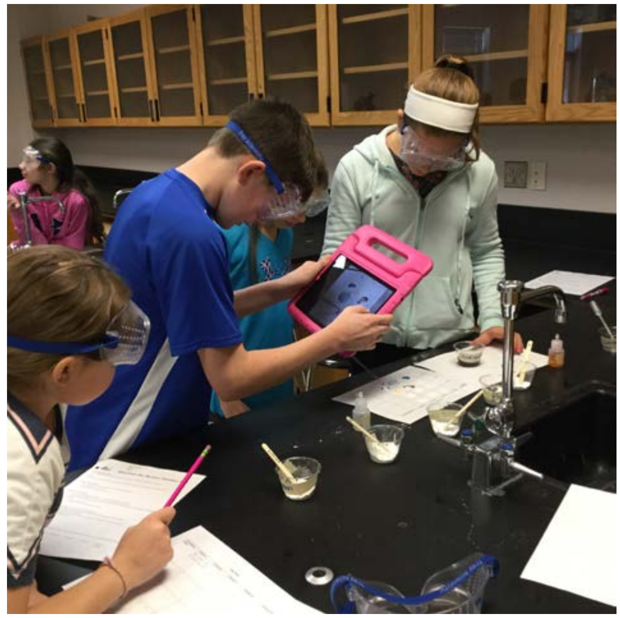
Summary of the Types of Picture Evidence Collected by Students Via the iPad

Group #	Materials	Procedure	Reactions of Powders with Liquids	Reactions Data Table	Written Data Table
1	9	2	22	1	0
2	1	0	5	1	0
3	3	0	27	1	0
4	0	0	14	1	0
5	0	0	14	2	1
6	1	0	17	2	0
7	0	0	16	1	0
Total	14	2	115	9	1

With the exception of student group number two, each student group documented the reaction of nearly every powder with every liquid either through a photograph or through a video. Every group took a picture of the completed testing table at the end of the experiment (see Table 4.3), but only Group 5 took a picture of a completed hand-written data, despite the fact that every student was responsible for recording their observations in the data table.

Table 4.3.

Typical Evidence Captured by Students Using iPad

Description of Photo or Screenshot	Photo or Screenshot
A student captures a video of a chemical reaction.	
A common piece of evidence captured with the iPad was picture of unidentified powders after reaction with unidentified liquids.	

Every lab group documented a picture of the completed data table that showed the powders reactions to water, vinegar, iodine, and the pH indicator.	

Each student group took an average of 9.7 videos, which contributed towards a total of 68 videos. The average total length of the videos recorded by the groups was two minutes and thirty-one seconds. Without exception, each video depicted the reaction of one of the powders with one of the liquids; as shown by the examples in Table 4.3, in no instance was an attempt made to identify the powder or the liquid. In some cases, students can be heard in the videos discussing the observed results stating, “It’s fizzing and turning black,” “I can see it dissolving the powder,” and “It kinda fizzed.” In other videos students can be heard providing an opinion such as “That’s so cool,” “Eeew,” and “That one was awesome.” Occasionally there is evidence of hypothesis generation such as when a student states, “Nothing is going to happen. It’s always the same with water.” There is little evidence of any intended narration; at no point in any video is a student speaking directly to the camera or intentionally narrating their observations. When asked later about this anomaly, one student reflected

> It was just random people talking and you could hear people in the background so maybe what I would do is I would have one group go to the lab at once and then they could explain it without other people in the background.

Students were required to cull through an average of 20.1 pictures and 9.7 videos prior to creating their screencasts. Despite this, when students were asked what they would do differently the next time they were allowed to use an iPad to collect evidence, half of the students said they would take additional pictures and video, stating they would record “More close up photos,” “More pictures and videos which would give more info,” and “Take pictures of other group’s experiments to prove a point.”

Decision-Making

When it came to documenting evidence with the iPad, the majority of the decision-making was spontaneous, as exemplified by a student’s comment, “We kinda just did the experiment and whenever we saw something that we thought might make a good picture or something that would work well in a video we took a picture or a video of that.” On occasion, students could be overheard prompting the videographer to take a picture during the lab exercise with statements such as “Here, take a picture” and “Take a video until it turns whatever color.” The lack of planning for documenting evidence via video may explain why a student from group six is overheard on a video stating, “Now we’re talking in it and we won’t be able to use it.” No sound at all can be heard in the videos of student groups three and seven. When questioned, one of the group members stated that she would have preferred to have “People talking about the thing that’s going on.”

Oftentimes, it was up to the discretion of the individual videographer to determine the type of evidence that should be recorded. One videographer stated, “I did it on my own with some help from them,” while a member of a different group stated, “We pretty much let her figure it out and when she said she was taking a picture we got ready.”

Occasionally, the group members prompted the videographer to record data. A boy from one of the focus groups said

> Yeah, like every time we went to a different chemical like iodine he just took a picture and then for like random ones…like we told him what to do but for random ones like he would pick a video if he wanted to.

Despite the apparent lack of planning, most groups exhibited a specific strategy regarding the use of photographs. Six of the seven groups took photos of nearly every powder reacting with every chemical, stating, "We just wanted to take a picture of everything so we just have it in case we needed it," and "We decided we were going to take a picture of each row once we did it and then take an overview picture of all of them. And then some pictures of the different powders." The desire to capture the chemical reactions was also exhibited in the videos. One student stated "We mostly wanted to have the chemical in action with how it is reacting, but for the most part if it is an after or before it is going to be a picture."

The groups supported the videographer and worked together to ensure that the evidence was collected with little argument. The decision to provide each group with only one iPad differed from the teacher's previous approach of allowing each student access to an unshared iPad. Despite this, students seemed to understand that limiting the number of iPads increased the collaborative nature of the group. When asked how issuing individual Pads would impact the group, the focus group of girls stated "I think it would make it more separate," "Probably more individual and there wouldn't be as much interaction," and, "People would be filming everything and not just one thing." Similarly, the focus group of boys stated "I think one per group is pretty good cause there's like different jobs you know. If everyone had an iPad everyone would be like 'get out of my way,'" "You're not taking all the photos and at the same time you're getting everything," and "Otherwise it would be snap, snap, snap" (indicates taking a picture). The collaborative effort of the group was particularly evident at one lab station where the videographer was not recording any written data. Rather, as he was using the iPad, another student in his group was recording data on both her data table and on his data table. Some students who were using the iPad felt that being the videographer excused them from recording data by hand; the videographer at one lab station asked, "Do we have to write down data, too?"

Summary

During the Mystery Powders laboratory exercise, one student from each lab group was provided with an iPad that was used to collect digital evidence. Although students approached this task with a minimum of planning, analysis of the photographs and videos revealed a similar pattern that demonstrated a focus on capturing chemical reactions as they occurred. Students made no effort to identify the specific reaction occurring in the photographs or to narrate the videos, making the majority of the evidence unusable due to its ambiguous nature. Additionally, although each student was responsible for recording their own written data, only one lab group documented a written data table as part of their data set.

Research Question #2: What Are the Characteristics of Screencasts When Using an App Installed on a Mobile Device to Create Student Arguments?

In addition to using mobile technology to document evidence, students also created a screencast of a scientific argument for the guiding question "How can physical and chemical properties be used to identify an unknown substance?" When creating a screencast in Explain Everything, the user is presented with individual slides capable of containing text, pictures, audio, and video. Students submitted their Explain Everything file, an XPL file, to Google Classroom for grading. The XPL file is an editable file that contains the raw material for a completed screencast. Explain Everything's XPL files have the capability of incorporating special effects such as the use of a laser pointer and a pen tool, thereby allowing the viewer to see the screencast as a series of interactive slides rather than as an MP4 file. Once the user has completed the screencast to his or her satisfaction, it can be saved as an MP4 file, which makes it accessible for viewing on a variety of devices. During this study, students did not convert their XPL file into an MP4 file, which allowed the evaluators to assess screencasts on a much more granular level.

Scientific Argumentation

Of the 25 students who made up the class, 24 submitted screencasts for evaluation; one student was unable to complete the activity due to a concussion. The remaining 24 screencasts were evaluated using a base rubric designed by McNeill and Krajcik (2012). Since the students had utilized a storyboard to organize their thoughts prior to creating the screencasts, each screencast followed a similar format in which the student identified the guiding question, made a claim, provided evidence, and supported their claim with evidence linked to scientific reasoning. This format, coupled with the ability to examine the individual slides that made up the XPL file, helped the evaluators to easily identify and score the claim, evidence, and reasoning sections of the screencast using the base rubric from McNeill and Krajick (2012). Class percentages for the claim, evidence, and reasoning components of a scientific argument are listed in Table 4.4;

individual student scores for the claim, evidence, and reasoning can be seen in Appendix L.

Table 4.4.

Class Percentages for Screencast Claim, Evidence, and Reasoning Components in Student-Created Screencasts

Raw Score	Claim %	Evidence %	Reasoning %
0	16.7	0	8.3
1	41.7	41.7	45.8
2	41.7	58.3	45.8

Claims

Student-created screencasts were evaluated for the accuracy and completeness of their claim. An accurate and complete claim was one that fully answered the guiding question, “How can physical and chemical properties be used to identify an unknown substance?” Using the base rubric from Krajick and McNeill (2009), students who provided complete and accurate claims received a score of 2. Failure to link the identity of the unknown powder to chemical and physical properties was interpreted as an incomplete claim, which resulted in a score of 1. Students who failed to make a claim or who made an inaccurate claim received a score of 0. Of the 24 screencasts that were evaluated, 41.7% of the class (ten students) received a score of 2 for submission of a complete and accurate claim, another 41.7% (ten students) received a score of 1 for their accurate but incomplete claim, and 16.7% of the class (four students) received a score of 0 because they either failed to make a claim or made an inaccurate claim.

Students who constructed a complete claim made statements such as “Using what we knew and observed of the other powders reactions, we were able to recognize that the unknown powder’s reactions were the same as powder B’s reactions” and “You can look at all your reactions and see which ones look the same and have the same reaction and therefore in our experiments it was B that the unknown powder matched to.”

Students who made incomplete claims correctly identified the unknown powder as powder B, but failed to make any reference to chemical or physical properties, instead making claims such as, “I say that the unknown powder is the same thing as powder B.” Other students attempted to link the test results to chemical change, but did so in an unclear manner. For example, student G15 wrote “My claim is that powder B is the unknown substance because of the following properties: the same odor and color.” Although an implied claim is present, the lack of clarity in written expression resulted in G15 receiving a score of 1 for her claim. Students who participated in peer review also identified the lack of a clearly stated claim that answered the guiding question as an issue, as shown in this statement:

> When you’re doing the screencast, um, make sure you’re actually answering the guiding question. Because someone didn’t answer the guiding question and I was watching their video. And I was like ‘what?’ And make sure that you focus on, like you answered everything first, and then add to the design.

Four students in the class either did not attempt to make a claim or made an inaccurate claim. In the case of student G2, she chose to narrate her screencast. Analysis of the slide corresponding to her claim shows 13 seconds of silence, indicating that her lack of a claim may have been due to a technical problem that she either did not detect or did not have time to address. Students B4 and G8 had implied but incorrect claims that focused on procedure, with G8 writing “You look for one or more other substances that have the same reactions to find out what the unknown substance is made of" and B4 narrated, "As you can see in this picture my group conducted experiments on the different powders to find which powder the unknown powder is similar to." Despite the lack of an accurate claim, three of the students who received a 0 for the claim portion of their science argument were able to cite evidence and provide reasoning (see Appendix L). One of the target learners, G11, struggled with understanding how to write a scientific argument. She submitted an incomplete screencast that was missing a reasoning section.

Evidence

The base rubric by McNeill and Krajick (2012) was also used to evaluate evidence present in each screencast. In order to receive a score of 2, students were required to provide both appropriate and sufficient evidence to support their claim; appropriate evidence was data that related to and supported the claim. Appropriate but insufficient evidence was coded as 1, and inappropriate or missing evidence was coded as a 0. All students provided evidence in their screencast, with 58.3% of the class (14 students) incorporating appropriate and sufficient evidence and the remaining 41.7% (ten students) providing appropriate but insufficient evidence.

Sources of evidence included the students' handwritten data table, as well as photographs and videos taken during the laboratory activity; students had access to their groups' digital evidence via Google Drive. All of the students incorporated at least one piece of digital evidence in their scientific argument; students who had made a complete and accurate claim were more likely to have submitted sufficient and appropriate evidence than were peers who had either made no claim or who had made a partial claim (see Table 4.5).

The participating teacher noted that the availability of digital evidence helped students to recall the laboratory procedures and results.

> I think it was really important that they collected that evidence because I really did feel that a lot of the kids went back. If you have them write a lab report normally they don't necessary remember what they did in the lab and they just kind of start writing until they're done and they turn it in. We found some of the kids used the evidence really well and some of the kids, you know, the evidence was just kind of there. But I think that no matter what, it helped them go back and remember what they did when they saw those pictures of the lab.

Reasoning

The base rubric by McNeill and Krajick (2012) was used to evaluate the reasoning portion of the screencasts. Reasoning was coded as a 2 if appropriate and sufficient, as a 1 if appropriate and insufficient, and as a 0 if inappropriate or missing. Eleven students (45.8% of the class) received a score of 2 for reasoning and another 11 students (45.8%) received a score of 1 for reasoning. Two students, or 8.3% of the class, received a score of 0 for reasoning.

When composing their reasoning, students were expected to link their evidence to physical and chemical properties. Two students, G11 and B7, received no credit for the reasoning portion of their scientific argument because they did not have time to finish their screencast and were subsequently missing the reasoning portion (according to the teacher, student B7 is a low-performing student and G11 has been identified as a target learner). Of the remaining 22 students, half were able to provide appropriate and sufficient reasoning based on scientific principles to explain why the evidence supported their claim. For example student G4 narrated her screencast by stating

> My evidence shows that powder B and the unknown powder are the same thing. When you looked at the reactions, you could tell that their physical and chemical changes were the same. So looking at items and observing their reactions,

> physical or chemical, can show you if two objects are of a same or different substance.

Students who received a score of 1 for the reasoning portion of their scientific argument failed to connect their evidence to physical and chemical changes. In most cases this was often a result of a failure to correctly address the guiding question; these students restricted their reasoning to simply identifying the unknown powder. For example, student G9 states, “If you look at the table you can see that all the circles in the same color had the same results.” Although she links her evidence to her reasoning, she does not connect the color change to chemical or physical properties. Since students were supposed to support their claim through evidence and reasoning, students who made insufficient claims had difficulty providing sufficient reasoning.

Relationship of Claim to Evidence and Reasoning

As shown in Table 4.5, students who either did not provide a claim or who provided an incomplete claim were more likely to provide incomplete reasoning. This is true of student G9, whose claim was “I say that the unknown powder is the same thing as powder B.”

Table 4.5.

*Relationship of Claim to Evidence and Reasoning Scores**

Claim Status	Partial Evidence	Sufficient Evidence	No Reasoning	Partial Reasoning	Sufficient Reasoning
No Claim (16.7)	12.5	4.2	4.2	8.3	4.2
Incomplete Claim (41.6)	29.1	12.5	4.2	29.1	8.3
Sufficient Claim (41.6)	8.3	33.3	NA	8.3	33.3

*All numbers are expressed as percentages

Although creating a slide about reasoning did not require students to incorporate pictures or video, some students reiterated their evidence on their reasoning slide, using drawing tools or other annotating tools to make their thinking transparent. For example, student G6 narrated her reasoning slide (shown in Figure 4.1) as follows:

> I know my evidence connects to my claim because it shows my claim is correct. It shows how some of the tests relate to the unknown substance and helps support it. It also helps show how physical and chemical properties can be used to identify an unknown substance.

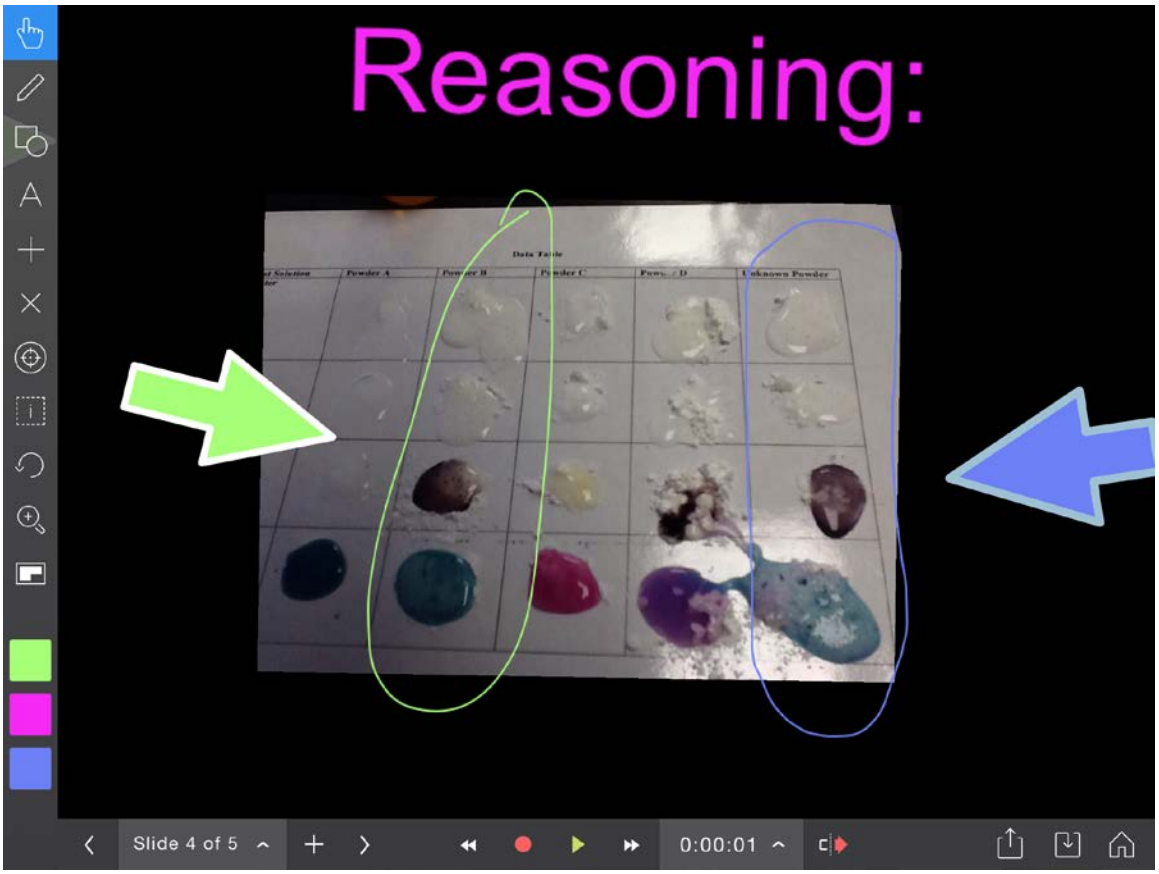


Figure 4.1. Student G6 Used Annotation to Show Her Thinking

<u>Student Approaches to Screencasting a Scientific Argument</u>

Writing a scientific argument was a newly introduced skill for students, who were scaffolded through the process with the use of a storyboard. Prior to beginning the construction of their screencasts, students were expected to create a rough sketch of the elements that they would place on each of their slides and to also write down some text that they planned to use in their screencast. In checking the storyboards, the participating teacher noted that many students wrote out a considerable amount of text.

> I think it was confusing to them…what the screen looked like and the dialog. For some reason they didn't get it. They thought they had to do a bunch of writing and it was just like 'No, are you going to use a picture here or are you going to have something written on the screen and then what are you going to say about it?'

