Fall 2013

A middle school science teacher's integration of technology with the science writing heuristic: a case study

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A MIDDLE SCHOOL SCIENCE TEACHER'S INTEGRATION OF TECHNOLOGY WITH THE SCIENCE WRITING HEURISTIC: A CASE STUDY

by

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A thesis submitted in partial fulfillment
of the requirements for the
Master of Science degree in Teaching and Learning
(Science Education)
in the Graduate College of
The University of Iowa

December 2013

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Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

MASTER'S THESIS

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ACKNOWLEDGEMENTS

There are many people who have helped make this endeavor possible that I would be remiss not to thank.

Many thanks go out to my committee, Dr. Brian Hand, Dr. Soonhye Park, and Dr. John Achrazoglou. Your guidance in my development as a researcher has impacted the course of my educational trajectory. Each of you, in our time together has taught me innumerable life lessons. Thank you for your continuing contributions to my educational growth.

Thank you, Sue Cline. You have been the best administrational support a graduate student could ever ask for, going above and beyond, time and time again. Moreover, without your kind words and thoughtful encouragement, I would have been lost.

To my friends in and out of the College of Education, thank you so much for putting up with me during all of this. I do not deserve you and am thankful you are in my life.

I am grateful for my family, who has not wavier in their support of me and my education. Thank you for helping make me the person I am today. While I will never be able to repay the sacrifices you have made for me, know I am grateful. I love you.

Special thanks go to Grant Garvey. An acknowledgement seems too little for the late nights, edits, and formatting. Your patience and faith in me never wavered. Thank you for your help, perseverance, and love.

Thank you to everyone who assisted me in this endeavor. What a long strange journey it has been.

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CHAPTER 1: INTRODUCTION

Living through the industrial revolution and seeing the tremendous scientific changes that occurred through technology had to have colored John Dewey's perspectives on science both in the world at large but also in his own classroom. Chiapetta (2008) paints a picture of schools at the time stressing two trends in Science education. One trend framed science within the world in which students existed, having students learn skills that would assist them to function in this new industrial and technologically rich society and the other trend stressed preparation for specific higher learning of science. During this time a progressive movement started to take place. One of the leaders of this movement was John Dewey. His generation had seen electricity go from a novelty to a prevalent useful tool. Dewey believed there was an overemphasis on science facts without enough emphasis on science reasoning, all the while arguing individuals could add their own personal knowledge which could give new dimension or depth to ideas (Barrow, 2006). Dewey (1910) proposed inquiry as a way of life and a "method of knowing" (p395). He considered it more than a method to be repeated but a way of thinking. His concepts of inquiry not only reflected what scientists did but also how they thought and reasoned and moreover he emphasized the need of these skills to be relevant in a student's life. This idea of inquiry proliferated and persists through the 21st century, and has been discussed by the National Research Council in the same way (2000, 2012) by talking about ideas of logical and critical thinking being necessary while being grounded in the individual frame of students.

The Industrial Revolution helped moved education from an apprentice based model to a school based model while still based on control, behavior management, and didactic teaching. Between the Progressive Movement and Cognitive Theory, inquiry based education remained a predominate impetus. The Digital Revolution and its technology currently looks to Science to help change education (Collins & Halverson

2009) and inquiry, once again, will still have a role to play and its predominance in current educational reform cannot be denied.

This notion of inquiry is still a central pillar of science education today (AAAS, 1993; National Research Council (NRC), 2000; Chinn & Malhotra, 2000). The NRC takes science inquiry even further linking science with technology, deriving standards stating “everyone” should be able to socially and openly engage in the consequential issues that arise. Indeed, the use of computer/technology based resources to present and cultivate more authentic learning environments for inquiry has become more prevalent in research and in classrooms (Rudolph, 2005), but a gap in the research appears at the elementary level with a focus on science and argumentation being taught in a Technologically Enhanced Learning Environment (TELE). In order to address this gap in the research and the eventual questions that arise, definitions must be given to some of the major concepts that will develop in this paper.

Inquiry in the Science Classroom

Inquiry based classrooms are different from other classroom types in many ways, and identifying and defining such classrooms is important. There is often discussion of hands-on activities or lab experiments being used to engage students in an inquiry based classroom. Unfortunately “hands-on” is simply not enough. Often hands-on activities are used to reaffirm didactically acquired knowledge, when used in this way these activities are not authentic inquiry. Chin and Malhotra (2001) describe that “hands-on inquiry tasks can range from capturing no features of authentic science to capturing many features” (p206) depending on its design and use. Concepts of authentic inquiry such as argumentation, reading, writing, and reasoning must be present in a classroom to be considered inquiry based. (Wallace, Hand, & Prain, 2004; Driver, et al. 1996; Schön, 1992.)