Screencast organization mirrored the storyboard template that had been provided to students, with each screencast containing the following slides: (a) guiding question, (b) claim, (c) evidence, and (d) reasoning, with the average screencast composed of 4.6 slides. Analysis of the XPL screencast files revealed three distinct approaches that included: (a) presentation of a text-only screencast, (b) reading the text verbatim as it appeared on the screencast slides, and (c) providing narration to explain the screencast slides (Appendix L contains the presentation mode for each student). Seven of the 24 students, or 29% of the class, did not utilize the recording feature of the app. They instead choose to represent their science argument entirely through written slides. This was somewhat unexpected, given that the teacher occasionally uses Explain Everything to record teacher-created videos that students are expected to watch at home as part of a flipped-classroom approach. When asked about the students' ability to transfer what they had seen from examples of screencasts to their own work, the teacher stated

> I don't think it transferred cause my videos are moving things around and I'm talking over top of them. I think they saw it (Explain Everything) as more of a PowerPoint. Either they didn't explore it or I didn't give them enough time to explore with that video aspect of it, of here, you can just move things around and talk over top of it, which they see in my flipped lessons. I think they still just see it as a PowerPoint presentation.

Of the remaining students who chose to speak during their screencast, seven students (29%) read verbatim the text present on their slides, while ten students (42%) chose to narrate the screencast. In comparing the average rubric score of the three presentation approaches, the ten students who chose to narrate their scientific argument scored 5.0 out 6.0 on the base rubric. Students whose screencast consisted of a text only presentation scored an average of 3.4 out of 6.0, while students who read verbatim what was written on their slides scored an average of 3.1 out of 6.0. As depicted in Table 4.6, eight of the students who narrated their slides also annotated as they presented their information, frequently using the pen tool and laser pointer to interact with their screencast.

Table 4.6.

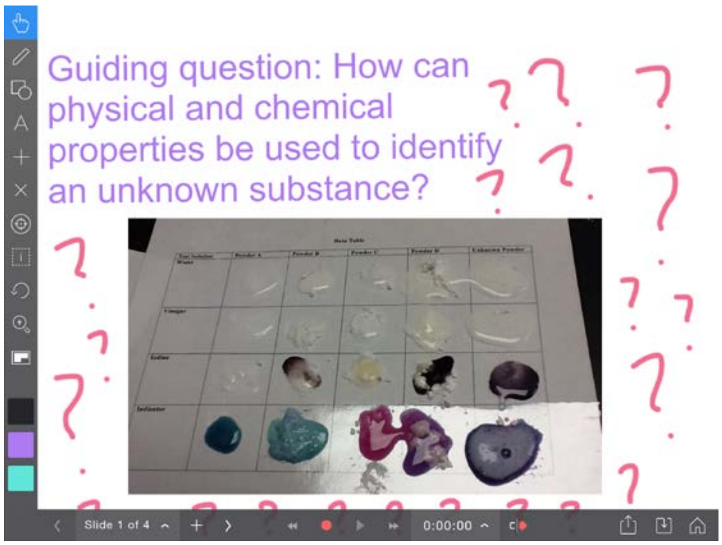
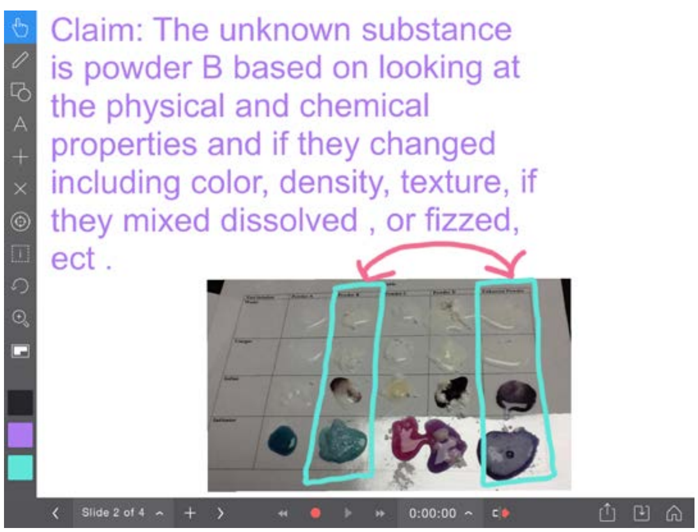
Average Score and Annotation Use for the Three Different Presentation Styles

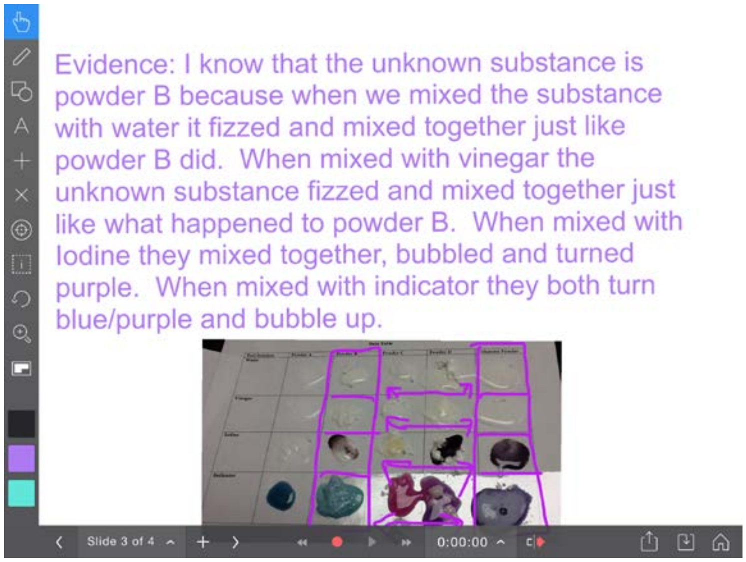
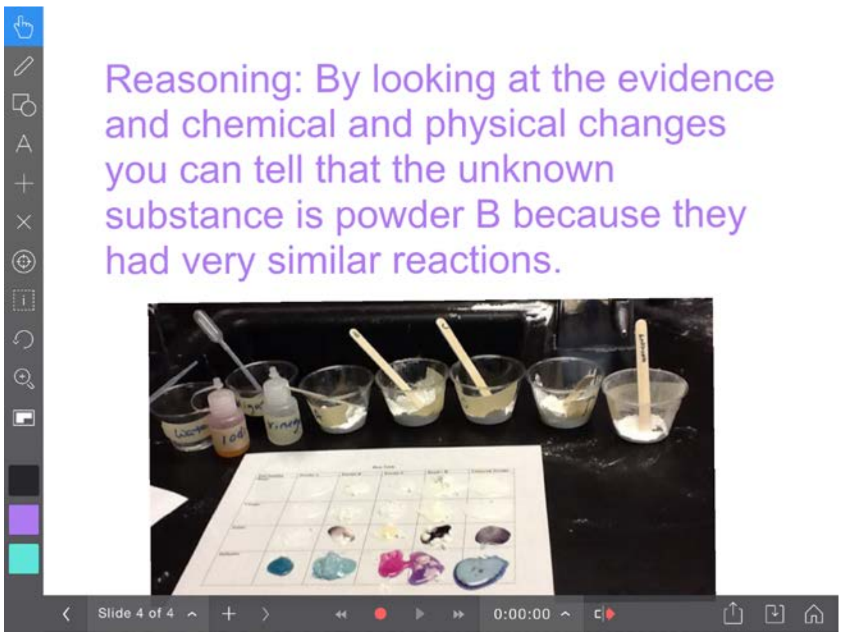
	Text Only	Read Verbatim	Narrated
Total Number of Screencasts	7	7	10
Number of Screencasts That used Annotations	0	4	8
Evidence Use: Observational	4	7	2
Evidence Use: Inferential	3	0	8
Average Base Rubric Score	3.4	3.1	5.0

Narrating the scientific argument did not necessarily mean greater sophistication; as depicted in Table 4.7, student G10 was able to achieve a score of 6 on her screencast through the use of a text-only presentation. Student G10 explains her choice to type, saying, “I think its easier to just type cause sometimes I go blank.” Her use of annotating tools, along with clearly worded text, enabled her to score as well as the majority of her peers who narrated their screencast. Similarly, two students who read their slides verbatim were able to score a 6 based on the clarity of their writing.

Table 4.7.

Screenshots from G10 screencast

Slide #	Screenshot
1	
2	

3	
4	

<u>Sense of Audience</u>

Students were given the option of either working in the science lab or in the hallway to complete their screencast. Students exhibited a number of behaviors that showed they were aware that they were creating a product that could potentially be viewed by others. The reaction of students to this potential audience was split, with some students experiencing insecurity and stress related to their perceived need to create a mistake-free screencast, while other students made attempts to interact and engage the audience. Those students who experienced anxiety and insecurity expressed discomfort with the narration process, citing reasons such as not liking the sound of their voice or finding the process awkward.

> G5: I don't like talking in mine.
>
> G10: Neither do I. I prefer to use text.
>
> G5: Because I sound like a dying screeching baby.
>
> G10: And I don't feel comfortable with the whole class hearing me talk. And I don't want them to hear me and I don't want to record in front of them. It's awkward.
>
> Interviewer: When you were figuring out how to make your presentation were you thinking about your audience?
>
> G10: Yeah. I felt awkward like recording when we were in the lab. I felt like I don't want to go out in the hall because there's people still there and I don't want them listening. I don't want to do it in the classroom either.

Other students who preferred to type, rather than use voice narration, did so out of a sense of perfection. When asked why he chose to type his screencast, student B7 responded, "I don't know. I just feel like I could mess up something but I feel like if you read it would be a lot easier." Similarly, the girls from one of the focus groups indicated that they felt their screencast needed to be mistake-free.

> G5: I hated doing it at school cause I was recording once and a woman teacher walked by with her heels and all throughout the video you could hear the heels. And in the video it sounds like its quiet but when you actually listen to it there's like a bunch of scuffling.
>
> G9: And background noises. Doors closing and stuff.

G5: There's one slide where I finished my claim and it was a 30-second pause like 'look at the video.'

Interviewer: Did you think talking was faster than writing?

G9: Yes, probably.

G5: No, cause I had to redo it a bunch of times cause when I said substances I always went like 'subances' (*sic*) so I had to do it a bunch of times.

G10: I think it is easier to just type it out.

G5: Yeah, and when you type it I like to make it look nice and then record, because then if people can't understand me they can just look at the screencast.

G10: I think it's easier to just type cause sometimes I go blank.

As shown in Table 4.8, some students acknowledged their awareness of an audience through the use of annotating tools or by thanking their audience for watching. For example, Student B5 used a laser pointer as he was talking to help the viewer understand what he was saying. He explains, "I just read what I typed over due to… umm… certainties that I probably will make a point. I used pointers to help guide whoever is listening."

Table 4.8.

Students Exhibited a Sense of Audience in a Variety of Ways

Description of Photo	Photo
Students who typed their screencasts often did so in a group setting.	

Students who narrated their screencast often preferred to work in a quiet place. This student worked in a corner beneath a lab station to record his screencast.	
This student recorded her screencast in hallway and away from her peers.	
Students who included a ‘thanks for watching’ slide indicated an awareness of a potential audience.	

<u>Discussion of Target Learners</u>

Three of the students who participated in the study were target learners. Target learners are those students who had been identified by their fifth grade teachers as in need of additional support. Target learners meet with an instructional support teacher (IST) bimonthly, during which time they have an opportunity to organize their notebooks and learn study strategies. The purpose of the instructional support process is to provide additional support for struggling learners and to hopefully reduce the possibility of such students requiring special education services. In terms of this study, target learner G11 did not complete her screencast. A second target learner, B2, was able to complete his screencast within the given time frame. Although he incorrectly stated that the unknown powder was a combination of powders B and D, his use of annotations yielded insight into his thinking (Figure 4.2).

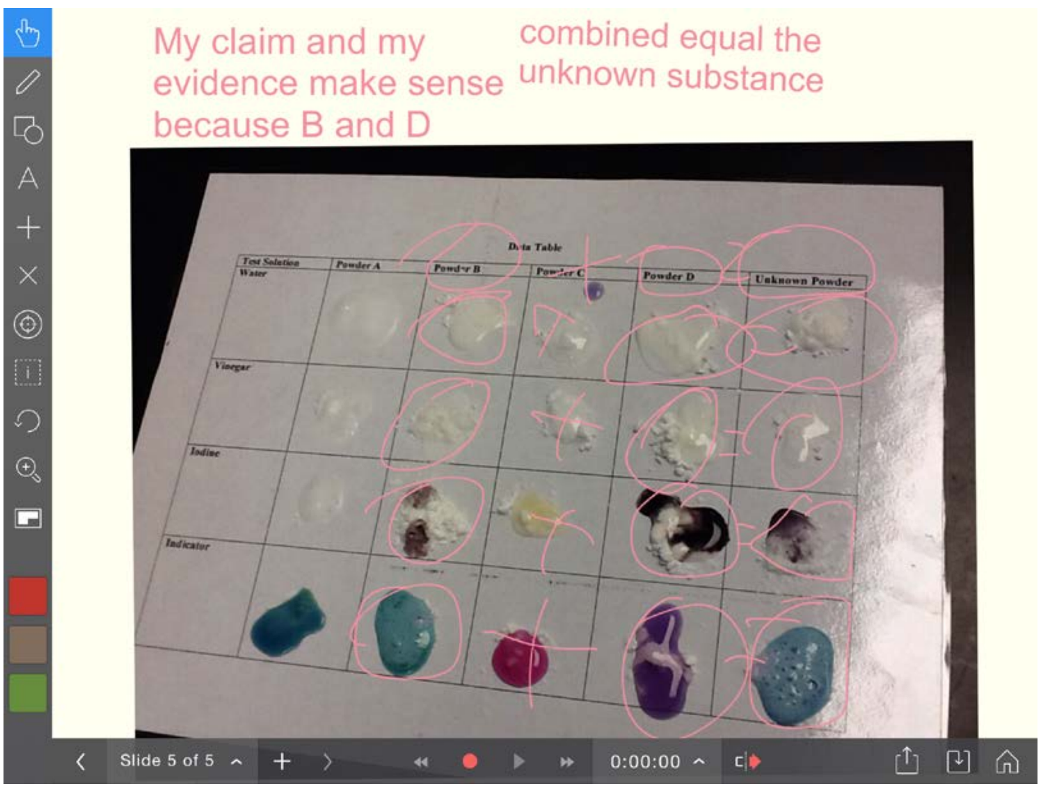


Figure 4.2. Annotations From Target Learner B2 Show Flawed Thinking

A third target learner, G13, demonstrated superior annotation skills while adopting a teaching persona throughout her screencast. Student G13 narrated her screencast for a total of 13 minutes and 44 seconds, surpassing other students who narrated their screencasts for an average of 93 seconds and surprising her teacher with her ability to clearly convey her thinking. The teacher stated:

> This particular student is a student who, when I would give my 5 minute videos at the beginning of the year and we were practicing note-taking and things like that, she would come in with one, maybe two sentences written down and that was her notes for the whole movie. Cause they have to be written down, whereas we know she went on for fifteen minutes talking so there is no way (says ‘no way’ loudly to emphasize) that she would have written anything close to that. Her writing is very minimalistic.

Student G13 goes beyond the requirements of the outline dictated by the storyboard through her inclusion of a slide titled “How did I find the properties for the unknown powder?” Although her thinking is incorrect, she attempts to explain the cause of fizzing when the unknown powders reacted with the liquids.

> So now… umm… let’s talk about how that actually happened. And how that happened is that the carbonation in the bubble from the stuff that we were putting on it formed them, to make them bubble and start to spit caused the atoms in the …um… in the powder …um …had a sorta like almost an allergic reaction but it was a chemical reaction to the…um… liquid we were putting on. And so, since you guys know about that now, let’s shout out all three main properties that you guys think are the main chemical properties for the unknown powder and the….um… the powder B, which is baking soda. So let’s shout them out. One, two, three …fizzing, bubbling, and color changing. That’s the ones that you probably will most see if you did this experiment over and over.

Student G13 also incorporates a rebuttal in her screencast, which demonstrates her ability to create a sophisticated scientific argument. McNeill and Krajick (2012) recommend that rebuttals be introduced only after students are proficient with the claim, evidence, and reasoning framework, since rebuttals are difficult for students who are just learning how to construct a scientific argument. In her rebuttal, Student G13 states “Nobody cares about powder A anymore, or powder C, or powder D.” Using powder C as an example (as shown in Figure 4.3), she then goes on to explain why the unknown powder could not be powder C, stating

> We know it's not powder C but here's an example. So, um, powder C did bubble but powder C is not the unknown powder because the unknown powder because it's yellow. It has to be, um, purple, like dark purple.

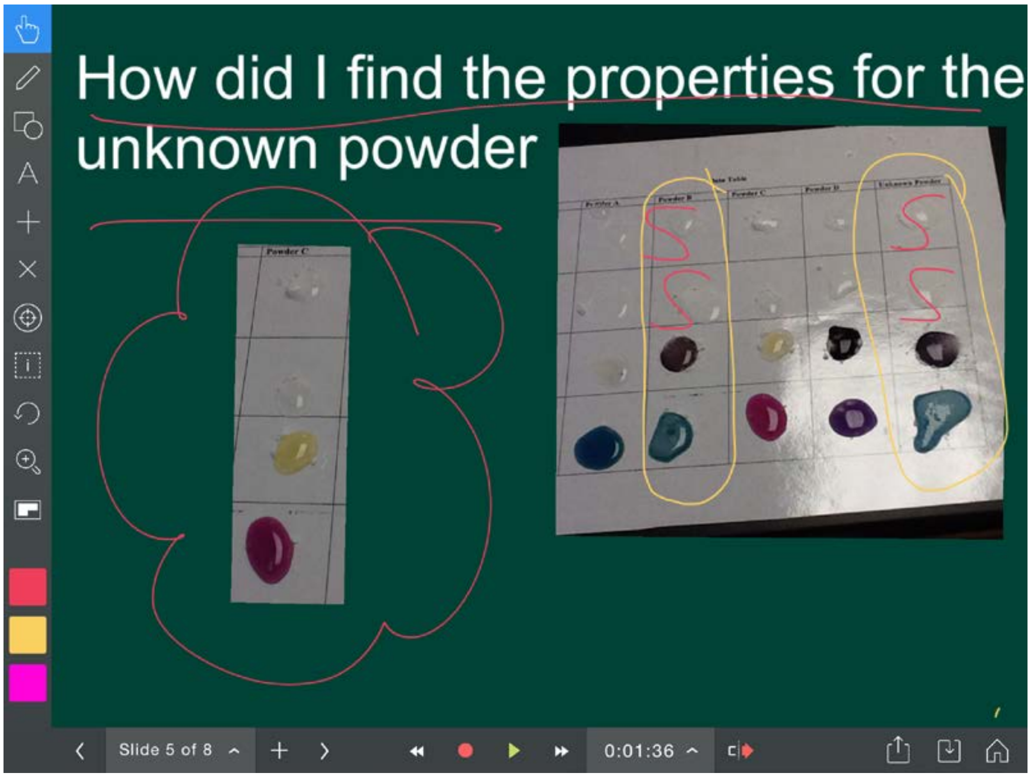


Figure 4.3. Student G13 Used Powder C to Explain Her Reasoning

Student G13 uses annotation throughout her narrated screencast as a way to teach her audience. As shown in Table 4.9, student G13 uses the drawing tool to make her point that powder B and the unknown powder are the same due to similar reactions with the four chemicals. Her advanced use of annotation, which included the ability to switch pen colors and switch between tools while narrating, surprised her teacher.

> I was surprised by her ability to use the app, the types of things that she was doing, like talking while switching pointers and switching between the different things that you can do is very difficult. It took probably four or five videos before I was good at doing that. 'Okay I'm talking while doing that, I have to bring this up on screen and make sure that you know'… it's definitely that dual processing.

> 'I'm talking here, but I also have to be thinking about what I have to bring up next.' And then just the ideas that she had about 'Okay I'm going to explain it, then I'm going to explain it again, then I'm going to quiz the audience to see if they know if I communicated it well enough to them and then wrap it up at the end.' For a student like that, I was blown away by how much she did.

Table 4.9.

G13's Use of Annotation When Discussing Evidence

Student G13 Narration and Corresponding Annotations	Screenshot
"The evidence is that the unknown powder and powder B have a chemical change and they are the same. They are the same because powder B" *(Student draws a circle in white around powder B's reaction to the first chemical)*	
"And the unknown powder" *(Student draws a circle in white around the unknown powder's reaction to the first chemical)*	

<table>
<tr>
<td>“Looks like the same thing for the first one”

(Student draws a two-headed arrow in white between powder B and the unknown powder)</td>
<td>
</td>
</tr>
<tr>
<td>“And then, for the second one, they still have the same reaction.”

(Student circles the second reaction for powder B and the unknown powder in yellow and adds an arrow)

“And now, for the third one, they have purple and they have the same one, too”

(Student circles and draws an arrow in green for powder B’s and the unknown powder’s reaction to the third chemical)

“Then, for the next one, they both turned blue and sort of a green, too, and they equal the same thing.”

(Student circles and draws an arrow in blue for powder B’s and the unknown powder’s reaction to the fourth chemical</td>
<td>
</td>
</tr>
</table>

"Nobody cares about powder A anymore." *(Student draws a squiggly line through powder A)* "Or powder C or powder D. We're just focusing on powder B" *(Student uses pointer tool to point to B)* "Cause they are the same ones. This one, this one, this one, this one, this one, this one, this one, this one, are all the same so you can clearly see they have a chemical change because they still have the chemical properties still in them while they are changing. And that is my evidence." *(Student uses the pointer tool to point to a specific reaction when saying 'this one')*	

Student G13 is aware of a potential audience but does not appear to be bothered by it. She appears to welcome an audience, at one point saying, "Alright, how did I find the properties for the unknown powder? Well, I'm gonna tell you." As the screencast progresses, the student takes on a teaching persona, using the screencast as an opportunity to educate others.

> We have to write a big S for the change of colors *(she writes an S in red to indicate same over test 3 and 4 for powders B and for the unknown powder).* Now, *(scribbling in yellow over powders A, C, and D)* let's write some of the properties down. So, let's write fizzing *(writes the word fizzing in red)* and then color *(writes the word color in red)* and then let's write miny (*sic*) explosion because when you put your hand over some of the …the um…the powders, like

> for this one, these two *(she scribbles over tests 1, 2, and 4 on powder B and on the unknown powder. She then circles test 3 for both powder B and for the unknown*)…if you put your hand over it you would feel the bubbles so let's write bubbly *(she writes the word bubbly).*

Still in teaching persona, G13 instructs her viewers, "So you need to make sure that you list the fizzing and the color changing and bubbly (G13 circles the words fizzing, color, bubbling in blue) cause those are actually three of the main important things for the chemical properties." Later in the screencast, student G13 quizzes the audience, "Now pause the video guys, and I'll give you some time to think and you guys can think of what it is."

When compared to her peers, G13's use of annotating tools, coupled with her sophisticated argument, was unique. What made this case even more remarkable was the fact that G13 is a target learner who has been diagnosed with Attention Deficit Disorder. According to the participating teacher, G13 performed poorly in all of her academic classes for the first third of her sixth grade year. Her performance stimulated a meeting between G13's team of teachers and G13's parents, during which time it was recommended that G13 be tested for special education services. The meeting occurred one day prior to the participating teacher and I evaluating G13's screencast.

<u>Summary</u>

Using a base rubric by McNeill and Krajick (2012), an analysis of twenty-four screencasts of scientific arguments was conducted. Results indicated that 41.7% of the students were able to make a complete and accurate claim linking the identity of an unknown powder to chemical and physical properties; a similar percentage (45.8%) held true for the reasoning portion of the rubric. When comparing the individual scientific argument components, the evidence portion of the scientific argument was strongest, with

58.3% of the class incorporating sufficient and complete evidence. In general, students who submitted complete and appropriate claims were more likely to submit sufficient and appropriate evidence and sufficient and appropriate reasoning, while students who submitted partial claims were more likely to submit partial evidence and partial reasoning.

Analysis of screencasts also revealed that students chose one of three approaches for presenting their scientific argument: (a) presentation of a text-only argument, (b) reading the argument verbatim as it appeared on the screencast slides, or (c) narrating their scientific argument. Although narrating the scientific argument did not necessarily mean a greater level of sophistication, students who chose to narrate their scientific argument scored an average 5.0 out of 6.0 on the base rubric, surpassing those who only provided text or who restricted themselves to reading the text verbatim. Students who narrated their screencast frequently utilized annotating tools as they spoke and addressed the viewer. Some students expressed anxiety with narrating their screencast or preferred using text because it was easier to eliminate mistakes. Among the students who participated were three target learners; one struggled to complete the assignment, a second student who was able to complete a partially correct scientific argument, and a third target learner who supported her sophisticated narrative with annotation. Her acute sense of audience led her to adopt a teaching persona that engaged her in teaching and quizzing the audience.

Research Question #3: How Do Students Utilize Evidence Collected via a Mobile Device to Support Their Claims?

Three basic patterns emerged regarding student approach to utilizing digital evidence collected during the laboratory activity. These patterns could be described as: (a) evidence used to add visual interest, (b) evidence used to support observations, and (c) evidence used to support inferences. These patterns were identified as a result of two separate analyses. Evidence from the individual screencasts was initially analyzed and categorized by the participating teacher and the researcher as being either an observation or an inference. In order for a student to have used data to support inferences, students needed to clearly link the reactions of the unknown powder to the reactions of one of the known powders to water, vinegar, iodine, and a pH indicator. When examining the use of evidence, 54.2% (13 students) used evidence to support their observations. The remaining 45.8% (11 students) used their evidence in an inferential manner.

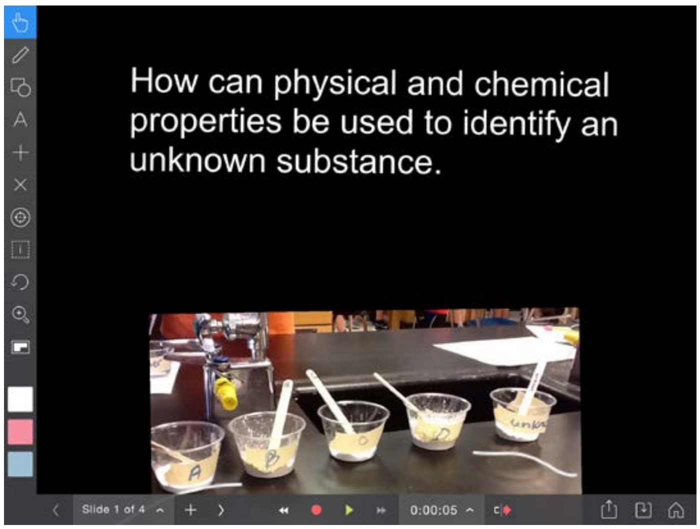
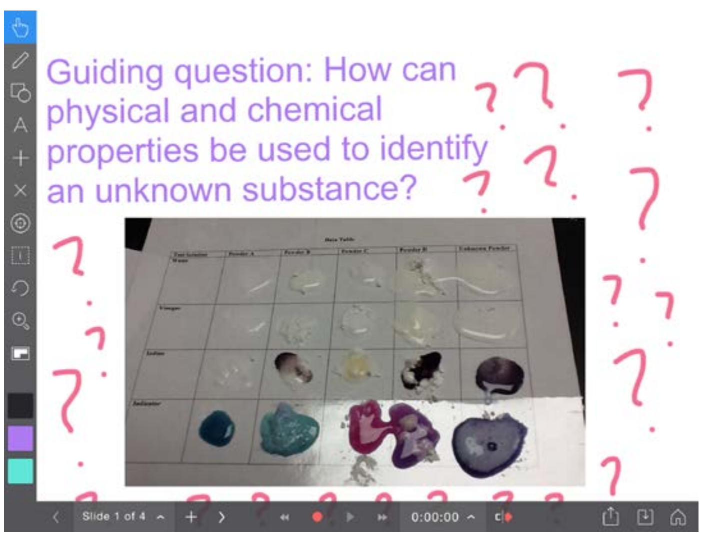
After the evidence had been classified as being used in an observational or inferential manner, I re-examined each piece of evidence to develop an understanding of its role in relation to the particular slide that housed the evidence. This was accomplished by comparing the evidence to any text, reading, or narration that accompanied the slide.

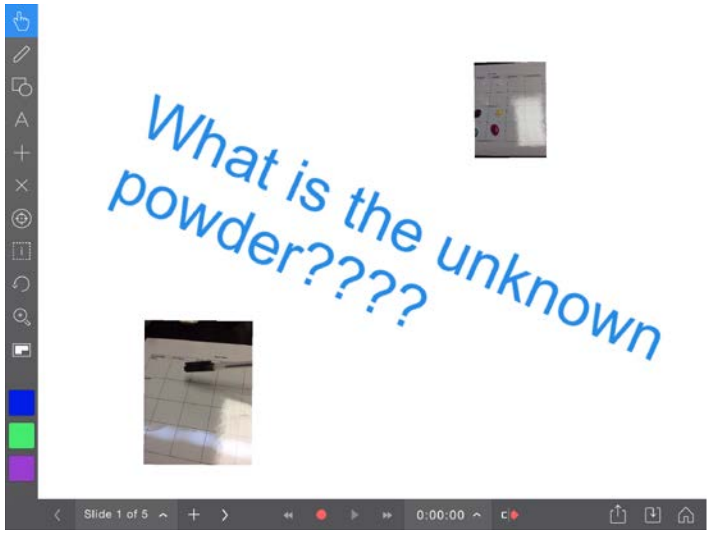
Evidence Used to Add Visual Interest

Eleven students, or 45.8% of the class, included pictures that served no obvious purpose in the construction of their science argument (Table 4.10 depicts examples of evidence used for visual interest). The inclusion of evidence used in such a manner most frequently occurred on the first slide in which students either wrote or stated the guiding question, students made no written or verbal references to the pictures. The most commonly used pictures were those depicting lab materials or those that featured the completed data table showing the chemical reactions. Some students cropped the pictures, which allowed them to position more than one on the slide.

Table 4.10.

Use of Evidence for Visual Interest

<table>
<tr><th>Description of Screenshot</th><th>Screenshot of Evidence</th></tr>
<tr><td>The most commonly used pictures that students used for visual interest were those depicting lab materials.</td><td>
</td></tr>
<tr><td>This student added visual interest to her first slide by incorporating the completed data table showing the chemical reactions.</td><td>
</td></tr>
</table>

Some students cropped the pictures, which allowed more than one picture to be used on the slide.	

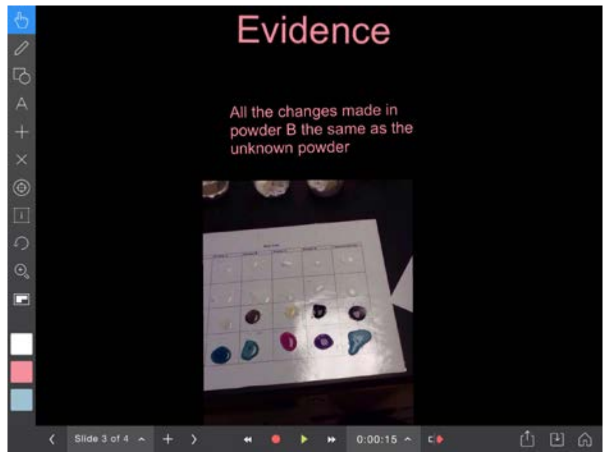
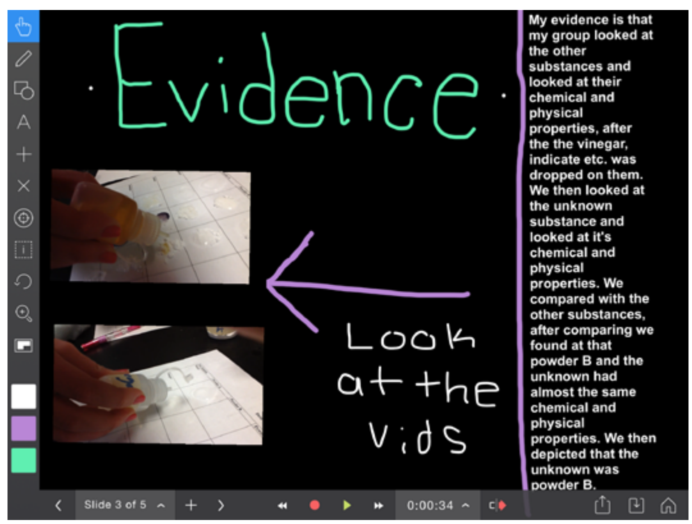
Evidence Used to Support Observations

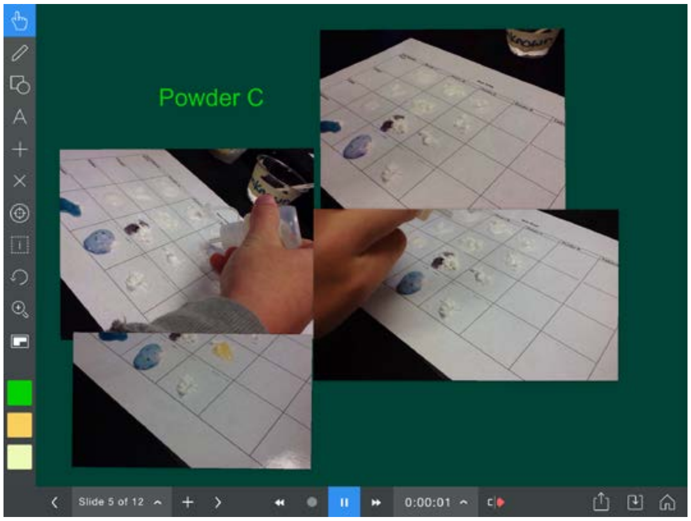
Students also used digital evidence, both pictures and video, to support their observations. Students who used evidence to support observations often fell short of explaining how the evidence connected to the phenomena observed during the laboratory activity. For example, some students read the text on the slide but did not clearly link the text to the evidence. As shown in Table 4.11, Student B9 read, “All the changes made in powder B are the same as the unknown powder,” but he never refers to the picture present on the slide. Student G5 also read the text on her slide and when finished she drew an arrow saying, “Look at the vids” as a way to draw the viewer’s attention to the evidence. The use of evidence in this manner provides little insight into student thinking and requires the viewer to create his or her own inferences from the evidence.

Some evidence that was incorporated into screencasts was done so for an unclear purpose. For example, the screencast created by student B8 includes slides consisting of a mix of pictures and video. He does not, however, specifically reference the images and videos, leaving it to the viewer to connect how the evidence justifies his claim. Table 4.11 contains screenshots of evidence used in an observational manner rather than an inferential manner.

Table 4.11.

Evidence Used to Support Observations

Student	Screenshot of Evidence
Evidence from student B9	
Evidence from student G5	

Evidence from student B8	

<u>Evidence Used to Support Inferences</u>

A third approach for using evidence was to use it to support inferential thinking. Making inferences refers to the ability to make an explanation from an observation, whereas observation refers to something that can be perceived by the senses. In the case of the Mystery Powders Lab, although nearly all of the students correctly surmised that the unknown powder and powder B were the same, they did not necessarily use the evidence in an inferential manner. Students primarily used their sense of sight to determine the reaction that a specific powder had to a specific liquid; it was up to the individual student to infer findings based on their observations. This required the student to clearly link the reactions of one of the powders to the reactions of an unknown powder. For example, statements such as "In this picture, it shows that the unknown substance and substance B have the same reaction to water" demonstrate that the student inferred the identity of the unknown powder by using what they knew about how the known powders reacted to water. Similarly, in the statement below, the student compares specific reactions of the unknown powder to the known powders:

> This is a picture of powder B and the unknown. In the first one they both made powdery water and kind of bubbled. They fizzed and dissolved in the second one. In the third one they changed from a yellow to a purple. In the fourth one they fizzed and started purple and changed to blue. My evidence goes to show that this is how you identify an unknown substance. I did the experiment and the unknown and B matched by their chemical changes.

As shown in Table 4.12, nine of the 11 students who had used evidence in an inferential manner were deemed to have provided appropriate and sufficient evidence to support their claim. Students B2 and G3 were the only students who used evidence in an inferential manner and received a partially correct score of 1. These students, who worked in the same lab group, incorrectly identified the unknown powder as being a mix of powders B and D. It is unclear why these two students came to this conclusion in light of the fact that their evidence does not support the findings. Analysis of student G3’s narrative indicates that she chose to ignore the test results related to the pH indicator, which led her to an incorrect finding. She states:

> For the unknown powder it turned black and hardened onto the powder. Also, when we put the indicator on it, it turned blue for powder B and for powder D it turned purple and fizzed and for the unknown powder it turned blue and fizzed.

Table 4.12.

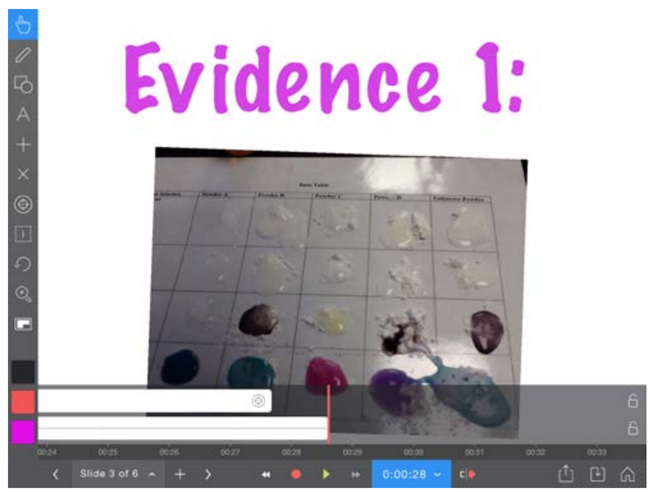
Use of Evidence According to Evidence Score

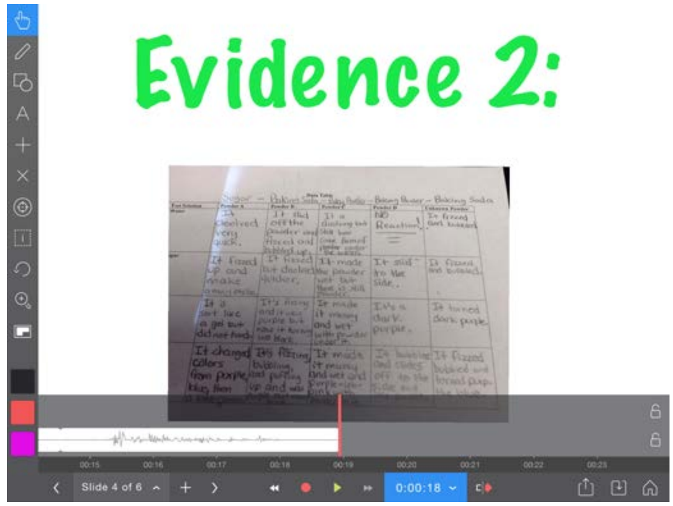
Evidence Score	Inferential	Observational
0	NA	NA
1	2	8
2	9	5

It is important to note that the ability to provide appropriate and sufficient evidence was not contingent on a student's ability to use the evidence in an inferential manner. Even though they used evidence in an observational manner, Table 4.12 shows that five students were able to provide appropriate and sufficient evidence to support their claim. For example, as the screenshots in Table 4.13 show, student G2 is able to provide both sufficient and appropriate evidence through her inclusion of the reaction data table and her written data table. In her narration she uses the evidence in an observational, rather than inferential manner.

Table 4.13.

G2 Uses of Sufficient Evidence

Narration	Screenshot
"As you can see for the first box of powder B, the unknown powder did the same thing. For the second box the unknown powder dissolved, too. For the third box they both turned the same color and for the fourth box both of them turned green after a while. That's why I think B is the unknown powder"	

"If you see in the table you can see each box for powder B and the unknown powder. They both did the same thing."	

<u>Annotating the Evidence</u>

Eleven of the 24 screencasts (45.8%) were determined to have included evidence that was inferential in nature. What distinguished the authors of these eleven screencasts from their peers was their use of annotation when describing the evidence. Students annotated the evidence by either drawing on it, highlighting it with the laser pointer as they read the text, or by cropping the picture for the purpose of making explicit the similarities between the reaction of powder B and the unknown powder to various liquids. The addition of annotation clarified student thinking and had the added effect of assisting the viewer in understanding the observed phenomena that had occurred during the experiment. Students had not been instructed in the use of annotation tools, nor had they been told to annotate the pictures. The teacher viewed the use of annotating by students to be innovative in nature:

> I think that was really interesting that some of them really took off on that. And the different ways that they annotated…some drew on the pictures, some people cropped the pictures so that you only saw the one portion, some people used the pointers to point out what they were talking about. So that was interesting to see the different varieties of ways that people discussed those pictures.

Students who chose to annotate digital photographs frequently used the completed reaction data table to compare the results of the unknown substance to the results of the other substances. For example, as Student G9's states in her screencast, "I think the unknown powder is the same as powder B because they had the same lab results." She then uses the pen tool to circle the reaction of powder B and the unknown powder, which helps the viewer to understand her thinking (see Figure 4.4).

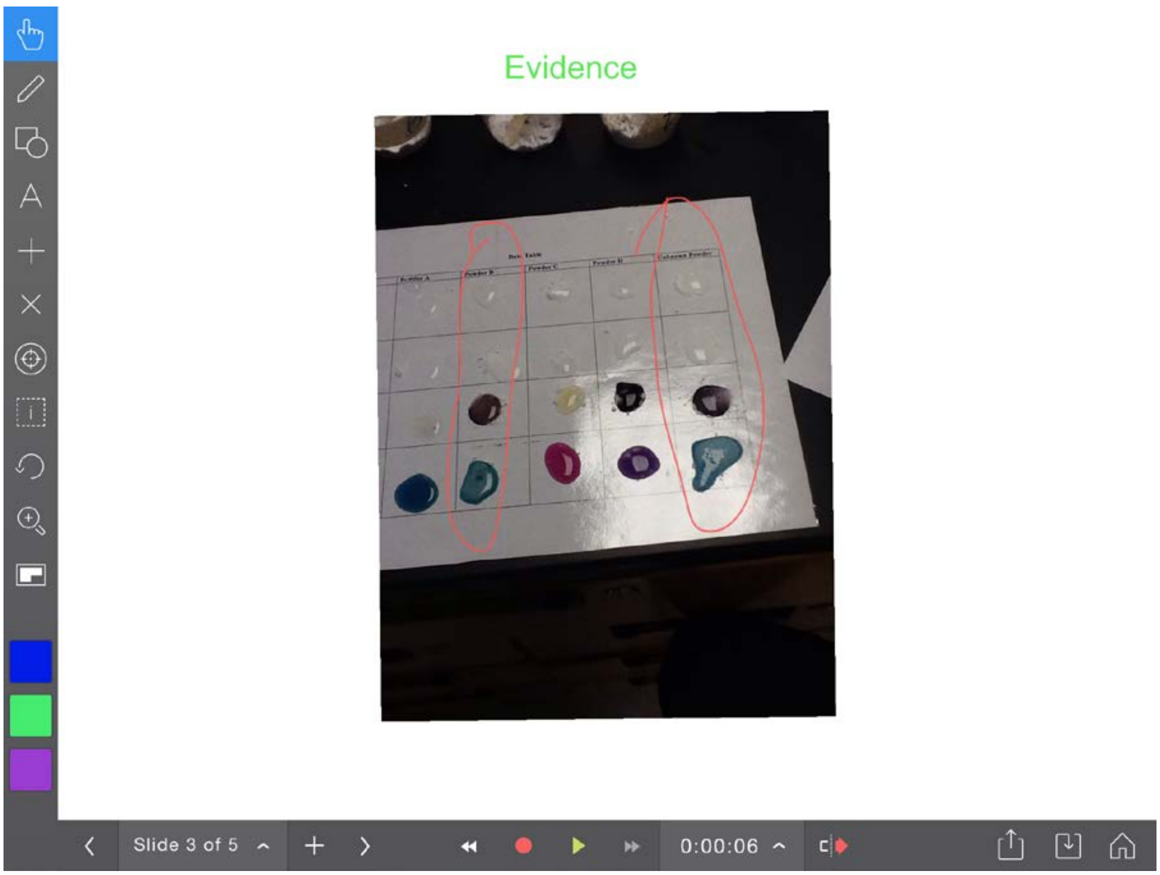


Figure 4.4. Student G9 Annotated Her Evidence

In addition to using a picture of the data table showing the chemical results, some students also incorporated a picture of the written data table as evidence. For example, student G4 places both of the data tables on her evidence slide and draws arrows with an equal sign to show the viewer that powder B and the unknown powder were the same (see Figure 4.5). She does not refer to the pictures, stating, “My evidence is that when you look at two different objects and then you use their physical and chemical…um…properties to define them by experimenting with them, you can recognize changes are the same and different in …um…other substances.”

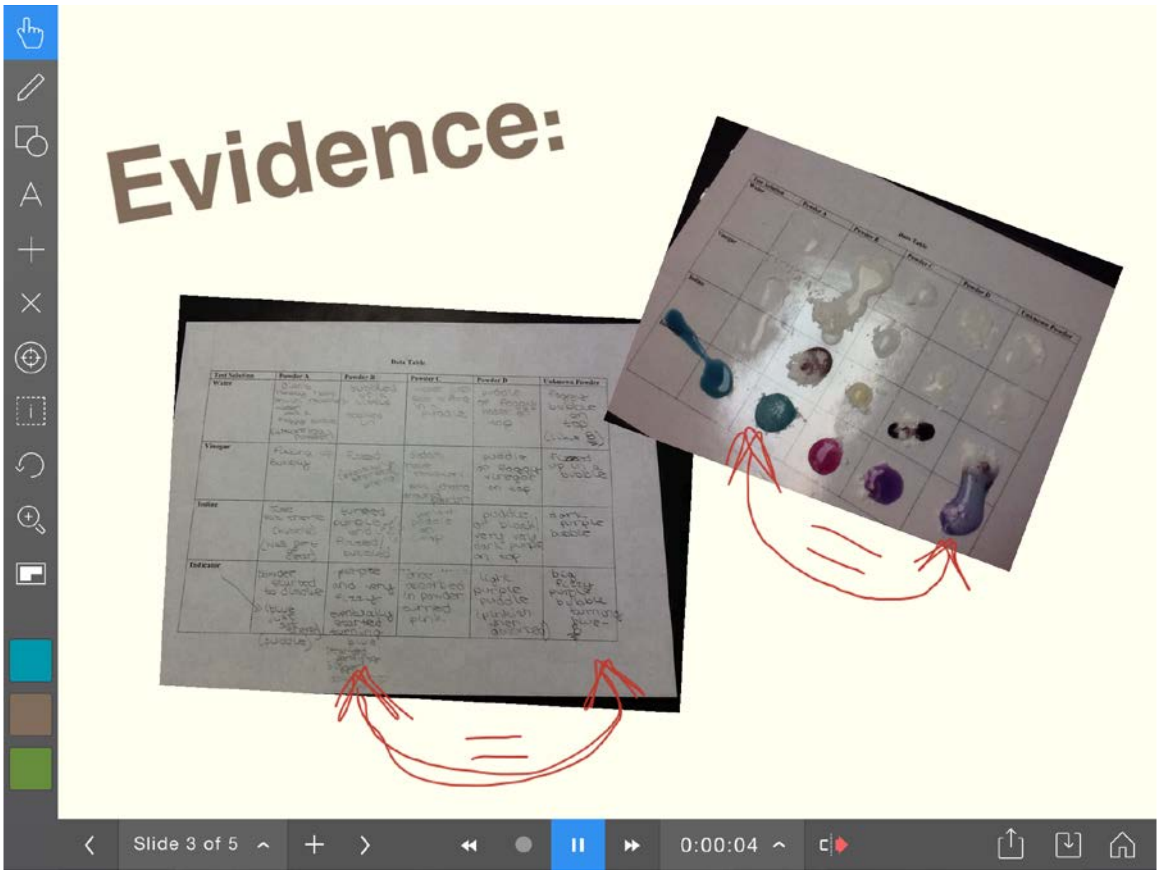


Figure 4.5. Evidence Provided by Student G4

Although most students who incorporated annotation into their screencast restricted themselves to annotating photographs, student B4 narrated over videos to explain what was happening. Student B4’s evidence slide contains four videos, two of which he plays during his screencast (see Figure 4.6). As he plays the first video student B4 can be overheard stating, “Here’s the reaction powder B had to the indictor. It’s starting to fizz and it’s purple and bubbly.” In the second video he says, “Here’s the reaction the unknown powder had to the indicator. As you can see they are pretty similar. They are both purple and fizzing and bubbly." Annotating over videos through narration allowed student B4 to demonstrate his inferential thinking.

Figure 4.6. Student B4 Narrated Several Videos as Evidence

Summary

Students used one of three approaches when incorporating digital evidence into their screencast: (a) the evidence served no apparent purpose other than to add visual interest, (b) the evidence was used to support observations, or (c) the evidence was used to support inferences. Typically, when using videos and photographs to support observations, students made no reference to their evidence, leaving it up to the viewer to connect the evidence to what the student had written or said in the screencast; 54.2% of the students incorporated some digital evidence for use in this manner. Since the Mystery Powders Lab was one that required inferential thinking, the use of evidence in this manner did little to provide insight into student thinking. The 45.8% of the students whose screencasts demonstrated inferential thinking did so by using tools such as the laser pointer and the pen tool to annotate the digital evidence. Annotations lent insight into student thinking and helped to clarify how observational evidence could be used to infer the identity of an unknown powder based on the chemical reactions of known powders to various liquids.

Research Question #4: What Are Student and Teacher Perceptions of the Value of Using a Mobile Device to Create Science Arguments?

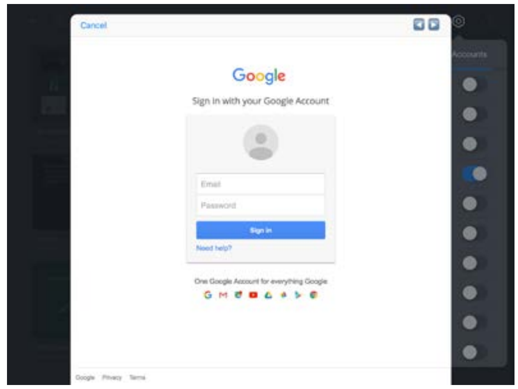
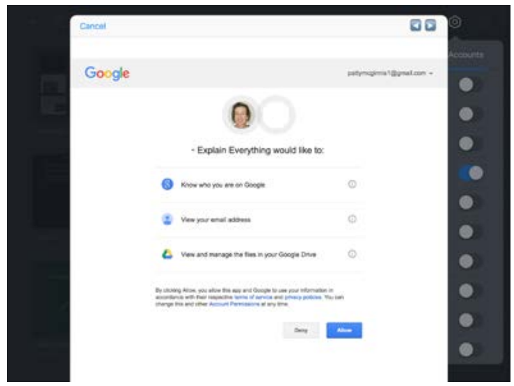
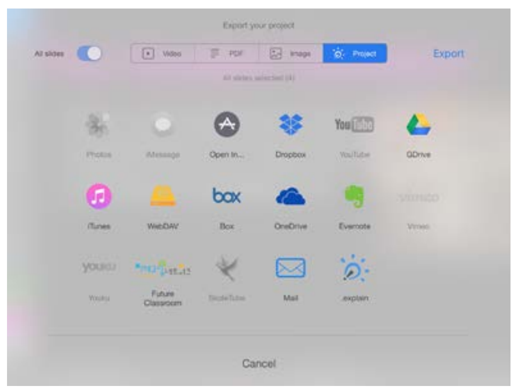
Interviews with both the participating teacher and with the two student focus groups yielded insight into their thoughts regarding the use of the technology to create scientific arguments. Many of these comments were related to workflow issues that arose when using Explain Everything as a tool for engaging students in creating screencasts of science arguments. Since the iPads were being used by two of the teacher's classes, students were required to upload their Explain Everything slides at the end of each work session. The goal in doing so was to enable students to access their work from any iPad that contained the Explain Everything app. This action had the additional benefit of ensuring that student work would not be lost in the event that another student accessed the iPad and accidently altered or deleted another student's work.

During the pilot screencast, problems arose related to the fact that students were sharing iPads. Previous to this study, students had been taught to access their Google Drive using a Google Drive app loaded on the iPads. It was discovered that projects uploaded via the Google Drive app often ended up in the Drive of students who had not logged themselves out of Google Drive on the iPad. In order for Explain Everything projects to be uploaded to the correct Google Drive account, students had to log into their Google Drive through the Explain Everything app; this process, depicted in Table 4.14, required several steps and was confusing for students due to its complexity. Student B7, who had experienced a problem with exporting said, “I had a bunch of difficulties because one time I forgot to export my video of the whole entire project. And it only saved on one iPad so I had to look everywhere for it.” Student B8 confirmed the problems with exporting by saying, “My only problem was exporting. It was kinda complicated to do that.”

Table 4.14.

Screenshots of Steps Required to Upload Screencasts to Google Drive

Description of Steps	Screenshot
1. In the settings section of Explain Everything, the Google Drive account needed to be turned on.	

2. Next, students needed to log into their Google Drive through Explain Everything.	
3. For the third step, students needed to select 'allow' to allow Explain Everything access to their Google Drive.	
4. Finally, students were required to select project, open Google Drive, and export the project	

Additionally, projects that were not properly saved often resulted in lost project slides, which resulted in frustration. When asked about the types of difficulties they encountered, the girls in one of the focus groups stated:

> G10: When Explain Everything deletes my projects it makes my life a lot harder.
>
> G9: Probably taking it and saving it to Drive and then reopening it and re-accessing it. And just the whole moving it from Google Drive to another iPad and

> loading it on. Every time I had to ask somebody else ‘How do you do this again?’ Remind me about this one more time because I can never remember that kind of stuff.
>
> G5: I wish we didn’t have to put it in Google Drive. Like we could just go on to the Explain Everything and add new video or something.
>
> G9: And then it saved in something littler [*sic*] like Explain Everything and you could just go. And because you have to log into Google Drive and that takes like 5 minutes to 10 minutes depending on how long it takes.
>
> G5: And sometimes you save it on someone else’s Drive.
>
> G9: I probably would prefer to do something like, I know a lot of people would disagree with me on this…I probably would prefer to do it on paper because I can never remember how to use technology.

When asked about the workflow issues, the teacher stated:

> I like this technology of Explain Everything, but I would definitely re-think the whole workflow. It’s definitely, at least in the beginning it’s too much of a workflow for them to overcome. But just like what we want with the kids, I think I was learning the most was when I was frustrated. I had to work through it and just like we do with the kids ‘I know you’re frustrated, work through it, figure something out’ and you know, it worked out really well.

Despite the frustrations encountered, students were overwhelmingly positive about the experience. Students who completed an exit slip stated that they enjoyed using Explain Everything because “You can make really cool presentations,” “It was pretty fun to do,” and “It is a different way to show people what you are thinking.” Although some of the students experienced frustration at times, it is important to note that for many students the end product was worth the difficulties they experienced. Student G10 summarized her thinking by saying, “It’s kind of frustrating to like add things and stuff and you have to go through all the steps. It’s just kind of hard but I like the final product.”

The enthusiasm for using screencasting as a tool even carried over into other classes as students experimented with using the Explain Everything app for other projects:

> Interviewer: Would you want to do another project like this?
>
> B8: Yes. I actually chose to do my poem for reading on Explain Everything.
>
> Interviewer: And is that because of what we had done in science class?
>
> B8: Yeah.
>
> Interviewer: Did you have to read the poem?
>
> B7: Yeah, and he put music in it and he got the light saber pointer and he pointed it as you're reading it. But it was the whole entire song and so the song was playing. Then it shows this paper there and he got the pointer and you could listen and read.

The teacher was also positive about the use of mobile technology, stating that he is planning to let his other classes explore using the iPads to document data for their spring science project,

> I think I'm going to show this to my classes when it comes time for science night because I think a lot of them really get interested in projects but it's hard for them to come up with a way to describe qualitative data.

When asked about the use of mobile devices to screencast a science argument, the teacher indicated that he would show the students more examples in the beginning of the project. "I think before I didn't know what a good example looked like, so now that we've done this I can pick some of these and tell the students this is what a good example would look like." In terms of student learning, the teacher valued the ability to playback the screencast for analysis. "I think that's kind of neat having that clear record that the students can play back and listen to."

<u>Summary</u>

Sharing iPads between students resulted in workflow issues that required students to navigate through several screens in order to upload and retrieve their projects. This created frustration for some students who lost portions of projects or who had difficulty following the upload process. Despite this, students valued their final products and enjoyed the opportunity to demonstrate their thinking via a screencast. The participating teacher acknowledged that workflow issues were challenging, but that mobile technology is a valuable resource for collecting data during laboratory activities.

Chapter Summary

This chapter presented the findings of a study that engaged a sixth grade science class in producing screencasts of a scientific explanation for the purpose of understanding how mobile technology can be used to support science practices. The results pertaining to each of the four research questions were addressed. Students used iPads to collect digital evidence in the form of photographs and videos that were taken during a guided laboratory activity. A total of 141 photographs and 68 videos were taken by individual videographers, whose job it was to document the evidence for their student group. Although this was accomplished with a minimum amount of planning, analysis of the photographs and videos showed that students were engaged in capturing chemical reactions as they occurred.

Each student used the digital evidence in their screencast, which was evaluated using a base rubric by McNeill and Krajcik (2012). Although all students correctly surmised that the unknown powder was powder B, only 41.6% of the students made a correct claim that linked the powder's reaction to physical and chemical properties.

Students who included an appropriate and complete claim were more likely to have incorporated appropriate and sufficient evidence and appropriate and sufficient reasoning into their science argument. Digital evidence was used to either add visual interest to the screencast, support observations, or support inferences.

Students adopted one of three approaches for presenting their science argument, either choosing to rely entirely on the text to communicate their thoughts, to read the text verbatim, or to narrate their thinking. Narrated screencasts were often accompanied by the use of annotations, which students used to convey their inferential thinking. Among the students who submitted screencasts were three target learners, one of whom created a sophisticated argument during which she used annotations to instruct her audience.

Although students enjoyed using Explain Everything to create their screencast, there were some problems related to workflow. Chapter five provides an analysis of the results, implications for teaching, and potential areas of additional research.

CHAPTER 5: DISCUSSION OF RESULTS AND CONCLUSIONS

This chapter is organized into several sections, beginning with a summary of the study, including a review of the research problem, research questions, and methodology. A review of the major findings as they pertain to each of this study's research questions is then discussed. This is followed by implications for teaching as related to using mobile technology for data collecting and scientific argumentation in the middle school science classroom. Suggestions for areas of future research regarding the integration of mobile technology as it relates to scientific practices are addressed, followed by a conclusion section.

Summary of the Study

The adoption of the NGSS includes a call for teachers to utilize science practices in a manner that approximates that of scientists (National Research Council, 2012). Among those practices is that of scientific argumentation, a practice that is often ignored within the K-12 science classroom (Sampson & Blanchard, 2012; Sampson & Schleigh, 2013). Argumentation requires students to support their claim with both evidence and scientific reasoning. This claims-making process is similar to that which occurs in the scientific community (Lead States, 2013b).

Since middle school students struggle with argumentation, possibly as a result of the complexity of the writing process (Stay, 1985), allowing students the opportunity to create an oral argument may be a viable alternative to written arguments. This study introduced students to the use of screencasting for argumentation. Screencasting is a relatively new technique that allows the user to capture their laptop or computer screen (Educause, 2006). Teachers have primarily used screencasts to create tutorials for students (Educause, 2006), but some educators are beginning to explore their use by students (Soto, 2014). The development of downloadable apps for mobile devices provides users with the ability to capture and interact with the screen content on their device. The use of the app Explain Everything, which was used for this study, allows the user to import digital material, narrate, and annotate for an interactive experience.

This study was conducted to assess the possibility of using screencasting as a method for engaging middle school students in scientific argumentation. Unlike previous studies pertaining to student-created screencasts, this study explored the use of mobile devices in capturing evidence during a laboratory exercise and examined how students used the evidence to support their scientific arguments. The following research questions were explored during this study

1. What are the characteristics of student-collected evidence when using a mobile device during inquiry?
2. What are the characteristics of screencasts when using an app installed on a mobile device to create student arguments?
3. How do students utilize evidence collected via a mobile device to support their claims?
4. What are student and teacher perceptions of the value of using a mobile device to create science arguments?

Twenty-five sixth grade students from a school in a suburb of southeastern Pennsylvania participated in the study. Several activities were carried out in the classroom prior to data collection and analysis. These included introducing the Explain Everything app and practice with the CER Framework developed by Krajcik and McNeill (2009). The data analyzed for this study involved digital evidence captured via iPads of a guided laboratory activity that engaged students in identifying an unknown powder. Following the lab activity, each student used the Explain Everything app to create a screencast that answered the guiding question "How can physical and chemical properties be used to identify an unknown substance?" Students were scaffolded through the argumentation process with a storyboard that had been modified using a science writing heuristic from Keys et al. (1999).

The data corpus for this study included: (a) digital evidence collected by students during the laboratory activity, (b) student-created screencasts, (c) observations, (d) a teacher interview, (e) two student focus groups, (f) field notes, (g) photographs, and (h) exit slips. A qualitative content analysis method was employed for the purpose of identifying findings related to the use of iPads for collecting digital evidence. Similarly, student screencasts and the use of digital evidence were analyzed using qualitative content analysis, as was student and teacher opinion regarding of the use of screencasting scientific arguments. Triangulation was achieved through the use of multiple data sources. Measures such as the use of an independent auditor who examined the results and findings, evaluation of screencasts by two raters, and member checks were employed to increase the study's trustworthiness.

Research Question Number 1: What Are the Characteristics of Student-Collected Evidence When Using a Mobile Device During Inquiry?

One of the affordances of mobile technology is that it allows users to capture images and record data (Hesser & Schwartz, 2013; Pendrill et al., 2014). During this study one student in each lab group was designated as videographer and instructed to document evidence in the form of photographs and/or video during the Mystery Powders Lab. The evidence was shared with the group members via a folder in Google Drive.

Finding: Students Exhibited Lack of Planning When Using the iPad to Capture Digital Evidence

In order to ensure that the results reflected the students' decision-making process, the students in this study received no direction regarding the type of evidence to capture with the iPad. Despite this, all of the lab groups approached the task in a similar manner via careful documentation of chemical reactions that occurred during the laboratory activity, with the seven laboratory groups collecting an average of 20.1 photographs and 9.7 videos. One of the commonalities of all groups was the spontaneous matter in which the iPad was used to capture evidence. There was little discussion or pre-planning regarding data collection, with much of the decision-making left up to the individual videographer. The groups did not work together to narrate the videos or to develop a method for identifying the specific reactions occurring in the photographs, leaving the decision-making up to the group's videographer. This resulted in evidence that was essentially useless in supporting claims, indicating the need for students to be scaffolded through the data collection process.

The results from this study indicate that students need to be taught how to utilize mobile devices in an optimal manner when engaged in data collection. Careful identification of data is an essential science practice. Actions such as teaching how to annotate data as it is collected, requiring student lab groups to develop a plan for collecting data prior to conducting a lab, and limiting the total number of photographs and videos that can be taken may result in more thoughtful decision-making regarding the types of evidence that should be documented. These recommendations have the added effect of promoting productive group discussion, thereby capitalizing on the benefits of social constructivism, a learning theory in which students construct learning via social interaction (Duffy & Cunningham, 1996).

The absence of identified studies that assess the use of mobile devices for data collecting during science activities makes it difficult to compare results of this study to previous studies; however, the use of technology for creating tags, titles, or audio notes that describe student-collected evidence should be considered. The use of an application designed to organize student-collected data should also be explored. *Zydeco* is one such application that was created by researchers from the University of Michigan. It has been recently released as a free application and is available for download from the iTunes app store. The use of *Zydeco* by middle school students has been found to support data interpretation and allows for easy retrieval and sorting of data sets (Kuhn et al., 2012). Although *Zydeco* was originally developed for use in the field, its use in the traditional lab setting may be a solution for annotating student-collected data.

<u>Finding: There Was Some Confusion Regarding the Responsibilities of the Videographer</u>

Mobile technology has been used successfully with K-12 students to capture data in the field. For example, a project conducted with high school students who took pictures of reptiles in the field was accomplished by assigning one student to act as the "photojournalist." The student groups then jointly decided upon hashtags for the photographs prior to publishing them to an Instagram account for sharing with the public (Huffling et al., 2014). For the students involved in this study, integrating the iPad into the laboratory setting resulted in some misconceptions regarding individual student responsibilities. Some videographers appeared confused about their role in the lab group, with at least two of the seven videographers restricting themselves to recording only digital evidence and not recording information on their individual data sheet. This indicates a need to clarify individual group roles so that each student understands the expectations regarding both their expected contribution to the group and the individual accountability they are required to demonstrate. It is important to note that when students are engaged in collaborative work, it is not unusual for misconceptions to arise regarding assigned tasks (Science Education Resource Center, 2011). Reviewing expectations or clarifying procedures is a recommended approach when addressing misconceptions related to group roles (Science Education Resource Center, 2011).

Research Question #2: What Are the Characteristics of Screencasts When Using an App Installed on a Mobile Device to Create Student Arguments?

Students in this study used the app Explain Everything to create scientific arguments for the guiding question "How can physical and chemical properties be used to identify an unknown substance?" A total of 24 screencasts were submitted to the teacher via Google classroom; although the class consisted of 25 individuals, one student had suffered a concussion and was unable to complete the activity due to limitations placed on him by his physician. Screencasts, which were submitted as an Explain Everything file, or XPL file, were evaluated using a base rubric developed by McNeill and Krajcik (2012). Students were expected to integrate digital evidence collected during the Mystery Powders Lab into a scientific argument that demonstrated their ability to connect observations to physical and chemical properties.

Finding: The Use of a Storyboard Template to Organize Student-Created Screencasts of a Scientific Argument Was Partially Successful

This study engaged students in the creation of screencasts that depicted their science argument for the guiding question "How can physical and chemical properties be used to identify an unknown substance?" The construction of claims and evidence is vital to the argumentation process, but students are weak in these skills (Cho & Jonassen, 2002). Students were scaffolded through the argumentation process using Krajcik and McNeill's (2009) CER Framework. Their framework, which is based on Toulmin's (1958) model of argumentation, provided a template for organizing arguments. This study required students to include a claim, or conclusion based on facts, evidence that supported the claim, and scientific reasoning that connected the evidence to the claim. Since argumentation was a newly introduced skill with which students had limited experience, the inclusion of a rebuttal was not required.

All of the screencasts followed a similar progression in which students identified the guiding question, made a claim, provided evidence, and supported their claim with evidence linked to the reasoning. This format followed the sequence outlined in a storyboard that students completed prior to creating their screencast. The common approach exhibited by students when creating their screencasts indicated that storyboarding their thoughts prior to screencast creation helped to scaffold students through the process of organizing their argument. This was not surprising, given that the use of storyboards is recommended for helping students organize their work prior to creating digital multi-media objects such as slow motion, stop motion, and videos (Hoban & Nielson, 2010; Hoban et al., 2013; Hofer & Swan, 2006).

As noted by the teacher, some students did not fully understand that the storyboard was a tool for organizing their thoughts. Rather, they wrote a large amount of text on their storyboard that they then incorporated into their screencasts. Given the fact that many of the students wrote a lot of text, they may have viewed the storyboard as being a script for their narration, rather than serving as an outline for their thoughts. The storyboards created in this study contrasted sharply to those in a study in which middle school girls created storyboards in preparation for creating a computer animation; their storyboards often contained only a picture with little text (Kelleher & Pausch, 2006). It is possible that the students in this study were unfamiliar with the concept of storyboarding, although it should be noted that the students in both studies received little practice with storyboarding.

Finding: The CER Framework Was Only Partially Successful in Providing Sufficient Scaffolding When Screencasting a Scientific Argument

Screencasts were evaluated using a base rubric developed by McNeill and Krajcik (2012). Four students received no credit for their claim because they either failed to make a claim or made an inaccurate claim. Although students had practiced with writing a scientific argument several times prior to this activity and had been provided with a storyboard to scaffold the process, these students may have needed additional scaffolding or time to write a claim. Of the 20 screencasts that included a claim, half contained an incomplete claim that correctly identified the unknown powder but fell short of connecting its identification to physical and chemical properties. Twelve of the 14 screencasts that were either missing a claim or had an incomplete claim also contained insufficient evidence, insufficient reasoning, or both. Of the ten screencasts that contained a complete claim, eight were found to contain sufficient and appropriate evidence and sufficient and appropriate reasoning. It may be inferred from these findings that the quality of the claim has the potential to impact the overall sophistication of the scientific argument. It is important to note that the lack of a claim or the submission of an incomplete claim did not preclude students from receiving full credit for the evidence and reasoning parts of their scientific argument. One student, student G2, was able to include appropriate and sufficient evidence and appropriate and sufficient reasoning. Her omission of a claim was probably due to a mistake she made when using Explain Everything, since analysis of the slide containing her claim reveals a recording containing 13 seconds of silence.

This study also examined how students use digital evidence collected via a mobile device to support their claims. Anecdotal evidence and personal experience has led me to believe that students often do not refer to their data when making claims, observations supported by McNeill and Krajcik (2012) and by Sandoval (2003) who stated “students seem to view data as something to be explained, but not necessarily as a necessary component of an argument” (Sandoval, 2003, p. 41). When evaluating a scientific argument with the base rubric, evidence was deemed sufficient and appropriate if it supported the student's claim. As previously discussed, failure to state a complete claim was often linked to the quality of evidence provided; seven of those students who wrote an incomplete claim also submitted insufficient evidence, while eight of the ten students who wrote a complete claim submitted sufficient and appropriate evidence. Students whose claims were restricted to identifying the unknown powder, rather than linking its identification to physical and chemical properties, typically submitted incomplete evidence or did not fully explain how they were able to infer identification by comparing the reactions of the unknown powder to the reactions of known powders.

As part of the argumentation process, students were also expected to link their evidence to scientific reasoning. In the case of the laboratory activity, the data was primarily observational in nature; students compared the response of an unknown powder to the responses of the known powders to water, vinegar, iodine, and a pH indictor. The ability for students to go beyond merely identifying the unknown powder required students to explain their inferential thinking. As noted when evaluating the evidence portion of the scientific argument, students who began their argument with an insufficient claim were more likely to provide insufficient reasoning than peers who had begun their scientific argument with a complete and accurate claim. Additionally, although coming to the correct conclusion and incorporating evidence was something nearly all of the students were able to master, 54% of the class stopped short of inferring, or developing an explanation from evidence that clearly explained the identity of the unknown powder based on physical and chemical properties.

Berland and Reiser (2008) reported similar findings in their study involving middle school students who used the CER Framework to create written science arguments, with 45% of the student responses failing to clearly describe how they used evidence to infer findings. Those students who differentiated between evidence and inference were “more likely to include persuasive statements” (Berland & Reiser, 2008, p. 46). In a separate study that used computer software to deliver prompts designed to assist students in linking evidence to an explanation, students were able to create a scientific explanation but had difficulty supporting their claims with cited data. The omission of language that clearly linked the claim to the cause created “low coherence explanations” (Sandoval, 2003, p. 34).

Some researchers have suggested that students perceive the goal of argumentation as being one that provides the “right answer” to the teacher (Berland & Reiser, 2008; Sandoval, 2003). It is possible that the use of the CER Framework may have placed artificial restrictions on the students in this study by requiring them to follow a specific approach when composing their argument. Students may have viewed the CER Framework as something that required them to simply plug in specific components. Tabak and Reiser (1999) suggested that developing complex explanations may come at the expense of the creation of evidence-based arguments. Their study of classroom discourse indicated that teachers tend to focus on having students support their claims with evidence rather than prioritizing the development of reasoning from evidence. By following the CER Framework, some students in this study may have focused on providing an argument that satisfied the framework at the expense of developing an explanation of the observed phenomena.

According to Berland and Reiser (2008), explanation making and argumentation are complimentary processes. They suggest that when engaging in argumentation that students be tasked with “(1) using evidence and general concepts to make sense of the specific phenomena being studied, (2) articulating these understandings, and (3) persuading others of these explanations by using the ideas of science to explicitly connect the evidence to the knowledge claims” (Berland & Reiser, 2008, p. 29). A key omission of the CER Framework is that authoring persuasive statements is not required (Berland & Reiser, 2008). Students in this study were engaged in the first two tasks identified by Berland and Reiser (2008), but did not participate in the social aspect of argumentation. In other words, the students did not defend their screencasts through classroom discourse. Rather, this study involved students in creating and supporting a claim related to a singular set of lab experiences that were used to explain a specific phenomenon. In reality, science is often far more complicated, consisting of ill-structured problems that require analysis of interconnected data (Sandoval, 2003).

A study by Shemwell and Furtek (2010) that examined discourse in the middle school science classroom found that evidence-based arguments were not linked to explicit conceptual talk. In other words, although students were able to construct an argument, their reasoning did not demonstrate a rich understanding of the concept under study. Students in the Shemwell and Furtek (2010) study did not expand on their arguments once they had completed their argumentation goal, leading the authors to believe that restrictions placed on reasoning may “inhibit conceptually rich discussion” (Shemwell & Furtek, 2010, p. 222). Although the students involved in this study had an opportunity to review screencasts produced by some of their peers, this research study did not incorporate whole class discussion as a pedagogical technique for supporting scientific argumentation. This decision was driven in part by the fact that the guiding question was fairly linear in its approach, which resulted in nearly every student making a similar claim in which they correctly identified the unknown powder as powder B. Additionally, the incorporation of argumentation via classroom discourse would have required substantial professional development on the part of the participating teacher.

Although this study did not extend to analyzing sentence construction, it was noted that students who used data in an observational manner often did so in a manner that implied that a relationship existed between the data and the claim. Without specific language that linked the claim to the evidence students were incapable of providing sufficient and appropriate reasoning. Similarly, when examining written explanations composed by high school students, Sandoval (2003) found that the incorporation of clear causal language differentiated high coherent explanations from low coherent explanations. Inclusion of words such as “because,” “due to,” and other language acted to clearly identify and connect claims to evidence and reasoning. It should be noted that the CER Framework does not support students in developing language that effectively links data to reasoning. This indicates a need for additional scaffolding, such as specific targeted lessons aimed at practicing the use of clear causal language.

The results of this study also underscore the importance of composing a complete and appropriate claim and may indicate the need for teachers to provide sufficient scaffolding related to the claim-making process. Conn (2012) recommends establishing a clear definition for the word “claim” and providing students with examples of well-constructed claims. Some researchers have used computer software to scaffold the argumentation process. For example, Sandoval and Reiser (2004) used a computer software program called *ExplanationConstructor* to scaffold high school students through argumentation and Laru et al. (2012) used scaffolding prompts delivered to middle school students via mobile phones. Such software, unfortunately, is not always readily available to teachers or may come with an associated cost, making it essential for teachers to develop alternative methods of scaffolding the argumentation process. Additionally, the ability to use computer-assisted scaffolding to support argumentation may be limited. In their study of undergraduate college students who wrote arguments in an economics course, Cho and Jonassen (2002) found that the computer-scaffolded group produced fewer warrants, or reasonings, than the unscaffolded group. Sandoval (2003) suggests that the use of technology to scaffold the argumentation process may need to be supplemented with classroom discourse targeted at helping students learn how to link data to reasoning.

Since writing claims was a new skill for students in this study, it is possible that their ability to write complete and accurate claims would improve with continued practice. A study carried out over the course of a school year demonstrated that when writing hypothesis, high school and middle school students were able to move from a non-analytic approach at the start of the year to being able to successfully provide scientific justifications by the close of the year (Rosebery, 1992). Given that argumentation is a more complex skill than hypothesis generation, students may require considerable practice in order to write complete and accurate claims that are supported with evidence and reasoning.

Finding: Students Who Narrated Their Screencasts Scored Better Than Their Peers Who Either Relied Solely on Text or Read Verbatim From Their Slides

Digital technology can be used to engage students in creating content for the purpose of explaining science concepts (Hoban et al., 2013). Screencasting is one such technology that can be used to engage students in creating a scientific argument. Screencasting apps available for mobile devices include numerous tools such as narration and annotation that can allow users to personalize their screencast. Screencast apps have the added advantage of providing insight into student thinking (Soto, 2014). Since middle school students often struggle with writing (Hand et al., 2004), providing an alternative vehicle that allows students to narrate their scientific arguments may be a viable alternative to the more traditional method of writing. Additionally, requiring the production of a scientific argument that explains phenomena observed during lab activities may serve as a performance task that can be used to assess NGSS performance expectations.

Studies indicate that conceptual understanding is best achieved by involving students in active thinking throughout the investigative process (Kahle et al., 2000; Minner et al., 2010). During this study, students were engaged in constructing a scientific argument in which they were expected to explain observed phenomena. Students adopted one of three approaches when creating their individual screencast, with 29% creating a text-only screencast, 29% reading verbatim the text present on their screencast, and 42% narrating their screencast. These results were a marked improvement over the pilot set of screencasts in which 16 of the 19 completed screencasts, or 84.2%, were text-only. Despite their familiarity with Explain Everything as a screencasting tool, 58% of the students either typed their entire screencast or simply read the text verbatim. These results were somewhat unexpected, given that the teacher occasionally creates flipped videos using Explain Everything.

Analysis revealed that students who narrated their screencasts scored an average of 5.0 out of 6.0 on the base rubric; students who composed text-only screencasts scored an average of 3.4 out of 6.0, and students who read verbatim from their slides scored an average of 3.1 out of 6.0. These results indicate that narrated science arguments are more sophisticated than non-narrated or science arguments that are read verbatim. These results are not surprising, given that among middle school students, oral arguments are more complex than written arguments (Berland & McNeill, 2009). Further research with larger populations of students is needed to validate these findings.

Finding: Narrating Screencasts Created Anxiety Among Some Students

The use of annotation tools provided insight into student thinking. The use of annotation also indicated that students were aware that they were creating a product for a potential audience. This is similar to findings by Soto (2014), whose study involved analysis of screencasts of mathematics problems solved by elementary students. Soto (2014) found that some of the students involved in her study exhibited a teaching persona in which they narrated their screencasts as if they were a teacher. In this study, student G13 was the only student to adopt a teaching persona during which she spoke directly to the audience, taught the topic, and quizzed the viewers on their knowledge.

Although some of the students involved in this study, such as student G13, seemed at ease with the possibility of their screencast being viewed by an audience, several students voiced discomfort during the focus group with having their product examined by their peers. In contrast to a study of middle school students who used narration rather than text when engaged in a literature project (Sadik, 2008), 29% of the students in this study chose to use text only. Awkwardness related to narrating their screencast in front of their peers, worries about the sound of their voice, and the feeling that their screencast needed to be mistake-free may have been the reason some students chose to restrict their screencast presentation to text only or to reading the text verbatim. The timid approach to screencasting exhibited by the students involved in this study was surprising, given that other studies have found that awareness of a potential audience can positively impact student motivation. In a study involving seventh grade students who uploaded photographs to a class VoiceThread, researchers concluded that awareness of a potential audience motivated students to carefully select images that supported claims in a “convincing manner” (O’Brien, Beach, & Scharber, 2007). Other studies conducted with high school students have linked the creation of digital products designed for sharing with others with increased student motivation (Gold et al., 2015; Green et al., 2013; Green et al., 2014). The findings of this study also conflict with a study conducted among low-performing eighth graders whose sense of audience enhanced their engagement in an activity in which they interacted with peers via audio annotations (O’Brien et al., 2007).

This study did not specifically explore student motivation and its link to student performance. It is possible that the adolescents participating in this study may have felt more vulnerable and insecure than students in other studies, which would impact their comfort level when narrating a screencast. It is also possible that as students develop familiarity with the app over time that they will explore creating interactive narrated screencasts, rather than producing stagnant presentations reminiscent of those created using PowerPoint.

Finding: Creating Screencasts Is a Viable Alternative for Struggling Writers to Demonstrate Their Knowledge

Writing a scientific argument was a newly introduced skill for the students engaged in this study, since the participating teacher had not previously included the practice of argumentation into his teaching. The teacher restricted the introduction of the CER Framework to two of his classes; the first class was the class where this study was conducted, and the second class was composed of high achieving and gifted students. Restricting inquiry and the practices that support inquiry to higher achieving learners is common among science teachers who feel that lower performing students are not capable of successfully participating in argumentation (Sampson & Blanchard, 2012). Although the teacher taught two additional science classes that consisted of regular education students mixed with special education students, he chose not to introduce those classes to argumentation out of concern that some of the students would not be able to successfully complete the activities.

Among the students who participated in this study were three target learners who met with varying degrees of success when creating a screencast of a scientific argument. One of the target learners, along with a low performing student, did not finish the screencast. This may have been due to misunderstanding the assignment or to needing more time or additional scaffolding. Although the second target learner submitted a science argument consisting of an incomplete claim, evidence, and reasoning, he was able to incorporate annotations that yielded insight into his thinking and complete the assignment within the given time frame. The third target learner, however, not only successfully navigated the software, but also was able to explicitly demonstrate her thinking in a manner far superior to any of her previously written work. Student G13 also incorporated a rebuttal into her argument, something that was unique among her peers. Rebuttals provide alternative explanations and counter evidence, and are often introduced only after students are proficient at making scientific explanations consisting of a claim, evidence, and reasoning (Krajcik & McNeill, 2009). Student G13's inclusion of a rebuttal, her superior use of annotating tools, and her heightened sense of audience resulted in a sophisticated argument that surpassed the arguments of the other students in this study.

Although no study could be located that specifically addresses screencasting scientific arguments by low performing students, a study of middle school students in a reading and writing intervention class found that reluctant writers were motivated by the use of audio annotations (Beach & O'Brien, 2015). Given that the sample size of this study was small, the use of mobile technology for creating narrated screencasts bears greater investigation to determine if screencasting can be a viable alternative for some low performing students who struggle with written work.

Research Question #3: How Do Students Utilize Evidence Collected via a Mobile Device to Support Their Claims?

One of the affordances of mobile technology is that it allows users to capture images and record data (Hesser & Schwartz, 2013; Pendrill et al., 2014). The digital evidence present in each of the 24 screencasts was examined and classified according to use. All of the students in this study incorporated at least one piece of digital evidence into their screencast; a marked improvement from the pilot screencast in which only 11 of the 19 submitted screencasts, or 57.9%, contained digital evidence.

Finding: Students Used Digital Evidence to Either Add Visual Interest to Their Screencast, Support Observations, or Support Inferences

Approximately half of the screencasts, 11 out of 24, contained images or videos that appeared to serve no purpose in the author's scientific argument. Rather, the digital evidence was used to add visual interest, most often accompanying the first slide where the guiding question was written. This may have been due to Explain Everything's resemblance to PowerPoint; screencasts constructed in Explain Everything are done so on a slide-by-slide basis. The students who participated in this study are familiar with PowerPoint and may have approached Explain Everything in similar manner in which they constructed slides with text and images, rather than as an interactive presentation that incorporated annotation and narration. Additionally, the inclusion of evidence that added visual interest had no relation to a student's overall science argument; time spent incorporating these digital pieces may have been better spent creating the actual science argument.

When examining how students used data to support their claims, approximately half of the class, 54%, used data to support observations, rather than using evidence in an inferential manner, a finding similar to a study conducted by Laru et al. (2012). Laru et al. (2012) found that 58% of middle school students who had received scaffolding prompts made low-level knowledge claims comprised primarily of observations rather than inferences. In this study, students used a storyboard to scaffold their science argument, whereas in the Laru et al. (2012) study, students received verbal scaffolding prompts to construct their arguments. Students in this study frequently did not reference the digital evidence or connect the evidence to the claim. Rather, students used evidence to imply an inference, but did not fully utilize the affordances of Explain Everything to explain their thinking. These findings are similar to a study conducted with classes of middle school students who used the CER Framework to compose written science explanations (Berland & Reiser, 2008). Results indicated that between 35% and 49% of the explanations contained ambiguous statements that did not clearly differentiate data from inference, making understanding the explanation unclear for readers who may have been unfamiliar with the specific setting (Berland & Reiser, 2008). Additional prompting by the teacher or the use of a modified storyboard that asks students to describe how the evidence can be used inferentially may assist students in making their thinking transparent.

Forty-six percent of the screencasts contained evidence that was inferential in nature. Although it was possible for students to submit sufficient and appropriate evidence that was observational in nature, the ability to make inferences is an important science skill, since scientists use both observations and inferences when constructing explanations (Hanuscin & Rogers, 2008). Berland and Reiser (2008) pointed out that understanding the difference between inference and evidence is essential to the inquiry process. Although students had reviewed the difference between observations and inferences when analyzing the *Doritos Super Bowl Commercial Cat Bribe*, the results of this study indicate that students need additional practice with making inferences. Since arguments are constructed when students make conclusions using inferences from evidence (Brodsky et al., 2013), students need to understand the difference between evidence and inferences in order to apply it when constructing a science argument.

Finding: Students Who Annotated Their Evidence Produced More Sophisticated Arguments Than Their Peers

Students who used evidence in an inferential manner were able to explain how observations could be used to infer the identity of an unknown substance based on its physical and chemical properties. What distinguished these students from their peers was the use of annotation when discussing the evidence. Of the ten students who narrated their scientific argument, eight of them annotated their slides as they were speaking to emphasize their evidence and/or reasoning, using the laser pointer and the pen tool to highlight, circle, or write directly on their slides. Similarly, Beach and O'Brien (2015) observed that middle school students drew on images for the purpose of highlighting attention to specific areas that supported their verbal analysis regarding the link between climate change and photosynthesis.

Of the seven students who read directly from their slides in this study, four used the laser pointer as they read to highlight what they were reading. The act of annotating helped to underscore the student's thinking, and in doing so, may have assisted the student in organizing and extending their thinking. In a previous study involving elementary students who solved math problems, it was found that the use of annotating tools such as the pen tool and the laser pointer helped students to clearly convey their thinking (Soto, 2014). A study that engaged middle school students in using the Diigo app to highlight and annotate virtual sticky notes found that the annotations helped the students to identify and share important information with their peers (Castek, Beach, Scott, & Cotanich, 2014). Similarly, this study indicates that drawing and annotation tools, when used with narration, may have significant potential for clarifying student thinking and may also help students develop sophisticated science arguments.

Interestingly, students had not been shown how to annotate the evidence, nor had students been instructed to annotate their evidence. It is unclear if students discovered the annotating tools on their own, of if they modeled tool use after watching flipped classroom videos created by the classroom teacher. Although annotating is often incorporated as a strategy to help students become better readers (Zywica & Gomez, 2008), students may need specific direction or examples of its use as it applies to annotating evidence. This could possibly be accomplished via practice using science text in which students use specific annotating symbols to identify the components of a scientific argument.

Research Question #4: What Are Student and Teacher Perceptions of the Value of Using a Mobile Device to Create Science Arguments?

This study also examined student and teacher perception of using mobile devices for the creation of science arguments.

<u>Finding: Sharing iPads Created Workflow Issues</u>

Many students encountered constraints regarding workflow that were driven primarily by complications related to sharing iPads between students. iPads are meant to be single-user devices, making the sharing of iPads difficult and resulting in a focus on problems related to workflow rather than attention to learning (Daccord, 2012). Unfortunately, as in the case of this study, teachers and students may have different access levels afforded to them by school district administrators, making it challenging to anticipate potential work flow issues. Unexpected updates to applications can also result in confusion for students who have become accustomed to the locations of a specific set of buttons on their screen. In the course of this study, workflow issues were encountered that impeded the ability of both the teacher and the students to easily create, access, and modify screencasts in Explain Everything.

Since this study occurred in a district that has not adopted a one-to-one platform, students were required to upload their Explain Everything XPL files at the close of class each day to ensure that their product would not be accidently deleted by a peer in another class. This action required signing in and out of Google Drive through the Explain Everything app, a process that was cumbersome at best. This had the effect of creating anxiety among students who were already dealing with learning how to use screencasting to construct a scientific argument. The effect that workflow constraints had on student productivity, motivation, and attitude requires further exploration, given the possibility that workflow issues may have interfered with the students' ability to concentrate fully on using the application to develop a scientific argument. There is evidence to support the idea that, if given additional practice over the course of the school year, students may become comfortable with the convoluted workflow. A study conducted in a college chemistry class revealed that students were initially frustrated with using an iPad to document their laboratory findings. Once they developed a comfort level with using the device, the students were able to overcome any initial problems (Hesser & Schwartz, 2013).

Although the teacher and the students were pleased with the final products, screencast creation took three school days, which is a considerable amount of time to invest in a project. It is important to acknowledge that science teachers are expected to cover a great deal of specific content in a limited amount of time. Although screencasting may be a tool teachers can use to support argumentation in the science classroom, a reliance on screencasting may mean that time spent on screencast production will occur at the expense of other curricular work. Finding the right balance will be essential, given that teachers will need to utilize screencasting often enough for students to develop both a comfort and proficiency level.

Implications for Teaching

The NGSS requires that teachers incorporate science practices in a manner that resembles the type of work that scientists conduct. Among those practices is argumentation, a practice often omitted in the K-12 science classroom (Ruiz-Primo et al., 2010). The *Framework for K-12 Science Education* states that students in grades six through eight need to be able to "construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning" (Lead States, 2013b, p. 63). Teachers will need to be open to the idea of engaging all learners in the science practices outlined in the NGSS. This will be challenging for those teachers who resist using inquiry out of concern that lower-performing students will not be able to successfully conduct inquiry activities. The participating teacher in this study was no exception to that thinking, restricting participation in the Mystery Powders Lab and the subsequent screencast creation to two of his classes; the two other classes containing special education students were taught the material via a traditional methodology that used a didactic approach supplemented with worksheets.

As this study shows, screencasting, especially when narrated and/or annotated, can reveal student thinking. Screencasting a science argument may also allow students to create more complex arguments than they would produce through written work. By requiring students to create and narrate science arguments of inquiry-based labs, teachers will gain deeper insight into their students' thinking. This has the added advantage of exposing misconceptions and of locating student thinking along a continuum of mastery.

For students to be successful at using screencasting for science arguments, teachers will have to spend time developing the skills that support argumentation. Although the students in this study were scaffolded through the CER Framework, it has been my experience that argumentation is a difficult practice and that students require numerous opportunities over the course of the school year if they are to apply the CER Framework successfully. Teachers should not get discouraged if students struggle with this higher level thinking skill. Given that many science classrooms place barriers on student thinking through their dependency on content-driven worksheets and verification labs, it is to be expected that teaching science as a set of practices to be conducted, instead of as a body of knowledge to be learned, will be difficult for both the teacher and the students.

As this study indicates, many middle school students struggled to create an appropriate and sufficient scientific argument. Students require scaffolding to properly carry out inquiry and science practices that support inquiry (de Jong & Joolingen, 1998; Kirschner et al., 2006; Thomas, 2000). Although students were scaffolded through the process, this study indicates that some students may have benefitted from additional scaffolding to ensure that they began their argument with an appropriate and complete claim. It is important to acknowledge that the results from this case study represent a specific classroom whose access was determined through purposeful sampling. As such, this study may not necessarily be generalizable or transferrable to other settings.

It is my belief that all students can successfully create a screencast of scientific arguments. Simply providing students with an iPad is not enough to ensure that students are productively engaged. The use of mobile technology needs to be done in a purposeful manner (Soto, 2014), with the chosen apps used for meeting specific learning objectives (Pepperdine University, 2010). Students need time to develop familiarity with applications such as Explain Everything. Many students in this study seemed to view Explain Everything as a type of interactive PowerPoint, rather than as a vehicle for narration and annotation. In order for students to take full advantage of Explain Everything's tools, they will need time and scaffolding to master the application—time that is in short supply in today's test-focused classrooms.

The use of mobile devices for engaging students in creating screencasts of science arguments holds great potential for the middle school science classroom. Teachers need to be prepared to develop alternative assignments to screencasting in the event that a student is unable to complete a screencast due to a concussion or other intervening issue. Teachers should also be aware that some students might experience anxiety if they are expected to narrate their screencasts. Scaffolding the narration process in a supportive learning environment may be key to overcoming these anxieties. Teachers will also need to be cognizant that sharing mobile devices between students may require the development of somewhat a convoluted workflow pattern that may add an additional level of complexity to any screencasting project. Developing an appropriate workflow pattern may also take considerable time on the teacher's part.

One place that teachers can start with technology integration is by using mobile technology to document laboratory data. In this study, the iPad was particularly useful for documenting qualitative data, data that students often struggle to adequately convey. The digital evidence captured during laboratory activities can help students recall what happened during the lab, can be used as a stimulus for a class discussion, or can be used by the teacher to update students who have been absent. Since the use of mobile technology in the science laboratory is a relatively new phenomenon, teachers will need to work with students to help them capture meaningful digital evidence. In order to improve meaningful data collection that can support science argumentation, it is recommended that teachers consider implementing actions such as: (a) teaching students how to annotate data as it is being collected, (b) requiring student lab groups to develop a plan for collecting data prior to conducting a lab, and (c) limiting the total number of photographs and videos that can be taken.

Although this particular laboratory activity did not fully meet the NGSS performance expectations for physical science at the middle school level, the use of a performance task is recommended when assessing NGSS performance expectations (Pellegrino, 2013). Since the creation of assessments that reveal the sophistication of student reasoning is difficult (Duncan & Rivet, 2013), and since screencasts provide insight into student thinking through verbal explanations (Soto, 2014), screencasting may be a useful approach teachers can employ when incorporating argumentation into their classroom.

For practitioners who wish to use mobile technology to support students in science practices, the following recommendations should be kept in mind.

- Consult with the school technology integrator or other specialist to create a clear workflow, particularly when sharing mobile devices between classes.
- Develop a set of expectations regarding the use of mobile technology when students are collecting digital evidence.
- Create a sample screencast that can be used by students as a template when developing their own screencast.
- Have students practice with the chosen screencasting app for the purpose of developing skills related to using the annotating and narrating features of the app.
- Allow adequate time for students to create screencasts and provide additional support as needed, particularly for students who may work slower than the average student.

Future Research

Given the recent passage of the NGSS, research concerning the use of technology to support science practices is both welcome and needed. In particular, the use of technology to support argumentation in the K-12 classroom is an area where little work has been conducted. This study has raised a number of interesting questions regarding the use of screencasting for exposing student thinking. The connection between annotating on a mobile device and inferential thinking as it relates to argumentation in science bears exploring. Uncovering why some students take advantage of an application's tools and why some do not is also important, especially if tool use is linked to the ability to demonstrate deeper conceptual understanding.

Screencasting an oral argument provides an alternative method to the traditional written scientific explanation. Although this study was not conducted with special education students, several struggling learners did participate, producing screencasts of varying quality. Studies that explore the use of screencasting with learners of all abilities are necessary. This should include research that examines how to best scaffold argumentation, particularly how to scaffold effective claim making, since the results of this study indicate that the quality of the claim impacts the quality of both the evidence and the reasoning aspects of science arguments.

This study also revealed that mobile technology could be used to support data collecting, but that teachers will need to develop scaffolding techniques to ensure students collect meaningful data. Additionally, teachers will need to develop procedures for easily sharing digital data between team members. If mobile technology is to have a place in the K-12 science classroom, there is also a need for researching how students use digital data and how the data can be used to develop inferential thinking.

It is my belief that technology can play an important role in supporting science practices. Understanding that role will require research on effective technology integration and scaffolding techniques for using mobile technology in a way that supports science inquiry.

Conclusions

This study examined how mobile devices can be used to support science practices in the middle school science classroom. Specifically, this study explored how students use mobile devices to collect digital data during laboratory activities and examined how students use the data when constructing screencasts of science arguments. The affordances of mobile devices make them attractive for use in the laboratory setting, allowing students to capture qualitative data that can be used to support science arguments. In order to be used as a data-collecting tool, students may need to be taught techniques that will aid them in capturing usable data. Analysis of the digital evidence collected during the laboratory activity indicated that, when using mobile devices to capture evidence, students approach the task in a somewhat haphazard manner that results in the collection of unsuitable pieces of evidence. The lack of preparation and an absence of group discussions regarding the data collection approach may have been contributing factors. Further research is needed to determine the level of scaffolding that students require if they are to use mobile devices as a data-gathering tool.

Students used the digital evidence in a variety of ways to supplement their screencasts, which included adding visual interest, supporting observations, and supporting inferences. Those students who used the evidence to support their inferences did so by employing Explain Everything’s annotating tools, which allowed them to clarify their thinking regarding the link between observations and scientific knowledge. Approximately half of the students in the study did not use the annotation tools when creating their screencast. It is possible that they may have incorporated annotations into their screencasts had they been provided with specific examples of annotated science arguments or with instruction on the use of Explain Everything’s annotating tools. No studies could be located that examined how students use digitally collected data when creating screencasts, marking these findings important. Since creating inferences from observations and data is an important scientific skill, further research that investigates how annotating tools can promote inferential thinking is recommended.

The narration and annotation tools make Explain Everything an attractive and potential application for engaging students in documenting oral scientific arguments. One of the unexpected findings was the reluctance that some students had to narrating their screencast. The anxiety encountered over knowing that others would view their screencast may have been instrumental in their decision to rely entirely on text or to read their screencast verbatim. Some students may have avoided narrating their scientific argument out of anxiety or stress due to discomfort with voice recording; others may have preferred to stick with writing text since it is a familiar or preferred presentation method. Anxiety over screencast quality also prevented students from taking advantage of the annotating and voice narration afforded by Explain Everything. Given that the decision to forego using these features may have impacted a student's ability to demonstrate their inferential thinking, this is an area that should be explored further.

Middle school students struggle with argumentation (Jonassen & Kim, 2010). Based on the argumentation scores achieved on the base rubric, this particular group of students was no exception. In this study, students were scaffolded through screencasting a scientific argument via exposure to the CER Framework and through the use of a storyboard. Scaffolding the process was only partially successful in helping students create science arguments. Some students may have misunderstood the guiding question, while others may not have understood the difference between observation and inference, something that is crucial in the argumentation process (Rau, 2009).

The use of screencasting for struggling writers is particularly intriguing, as is evidenced by the sophisticated science argument created by one of the target learners. Although teachers often express that lower performing students are not capable of participating in scientific argumentation (Sampson & Blanchard, 2012), this study revealed that two of the three target learners in the study were able to successfully complete their screencast. Given that the NGSS were written to address the needs of all learners (National Research Council, 2012), screencasting may provide a viable alternative for struggling students to convey their conceptual understanding of scientific principles. Examination of the impact that screencasting can have on low performing students, including the level of scaffolding they require to effectively utilize annotation and narration tools, represents a rich source of possible research studies.

This study showed that mobile devices could be used in the classroom for the purpose of capturing digital evidence that can be incorporated into screencasts of scientific arguments. The affordances of mobile devices, which include portability, connectivity, and affordability, make them an important tool in supporting science practices. The relatively small size and lightweight nature of mobile devices allows users to easily transport and position the device when capturing digital evidence such as sounds, photographs, and video. The multimodality of mobile devices allows users to combine images with sound and text, which can be particularly useful when annotating digital evidence. In terms of creating screencasts, perhaps the most important affordance of mobile devices is their connectivity, or the use of an app to visualize connections between text, images, and video (Beach & O’Brien, 2015).

This study revealed that middle school students could take the advantage of the affordances of mobile technology to successfully create screencasts of scientific arguments. The results of this study also indicate that annotation and narration tools provide insight into student thinking and may act to promote inferential thinking about science phenomena. Screencasting may be a viable alternative to written work and, in fact, may allow struggling students an opportunity to clearly convey their knowledge. These findings mark this study as one that may have profound impact on science classrooms, given that the NGSS performance expectations are best assessed through the use of performance tasks that expose student thinking.

REFERENCES

Addus, R., Gunel, M., & Hand, B. (2007). Comparing an inquiry-based approach known as the science writing heuristic to traditional science teaching practices: Are there differences? *International Journal of Science Education, 29*(14), 1745-1765.

Argument-Driven Inquiry. (2014). Argument-driven inquiry. Retrieved from http://www.argumentdriveninquiry.com/instructional-materials.html

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children, 46*(2), 26-29.

Barber, J., Pearson, D., & McNeill, K. (n.d.). *Classical and Rasch analysis of: Writing modality* (Technical report for Carnegie Corporation of New York Grant #B8780). Retrieved from http://sciencearguments.weebly.com/uploads/2/6/4/3/26438648/techreport_writing_final.pdf.

Barrow, L. (2006). A brief history of inquiry: From Dewey to standards. *Journal of Science Teacher Education, 17*(3), 265-278.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544-559.

Beach, R., & O'Brien, D. (2015). Fostering students' science inquiry through app affordances of multimodality, collaboration, interactivity, and connectivity. *Reading and Writing Quarterly, 31*(2), 119-134.

Belland, B., Glazewski, K., & Richardson, J. (2008). A scaffolding framework to support the construction of evidence-based arguments among middle school students. *Educational Technology Research & Development, 56*(4), 401-422.

Berkeley. (2015). Cognitive constructivism. Retrieved from gsi.berekely.edu/gsi-guide-contents/learning-theory-research-cognitive-constructivism

Berland, K., & McNeill, K. M. (2009). *Using a learning progression to inform scientific argumentation in talk and writing*. Paper presented at the Learning Progressions in Science (LeaPS) Conference. Iowa City, Iowa.

Berland, L. K., & Reiser, B. J. (2008). Making sense of argumentation. *Science Education, 93*(1), 26-55.

Bressler, D. (2014, June). It's better to talk with honey than vinegar: Insights into collaborative learning within mobile AR games. In A. Ochsner, J. Dietmeier, C. C Williams, & C. Steinkuehler (Eds.), *Proceedings GLS 10 Games + Learning + Society Conference, Vol. 4* (pp. 46-53). Paper published at GLS 10 Conference, Madison, WI.

Brodsky, L., Falk, A., & Beals, K. (2013). Helping students evaluate the strength in evidence in scientific arguments: Thinking about the inferential distance between evidence and claims. *Science Scope*, *36*(9), 22-28.

Brown, A. L., & Campion, J. C. (1995). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: The MIT Press.

Brown, S., & Kappes, L. (2012). Implementing the common core standards: A primer on "close reading of the text." Washington, DC: The Aspen Institute. Retrieved from http://files.eric.ed.gov/fulltext/ED541433.pdf.

Bybee, R. W. (2013). *Translating the NGSS for classroom instruction*. Arlington, VA: NSTA Press.

Cakir, M. (2011, January). Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education [Review of the book *Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education*, L.B. Flick, & N. G. Lederman (Eds.)]. *Science and Education*, *20*(33), 381-387.

Castek, J., Beach, R., Scott, J., & Cotanch, H. (2014). Examining middle school students' use of Diigo annotations to engage in collaborative argumentation. In R. Anderson & C. Mims (Eds.), *Digital tools for writing instruction in k-12* *settings: Student perceptions and experiences* (pp. 80-101). Hershey, PA: IGA Global.

Cavagnetto, A. R. (2010). Argument to foster scientific literacy: A review of argument interventions in k-12 science contexts. *Review of Educational Research, 80*(3), 336–371.

Cavanagh, S. (2011). Science competitions integrated into classroom curriculum. *Education Week, 30*(27), s10-s11.

Character.org. (n.d.). National schools of character. Retrieved from http://character.org/schoolof-character/national-schools-of-character-overview/

Chinn, C., & Malhotra, B. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education, 86*(2), 175-218.

Cho, K-L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. In *Proceedings of the 2006 IEEE Symposium on Visual Languages and Human-Centric Computing* (pp. 165-172). New York, NY: IEEE.

Chou, C. C., Block, L., & Jesness, R. (2012). A case study of mobile learning pilot project in k-12 schools. *Journal of Educational Development and Exchange, 3*(2), 11-26.

Coburn, A. (2000). An inquiry primer. *Science Scope, 23*(6), 42-45.

Coburn, C.E., Russell, J. L., Kaufman, J., & Stein, M.K. (2012). Supporting sustainability: Teachers' advice networks and ambitious instructional reform. *American Journal of Education, 119*(1), 137-182.

CommercialsAtMost. (2012, February 5). Doritos Super Bowl commercial dead cat bribe [Video file]. Retrieved from https://www.youtube.com/watch?v=GQ4K-TZXt7E

Conn, J. (2012, September 6). Helping students make evidence-based claims [Web blog post]. Retrieved from http://www.clearbiology.com/helping-students-make-evidence-based-claims/

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Boston, MA: Pearson.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Daccord, T. (2012, September 27). 5 critical mistakes schools make with iPads (and how to correct them). [Web blog post]. Retrieved from http://www.edudemic.com/5-critical-mistakes-schools-ipads-and-correct-them/

Deaton, C. C. M., Deaton, B. E., Ivankovic, D., & Norris, F. A. (2013). Creating stop motion videos with iPads to support students' understanding of cell processes. *Journal of Digital Learning in Teacher Education, 30*(2), 67-73.

de Jong, T., & Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68*(2), 179-201.

Driver, R., Newton, P., & Osborne, J. (1998). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Duffy, T., & Cunningham D. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology* (pp.170-198). New York, NY: Simon and Schuster.

Duncan, R. G., & Rivet, A. E. (2013). Science learning progressions. *Science, 339*(6118), 396-397.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7-22.

Dyson, L. E. (2012). Student-generated mobile learning: A shift in the educational paradigm for the 21st century. In L. E. Dyson (Ed.), *anzMLearn Transactions on Mobile Learning* (pp. 15-19). Sydney, Australia: University of Technology, Sydney.

Edelson, D. C. (2001). Learning-for-use: A framework for the design of technology supported inquiry activities. *Journal of Research in Science Teaching, 38*(3), 355-385.

Educause Learning Initiative. (2006, March). 7 things you should know about…screencasting. Retrieved from https://net.educause.edu/ir/library/pdf/ELI7012.pdf

Eltinge, E., & Roberts, C. (1993). Linguistic content analysis: A method to measure science inquiry in textbooks. *Journal of Research Science Teaching, 30*(1), 65-83.

Enderle, P., Grooms, J. Campbell, H., & Bicket, R. (2013). Cross-cutting writing: Scientific argumentation, the common core, and the ADI model. *Science Scope, 37*(1), 16-22.

Explain Everything. (2015). Explain everything, animate your thinking. Retrieved from http://explaineverything.com.

Fogelman, J., McNeill, K. L., & Krajcik, J. (2011). Examining the effect of teachers' adaptations of a middle school science inquiry-related curriculum unit on student learning. *Journal of Research in Science Teaching, 48*(2), 149-169.

Friesen, S., & Scott, D. (2013). *Inquiry-based learning: A review of the research literature*. Retrieved from http://galileo.org/focus-on-inquiry-lit-review.pdf

Furtek, E. M., Hardy, I., Beinbrech, T., Shavelson, R. J., & Shemwell, J. T. (2008). *A framework for analyzing reasoning in science classroom discourse*. Paper presented at the Annual Meeting of the American Educational Research Association, New York, New York.

Gold, A. U., Oonk, D. J., Smith, L., Boykoff, M. T., Osnes, B., & Sullivan, S. B. (2015). Lens on climate change: Making climate meaningful through student produced videos. *Journal of Geography*, 0, 1-12.

Goss, M., & Brodsky, L. (2014). *Introducing and assessing argumentation in your science classroom* [PowerPoint slides]. Retrieved from http://sites.scienceandliteracy.org/sites/scienceandliteracy.org/files/presentation/Seeds_ArginClassroom_NSTA_2014.pdf

Green, L. S., Chassereau, K., Kennedy, K., & Schriver, M. (2013). Where technology and science collide: A co-teaching experience between middle grades science methods and instructional technology faculty. *Journal of Technology and Teacher Education*, *21*(4), 385-408.

Green, L. S., Inan, F. A., & Maushak, N. (2014). A case study: The role of student generated vidcasts in k-12 language learner academic language and content acquisition. *Journal of Research on Technology in Education, 46*(3), 297-324.

Grossman, K. (2013, September 11). *What's the difference?* [Video file]. Retrieved from http://www.knowmia.com/watch/lesson/18445

Hand, B., Wallace, C. W., & Yang, E. M. (2004). Using a science writing heuristic to enhance learning outcomes from laboratory activities in seventh-grade science: Quantitative and qualitative aspects. *International Journal of Science Education, 28*(2), 131-149.

Hanuscin, D. L., & Rogers, M. A. P. (2008). Learning to observe and infer. *Science and Children, 45*(6), 56-57.

Harlan, W. (2013). *Assessment & inquiry based science education: Issues in policy and practice*. Trieste, Italy: Global Network of Science Academies Science Education Programme.

Hazzard, E. (2014). A new take on student lab reports. *The Science Teacher*, *81*(3), 57-61.

Hendrickson, S. (2006). A backward approach to inquiry. *Science Scope, 29*(4), *30-33.*

Hesser, T. L., & Schwartz, P. M. (2013). iPads in the science laboratory: Experience in designing and implementing a paperless chemistry laboratory course. *Journal of STEM Education*, *14*(2), 5-9.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark. *Educational Psychologist, 42*(2), 99-107.

Hoban, G., & Nielsen, W. (2010). The 5Rs: A new teaching approach to encourage slowmations of science concepts. *Teaching Science*, *56*(3), 33-38.

Hoban, G., Nielson, W., & Shepherd, A. (2013). Explaining and communicating science using student-created blended media. *Teaching Science, 59*(1), 32-35.

Hoban, G. F., & Nielson, W. S. (2014). Creating a narrated stop-motion animation to explainscience: The affordances of “slowmation” for generating discussion. *Teaching and Teacher Education, 42*, 68-78.

Hofer, M., & Swan, K. O. (2006). Technological pedagogical content knowledge in action: A case study of a middle school documentary project. *Journal of Research on Technology in Education, 41*(2), 179-200.

Hohenshell, L. M., & Hand, B. (2006). Writing-to-learn strategies in secondary school cell biology: A mixed methods study. *International Journal of Science Education, 28*(2-3), 261-289.

Hsu, Y. -C., Ching, Y. -H., & Snelson, C. (2014). Research priorities in mobile learning: An international Delphi study. *Canadian Journal of Learning and Technology, 40*(2), 1-22.

Hu, H., & Garimella, U. (2014). iPads for STEM Teachers: A case study on perceived usefulness, perceived proficiency, intention to adopt, and integration in K-12 instruction. *Journal of Educational Technology Development and Exchange, 7*(1), 49-66.

Huffling, L., Tomasek, T., Matthews, C., Benavides, A., Carlone, H., & Hegedus, T. (2014). Using mobile devices in the field. *The Science Teacher, 81*(6), 35-40.

Huang, Y.-M., Lin, Y.-T., & Cheng, S.-C. (2010). Effectiveness of a mobile plant learning system in a science curriculum in Taiwanese elementary education. *Computers & Education, 54*(1), 47-48.

Hutchison, A., Beschorner, B., & Schmidt-Crawford, D. (2012). Exploring the use of the iPad for literacy learning. *The Reading Teacher, 66*(1), 15-23.

Hutner, T. L., & Sampson, V. (2015). New ways of teaching and observing in science class. *Kappan, 9*(8), 52-56.

Hwang, G.-J., & Chang, H.-F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education, 56*(4), 1023-1031.

Jimenez-Aleixandre, M. P., & Erduran, S. (2007). Argumentation in science education: An overview. In S. Erduran & M. P. Jimenez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 3-28). Dordrecht, Netherlands: Springer.

Jonassen, D.H., & Kim, B. (2010). Arguing to learn and learning to argue: Design justification and guidelines. *Educational Technology Research and Development, 58*(4), 439-457.

Johnson, C., Kahle, J., & Fargo, J. (2006). Effective teaching results in increased science achievement for all students. *Science Education, 91*(3), 317-383.

Kahle, J. B., Meece, J., & Scantlebury, K. (2000). Urban African-American middle school science students: Does standards-based teaching make a difference? *Journal of Research in Science Teaching, 37*(9), 1010-1041.

Kelleher, C., & Pausch, R. (2006). Lessons learned from designing a programming system to support middle school girls creating animated stories. In J. Grundy & J. Howse (Eds.) *IEEE Symposium on Visual Languages and Human-Centric Computing* (pp. 165-172). Brighton, United Kingdom.

Kentucky Department of Education. (1996). *Designing an effective performance task for the classroom*. Frankfort, KY: Kentucky Department of Education.

Kessler, J. H., & Galvan, P. M. (2007). *Inquiry in action*. Washington, DC: American Chemical Society.

Keys, C. W. (1999). Revitalizing in science genres: Connecting knowledge production with writing to learn science. *Science Education, 83*(2), 115-130.

Keys, C. W., Hand, B., Prain, V., & Collins, S. (1999). Using the science writing heuristic as a tool for learning from laboratory investigations in secondary science. *Journal of Research in Science Teaching, 36*(10), 1065-1084.

Knight, A. M., & Grymonpré, K. (2013). Assessment students' arguments: How strong are their justifications? *Science Scope, 36*(9), 51-59.

Kim, M. C., Hannafin, M, J., & Bryan, L. A. (2007). Technology-enhanced inquiry tools in science education: An emerging pedagogical framework for classroom practice. *Science Education, 91*(6), 1010-1030.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry based teaching. *Educational Psychologist,* 41(2), 75-86.

Krajcik, J., & McNeill, K. L. (2009). *Designing instructional materials to support students' writing scientific explanations: Using evidence and reasoning across the middle years*. Paper presented at the 2009 Annual International Conference Grand Challenges and Great Opportunities in Science Education National Association for Research in Science Teaching, Garden Grove, CA.

Kuhn, D. (2010). Teaching and learning science as argument. *Science Education, 94*(5), 810-824.

Kuhn, A., McNally, B., Schmoll, S., Cahill, C., Lo, W-T., Quinanta, C., & Delen, I. (2012, May). How students find, evaluate, and utilize peer-collected annotated multimedia data in science inquiry with Zydeco. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 3061-3070). ACM.

Lai, C. -H., Yang, J. -C., Chen, E. -C., Ho, C. -W., & Chan, T. -W. (2007). Affordances of mobile technologies for experiential learning: The interplay of technology and pedagogical practices. *Journal of Computer Assisted Learning*, *23*(4), 326-337.

Laru, J., Jarvela, S., & Clariana, R.B. (2012). Supporting collaborative inquiry during a biology field trip with mobile peer-to-peer tools for learning: A case study with k-12 learners. *Interactive Learning Environments, 20*(2), 103-117.

Lead States. (2013a). *Next generation science standards: For states, by states* (Volume 1). Washington, DC: National Academies Press.

Lead States. (2013b). *Next generation science standards: For states, by states* (Volume 2). Washington, DC: National Academies Press.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*(6), 497-521.

Lee, M. J. W., Pradhan, S., & Dalgarno, B. (2008). The effectiveness of screencasts and cognitive tools as scaffolding for novice object-oriented programmers. *Journal of Information Technology Education*, 7, 61-80.

Lehtinen, A., & Viiri, J. (2014). Using tablets as tools for learner-generated drawings in the context of teaching the kinetic theory of gases. *Physics Education*, *49*(3), 344-348.

Linton, D. L., Pangle, W. M., Wyatt, K. H., Powell, K. N., & Sherwood, R. E. (2014). Identifying key features of effective active learning: The effects of writing and peer discussion. *CBE Life Science Education*, *13*(3), 469-477.

Lu, J., & Zhang, Z. (2013). Assessing and supporting argumentation with online rubrics. *International Education Studies*, *6*(7), 66-77.

Martin-Hauser, L. (2002). Defining inquiry. *The Science Teacher, 69*(2), 34–37.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tal, R. T. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching, 41*(10), 1063-1080.

Mayes, R. (n.d.). Rational reconstruction 1: Argument and explanation. Retrieved from http://www.csus.edu/indiv/m/mayesgr/phl4/tutorial/phl4rationalrecon1.htm

McNeill, K. L., & Gonzalez-Howard, M. (n.d.). I introduced the claim-evidence reasoning framework…now what? [PowerPoint slides}. Retrieved fromhttp://www.katherinelmcneill.com/uploads/1/6/8/7/1687518/nsta_beyondcer_205vfinalv2.pdf

McNeill, K. L., & Krajcik, J. S. (2012). *Supporting grade 5-8 students in constructing explanations in science: The claim, evidence, and reasoning framework for talk and writing*. Boston, MA: Pearson.

Merriam, S. (1988). *Case study research in education: A qualitative approach*. San Francisco, CA: Jossey-Bass.

Merrill, W. L. (2012). There's an app: Recharge your students with technology. *Middle Ground, 15*(4), 16-17.

Miles, M.B. & Huberman, A.M. (1994). *Qualitative data analysis* (2nd ed). Thousand Oaks, CA: Sage.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction--what it is and does it matter? Results from a research synthesis years 1984-2002. *Journal of Research in Science Teaching,* 47(4), 474-496.

Moreno, N., & Tharp, B. (2006). How do students learn science? In J. Rhoton, & P. Shane (Eds.), *Teaching Science in the 21st Century* (pp. 292-305). Arlington, VA: NSTA Press.

Morris, C., & Chikwa, G. (2014). Screencasts: How effective are they and how do students engage with them? *Active Learning in Higher Education, 15*(1), 25-37.

Morrow, S. L. (2005). Quality and trustworthiness in qualitative research in counseling psychology. *Journal of Counseling Psychology, 52*(2), 250-260.

Mundy, D., Stephens, D., & Dykes, K. (2010). Facilitating low cost interaction in the classroom through standard mobile devices. In J. Herrington, & B. Hunter (Eds.), *Proceedings of World Conference on Educational Media and Technology* (pp. 1819-1825). Toronto, Canada: Association for the Advancement of Computing in Education.

Nagle, B., Hariani, M., & Siegel, M. (2005). In R. Yagar (Ed.). *Exemplary science in grades 5-8* (pp. 153-162). Arlington, Virginia: NSTA Press.

National Association of State Boards of Education. (2013, April 9). NASBE statement on the next generation science standards. Retrieved from http://www.nasbe.org/press-releases/nasbe-statement-on-the-next-generation-science-standards/

National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academies Press.

National Research Council. (2012). *A framework for k-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

National Research Council. (2014). *Developing assessments for the next generation sciencestandards.* Washington, DC: National Academies Press.

Neill, D. M., & Medina, N. J. (1989). Standardized testing: Harmful to educational health. *Phi Delta Kappan, 70*(9), 688-697.

O'Brien, D., Beach, R., & Scharber, C. (2007). 'Struggling' middle schoolers: Engagement and literate competence in a reading intervention class. *Reading Psychology, 28*(1), 51-73.

Olson, J. K. (2009). Being deliberate about concept development: Effectively moving students from experience to understanding. *Science Scope, 46*(6), 51-55.

Osborne, J. F., & Patterson, A. (2010). Scientific argument and explanation: A necessary distinction? *Science Education, 95*(4), 627-638.

Pellegrino, J. W. (2013). Proficiency in science: Assessment challenges and opportunities. *Science, 340*(6130), 320-323.

Pena, R. (2011). *The impact of podcasts, screencasts, and vodcasts on student achievement in the science classroom.* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Database. (UMI No. 3483006).

Pepperdine University. (2010). iPad research study. Retrieved from http://community.pepperdine.edu/it/tools/ipad/research/default.htm

Pendrill, A.-M., Ekstrom, P., Hansson, L., Mars, P., Ouattara, L., & Ryan, U. (2014). The equivalence principle comes to school---falling objects and other middle school investigations. *Physics Education, 49*(4), 425-430.

Pilburn, M., Sawada, D., Falconer, K., Turley, J., Benford, R., & Bloom, I. (2000). *Reformed teaching observation protocol (RTOP).* Tempe, AZ: Arizona Collaborative for Excellence in the Preparation of Teachers.

Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, R., Duncan, R. G., … Soloway, E. (2004). A scaffolding design framework for software to support science inquiry. *The Journal of the Learning Sciences 13*(3), 337-386.

Rau, G. (2009). A new twist on “mystery boxes.” *The Science Teacher, 76*(8), 30-35.

Rivard, L. P., & Straw, S. B. (2000). The effect of talk and writing on learning science: An exploratory study. *Science Education*, *84*(5), 566-593.

Rop, C. (2003). Spontaneous inquiry questions in high school chemistry classrooms: Perceptions of a group of motivated learners. *International Journal of Science Education, 25*(1), 13-33.

Rosebery, A. S. (1992). Appropriating scientific discourse: Findings from language minority classrooms. *The Journal of Learning Sciences, 1*(2), 61-94.

Ruiz-Primo, M. A., Li, M., Tsai, S. P., & Schneider, J. (2010). Testing one premise of scientific inquiry in science classrooms: Examining students’ scientific explanations and student learning. *Journal of Research in Science Teaching, 47*(5), 583-608.

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. *Educational Technology and Research Development, 56*(4), 487-506.

Salmon, W. C. (1998). *Causality and explanation*. New York: Oxford University Press.

Sampson, V., & Blanchard, M. R. (2012). Science teachers and scientific argumentation: Trends in views and practice. *Journal of Research in Science Teaching, 49*(9), 1122-1148.

Sampson, V., Carafano, P., Enderle, P., Fannin, S., Grooms, J., Southerland, S. A., . . . Williams, K. (2015). *Argument-driven inquiry in chemistry: Lab investigations for grades 9-12*. Arlington, VA: NSTA Press.

Sampson, V., & Gleim, L. (2009). Argument-driven inquiry to promote the understanding of important concepts and practices in biology. *The American Biology Teacher, 71*(8), 465-472.

Sampson, V., Grooms, J., & Walker, J. P. (2010). Argument-driven inquiry as a way to help students learn how to participate in scientific argumentation and craft written arguments: An exploratory study. *Science Education, 95*(2), 217-257.

Sampson, V., & Schleigh, S. (2013). *Scientific argumentation in biology: 30 classroom activities.* Arlington, VA: NSTA Press.

Sandoval, W. A. (2003). Conceptual and epistemic aspects of students' scientific explanations. *The Journal of the Learning Sciences, 12*(10), 5-51.

Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education, 83*(3), 345-372.

Schreier, M. (2014). Qualitative content analysis. In E. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 170-183). London: SAGE Publications.

Science Education Resource Center Carleton College. (2011). Cooperative learning: Monitor and intervene. Retrieved from serc.carleton.edu/introgeo/cooperative/monitor.html

Seddon, G. M., & Pedrosa, M. A. (1988). A comparison of students' explanations derived from spoken and written methods of questioning and answering. *International Journal of Science Education, 10*(3), 337-342.

Sha, L., Looi, C.-K., Chen, W., & Zhang, B. H. (2012). Understanding mobile learning from the perspective of self-regulated learning. *Journal of Computer Assisted Learning, 28*(4), 366-378.

Shemwell, J. T., & Furtak, E. M. (2010). Science classroom discussion as scientific argumentation: A study of conceptually rich (and poor) student talk. *Educational Assessment*, *15*(3-4), 222-250.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*(2), 63-75.

Smith, P. L., & Ragan, T. J. (2005). *Instructional design* (3rd ed.). Hoboken, NJ: John Wiley & Sons.

Song, Y., Wong, L.-H., & Looi, C.-K. (2012). Fostering personalized learning in science inquiry supported by mobile technologies. *Educational Technology Research and Development*, *60*(4), 679-701.

Soto, M. M. (2014). *Documenting students' mathematical thinking through explanations and screencasts* (Doctoral Dissertation). Retrieved from ProQuest. (Accession No. 3637899).

Stay, B. L. (1985). Talking about writing: An approach to teaching unskilled writers. *Journal of Teaching Writing, 4*(2), 248-253.

Stoddart, T., Abrams, R., Gasper, E., & Canaday, D. (2000). Concept maps as assessment in science inquiry learning: A report of methodology. *International Journal of Science Education, 22*(12), 1221-1246.

Stucky, S. E. (2012). *Examining the impact of student-generated screencasts on middle school science students' interactive modeling behaviors, inquiry learning, and conceptual development* (Doctoral dissertation). Retrieved from http://libres.uncg.edu/ir/asu/f/stuckey,%20scott_2012_dissertation.pdf

Tabak, I., & Reiser, B. J. (1999). *Steering the course of dialog in inquiry-based science classrooms.* Paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

The Concord Consortium. (2016). Inquiry space: Learning science by doing science. Retrieved from https://learn.concord.org/inquiryspace.

Tienken, C. (2013, January 8). TIMSS implications for U.S. education [Web log post]. Retrieved from http://christienken.com/2013/01/08/test-post/

Thomas, J. W. (2000). *A review of research on problem-based learning.* Retrieved from Buck Institute for Education website: http://www.bie.org/research/study/review_of_project_based_learning_2000.

Toulmin, S. (1958). *The uses of argument*. Cambridge, UK: Cambridge University Press.

Trumbull, D., Scarano, G., & Bonney, R. (2006). Relations among two teachers' practices and beliefs, conceptualizations of the nature of science, and their implementation of student independent inquiry projects. *International Journal of Science Education*, *28*(14), 1717-1750.

Van Dusen, B., & Otero, V. (2012). Influencing students' relationships with physics through culturally relevant tools. In P. V. Engelhardt, A. D. Churuklan, & N. S. Robello (Eds.), *Physics Education Research Conference Proceedings* (pp. 410-413). Philadelphia, PA: American Institute of Physics.

van Kampen, P., Banahan, C., Kelly, M., McLoughlin, E., & O'Leary, E. (2004). Teaching a single physics module through problem based learning in a lecture-based curriculum. *American Journal of Physics*, *72*(6), 829-834.

Waight, N., & Khalick, F. (2010). From scientific practice to high school science classrooms: Transfer of scientific technologies and realization of authentic inquiry. *Journal of Research in Science Teaching, 48*(1), 37-70.

Wallace, C. S. (2004). An illumination of the roles of hands-on activities, discussion, text reading, and writing in constructing biology knowledge in seventh grade. *School Science and Mathematics, 104*(2), 70-78.

Wallace, D. J., & Witus, A. E. (2013). Integrating iPad technology in earth sciences k-12 outreach courses: Field and classroom applications. *National Association of Geoscience Teachers, 61*(4), 385-395.

Welch, W., Klopfer, L., Aikenhead, G., & Robinson, J. (1981). The role of inquiry in science education: Analysis and recommendations. *Science Education, 65*(1), 33–50.

Wilson, R., Goodman, J., Bradbury, L., & Gross, L. (2013). Exploring the use of iPads to investigate forces and motion in an elementary science methods course. *Contemporary Issues in Technology and Teacher Education, 13*(2), 105-126.

Yin, R. K. (2009). *Case study research: Design and method* (4th ed.). Thousand Oaks, CA: Sage.

Yin, R. K. (2012). *Applications of case study research*. Thousand Oaks, CA: Sage.

Zhang, B. H., Looi, C-K., Chia, G., Wong, L.-H., Chen, W., So, H.-J., …Norrie, C. (2010). Deconstructing and reconstructing: Transforming primary science learning via a mobilized curriculum. *Computers and Education, 55*(4), 1504-1523.

Zion, M., & Mendelovici, R. (2012). Moving from structured to open inquiry: Challenges and limits. *Science Education International, 23*(4), 383-399.

Zion, M., & Slezak, M. (2005). It takes two to tango: In dynamic inquiry, the self-directed student acts in association with the facilitating teacher. *Teaching and Teacher Education, 21*(7), 875-894.

Zywica, J., & Gomez, K. (2008). Annotating to support learning in the content areas: Teaching and learning science. *Journal of Adolescent and Adult Literacy, 52*(2), 155-164.

APPENDIX A

Activities Designed to Scaffold Screencasting the Argumentation Process

Table A.1

Activities Designed to Scaffold Screencasting the Argumentation Process

Activity	Source	Guiding Question	Product
Introduction to the Explain Everything app	Teacher	NA	Creation of an individual screencast
Introduction to the CER Framework	Teacher	Do you need a cell phone?	Group Argument placed on Whiteboard
Practice using the CER Framework	*Doritos Super Bowl Commercial Dead Cat Bribe* http://tinyurl.com/ptt54od	What happened to the cat?	Group Argument placed on Whiteboard
Penny Lab	Participating Teacher	How does soap change how many drops of water fit on the surface of a penny?	Group Screencast
Physical and Chemical Changes	Dr. Patrick Enderle (permission has been given to use his unpublished lab)	What set of rules can be used to distinguish chemical and physical changes?	Individual Screencast
Mystery Powders Lab	Kessler, J., & Galvin, P. M. (2007). *Inquiry in Action*. USA: American Chemical Society	How can physical and chemical properties be used to identify an unknown substance?	Individual Screencast

APPENDIX B

Scaffolding for Argumentation on a Whiteboard

Table B.1

Suggested Layout of Argument on a Whiteboard (Modified from Sampson et al., 2015)

The Guiding Question:	
Our Claim:	
Our Evidence:	**Our Reasoning:**

APPENDIX C

Checklist for Peer Evaluation

Checklist for Peer Evaluation

Claim

- ☐ Student (s) provide a claim
- ☐ Student (s) did not provide a claim

Evidence

- ☐ Student (s) provided inappropriate evidence
    - ☐ Inaccurate/Implausible, or
    - ☐ Irrelevant to the claim, or
    - ☐ Does not support the claim
    - ☐ Only one piece of evidence is provided

- ☐ Student (s) provided appropriate evidence
    - ☐ Accurate/Likely, or
    - ☐ Relevant to the claim, or
    - ☐ Supports the claim
    - ☐ At least two pieces of evidence are provided

Reasoning

- ☐ Student (s) provided inappropriate reasoning (s)
    - ☐ Inaccurate/Unlikely, or
    - ☐ Irrelevant to the claim, or
    - ☐ Does not support the claim

- ☐ Student (s) provided appropriate reasoning (s)
    - ☐ Accurate/Plausible, or
    - ☐ Relevant to the claim, or
    - ☐ Supports the claim

Reviewer Comments:

APPENDIX D

Scaffolding Prompts for Penny Lab

Scaffolding Prompts for Penny Lab

Your group needs to create an argument that answers the guiding question

Claims: Select the best claim below based on your evidence

1. Fewer drops of water fit on the penny when there was soap in the water.

2. More drops of water fit on the penny when there was soap in the water.

3. More drops fit with soap and less drops without soap.

4. It made more fit.

5. It made less fit.

Reasoning: Select the best reasoning statement based on your evidence

1. The surface tension of the water was broken by the soap's molecules

2. More drops fit on the penny when there was no soap. This happened because water can sit on the penny. This was not our hypothesis so we must have done the experiment incorrectly.

APPENDIX E

Storyboard Template

Table E.1

Storyboard Template

Prompt	Sketch or Describe iPad Screen	Notes for Dialog
What is the guiding question?		
What is your claim? (Hint: answer the guiding question)		
What is your evidence? Describe at least 1 piece of evidence (can be pictures, data tables, observations, etc.)		
What is your scientific reasoning? (How does your evidence connect to your claim?)		

APPENDIX F

Base Rubric

Table F.1

Base Rubric

Score	**0**	**1**	**2**
Claim	Does not make a claim, or makes an inaccurate claim	Makes an accurate but incomplete claim	Makes an accurate and complete claim
Evidence	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support the claim)	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence	Provides appropriate and sufficient evidence to support claim
Reasoning	Does not provide reasoning, or only provides inappropriate reasoning	Provides reasoning that connects the evidence to the claim. May include some scientific principles or justifications for why the evidence supports the claim, but not sufficiently	Provides reasoning that connects the evidence to the claim. Includes appropriate and sufficient scientific principles to explain why the evidence supports the claim

APPENDIX G

Classroom Set-Up for Mystery Lab

Figure G.1 Classroom Set-Up for Mystery Lab

APPENDIX H

Group Observation Protocol Form

Group Observation Protocol Form

Date: ________________
Observer: _____________
Group/Table #: ________

*Code for Interactions H = Half of members engaged in task
A = All members of group engaged in task
MI = Minority of members engaged in task
MA = Majority of members engaged in task
N = No members of group engaged in task

Student Group Behavior*	**5 min**	**15 min**	**25 min**	**35 min**
Interactions				
Listening to teacher				
Interacting with teacher (responding or asking a question)				
Discussing data with peer				
Discussing observed phenomenon				
Laboratory Work				
Conducting experiment				
Cleaning lab station				
Technology Interactions				
Using iPad to record or document data				
Using iPad to create screencast				
Using iPad to playback screencast				
Other Actions				
Writing (pencil/paper)				
Off-task behavior				
Disengaged				
Other				

Notes:

APPENDIX I

Teacher Interview Questions

Teacher Interview Questions

1. Describe what you believe are the benefits of using iPads to create screencasts of science arguments.

2. Describe what you believe are the negatives of using iPads to create screencasts of science arguments.

3. What impact do you feel the utilization of screencasting had on student learning?

4. If you were to repeat this activity, what would you do differently?

5. What unexpected issues related to pedagogy arose during this study? How did you deal with them?

6. What unexpected issues related to technology use arose during this study? How did you deal with them?

APPENDIX J

Student Focus Group Questions

Student Focus Group Questions

1. Describe how you used the iPad to collect data during your lab activity.

2. How did your group decide what data to collect?

3. If you were to use the iPad to collect data during another lab activity, what would you do differently?

4. Describe any difficulties you encountered when creating the screencasts.

5. How did you deal with those difficulties?

6. If you were to create another screencast of a science argument, what would you do differently?

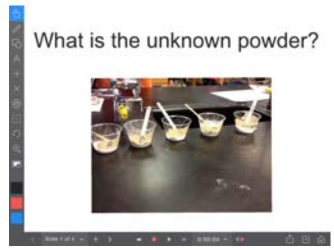
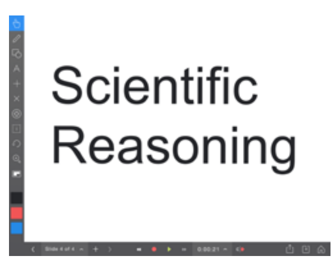
7. What impact do you feel the making the screencast had on your learning?

APPENDIX K

Sample of Data Table for Analyzing Screencast

Table K.1

Sample of Data Table for Analyzing Screencast

Slide #	What Was Said	Notes	Screenshot
1	The guided question is what is the unknown powder	1 photo not referred to	
2	My claim is the powder is a mixture of B and Powder D	Circles the words powder B and powder D while talking	
3	My evidence is that here when we were putting iodine on it, powder B it hardened and turned purple and for powder D it turned black. For the unknown powder it turned black and hardened onto the powder. Also, when we put the indicator on it, it turned blue for powder B and for powder D it turned purple and fizzed and for the unknown powder it turned blue and fizzed. Lastly, I know that, um, both column B, column D, and the unknown powder were all chemical changes. I know this because they either changed colors or changed the state of what they were before, made noises, or smelled.	Had 2 photos; enlarges one. Circles Powders B and D on the photo as she talks.	
4	Finally, scientific reasoning. My scientific reasoning is that both column B and column D were chemical changes and for the unknown powder the whole column was chemical changes. I know that because in chemical changes they will change color, fizz, make noises or smells	Made the words 'scientific reasoning' smaller	

APPENDIX L

Summary of Presentation Mode, CER Scores, and Use of Evidence

Table L.1

Summary of Presentation Mode, CER Scores, and Use of Evidence

Student	Claim Score	Evidence Score	Reasoning Score	Total Score	Presentation Mode**	Use of Evidence***
B1*	NA	NA	NA	NA	NA	NA
B2	1	1	1	3	T	I
B3	2	2	2	6	N	I
B4	0	2	1	3	N	I
B5	1	1	1	3	R	O
B6	1	2	2	5	N	O
B7	1	1	0	2	T	O
B8	2	2	2	6	R	O
B9	1	1	2	4	R	O
B10	1	1	1	3	R	O
G1	1	1	1	3	T	O
G2	0	2	2	4	N	O
G3	2	1	1	4	N	I
G4	2	2	2	6	N	I
G5	2	2	2	6	R	O
G6	2	2	2	6	N	I
G7	1	1	1	3	R	O
G8	0	2	1	3	T	O
G9	1	2	1	4	N	I
G10	2	2	2	6	T	I
G11	0	1	0	1	R	O
G12	2	2	2	6	N	I
G13	2	2	2	6	N	I
G14	2	1	1	4	T	O
G15	1	2	1	4	T	I

*Did not participate due to concussion
**Indicates if students only used text (T), read directly from their slides (R), or narrated the screencasts (N)
***Indicates if students used evidence as an observation (O) or inference (I)

APPENDIX M

IRB Approval Letter

BOISE STATE UNIVERSITY
RESEARCH AND ECONOMIC DEVELOPMENT

Date: August 26, 2015

To: Patricia McGinnis cc: Yu-hui Ching

From: Social & Behavioral Insitutional Review Board (SB-IRB)
c/o Office of Research Compliance (ORC)

Subject: SB-IRB Notification of Approval - Original - 104-SB15-151
Utilizing Screencasts as a Tool for Constructing Arguments that Address Practices Identified by the Next Generation Science Standards

The Boise State University IRB has approved your protocol submission. Your protocol is in compliance with this institution's Federal Wide Assurance (#0000097) and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46).

Protocol Number:	**104-SB15-151**	Received:	8/18/2015	Review:	Expedited
Expires:	**8/25/2016**	Approved:	8/26/2015	Category:	6, 7

Your approved protocol is effective until 8/25/2016. To remain open, your protocol must be renewed on an annual basis and cannot be renewed beyond 8/25/2018. For the activities to continue beyond 8/25/2018, a new protocol application must be submitted.

ORC will notify you of the protocol's upcoming expiration roughly 30 days prior to 8/25/2016. You, as the PI, have the primary responsibility to ensure any forms are submitted in a timely manner for the approved activities to continue. If the protocol is not renewed before 8/25/2016, the protocol will be closed. If you wish to continue the activities after the protocol is closed, you must submit a new protocol application for SB-IRB review and approval.

You must notify the SB-IRB of any additions or changes to your approved protocol using a Modification Form. The SB-IRB must review and approve the modifications before they can begin. When your activities are complete or discontinued, please submit a Final Report. An executive summary or other documents with the results of the research may be included.

All forms are available on the ORC website at http://goo.gl/D2FYTV

Please direct any questions or concerns to ORC at 426-5401 or humansubjects@boisestate.edu.

Thank you and good luck with your research.

Mary E. Pritchard

Dr. Mary Pritchard
Chair
Boise State University Social & Behavioral Insitutional Review Board

1910 University Drive Boise, Idaho 83725-1139
Phone (208) 426-5401 orc@boisestate.edu

This letter is an electronic communication from Boise State University