The Science Writing Heuristic (SWH) approach is an inquiry based classroom approach that attempts to explicitly and implicitly link science education with critical thinking and argumentation. While the practices of science communities might differ from geology to physics, the root of all communities lay in argumentation as a way to bring community consensus on different claims and ways to publicize how different methods and justifications are made for those claims. (Haack, 2003; Akkus, Gunel, & Hand, 2007) Through writing and argumentation SWH is able to emphasize scientific literacy in the classroom that reflects authentic inquiry in scientific communities. SWH also puts great emphasis on negotiated social interactions to help students make connections between big ideas and their own claims and evidence (Akkus, Gunel, & Hand, 2007). In such a student-centered environment, with students negotiating their own understanding through argumentation with their peers, it becomes the teacher's responsibility to create what Simon (1995) calls a Hypothetical Learning Trajectory. This trajectory is used, by the teacher, to predict the learning path students might take, and allows the teacher to create content rich situations for students to discuss and explore. This action of creating the trajectory allows for the increase of "Student voice" defined by Martin and Hand (2009) as "opportunity for students to engage in dialogical interactions with the teacher and as well as in the social contexts with peers (p21)." The development of "Student Voice" within an inquiry based learning environment allows for students to personally develop scientific reasoning skills and literacy (Driver, Newton, Osborn, 2000) which has been the purpose of Science education reform since the time of Dewey. Driver et al. (2000) goes on to posit that the role of teachers in this situation is one of guidance, allowing for and providing opportunities for students to use tools for authentic inquiry in science classrooms with argumentation being a major focus.

The SWH approach is a clear representation of an inquiry rich environment for students to come to know and discuss science content and ideas. Thus, classrooms which are implementing the SWH approach for students and teachers can be defined as an inquiry based classroom. Another idea in need of definition is a Technologically Enhanced Learning Environment (TELE)

Technology in the Classroom

In their book Rethinking Education in the Age of Technology: the Digital Revolution and the Schools, Collins and Halverson (2009) discus education moving from data driven models of “Just in case” learning, where students learn and memorize information that might be useful for themselves in the future to “Just in time” learning, where students learn how to use mobilize different resources and use critical thinking to parse information as needed. This shift to using technology as tools in the classroom to help students learn and think about content, represents authentic classroom science (Brush & Saye, 2004; Dornisch & Sperling, 2006; Eslinger et al 2008) as well as represents many of the tenants the NRC (2012) put forth when linking science and technology standards. Collins and Halverson (2009) highlight the interaction needed between students, texts, simulations, and peers and how these different interactions can be accomplished through technology and with the aid of technology. Their assertions indicate an inquiry based slant to how technology can be used in education.

Edelson (2000) outlines the necessity for technology to play a role in science education to be threefold. First, computer and digital technologies have become increasingly important to scientific practice. Since school inquiry should reflect the authentic inquiry done by scientists, within the schools’ means, there should be a reflection of the technology use as well (Chin &Malhotra, 2001). Trends such as data collection and modeling, and communication of results can all done on computers and this trend can be easily translated into the classroom. The second reason technology should be included in science education is computers offer easier ways for individuals to store, organize, manipulate, revise, reproduce, and present information. A broad definition of Cognitive Load Theory supports this second tenant (Chandler & Sweller, 1991) and describes how different instructional materials’ organization and presentation have significant effects on students’ ability to problem solve and critically think. The amount of cognitive load helps or hinders students’ transitions from novice to expert.

There is a great possibility to use digital technology to help decrease cognitive load. The third reason for technology's inclusion in science education is simply its prevalence in society and how technology has become reflected in public education.

A Technologically Enhanced Learning Environment (TELE), for the purposes of this study, adheres to the concepts of "just in time" learning tools and meets Edelson's (2000) ideas of technological necessity. Within this research a TELE's technology is represented by an environment which has mobile technology, social software, multitudes of applications, computer generated simulations, game based learning, and other device oriented learning mechanisms. This distinction is important to make because of the rapid evolution of technology, and what might have been technological at the turn of the century no longer satisfies the criteria.

After defining a few major concepts within this study the purpose begins to emerge.

Purpose of the Study

Collins and Halverson (2009) make the grand conjecture that technology has transform society at large, becoming central to how people consume and produce information going as far to claim that it affects how people calculate and think. Edelson (2000) would agree by pointing out the need for computers to be included in teaching scientific practices. Argumentation as a pillar of science inquiry could use technology and specifically TELE to support its integration within the science content. A gap in the researcher, explored further in the literature review, indicates little attention has been given to TELE support of argumentation outside of technology designed applications. The purpose of this study is to apply a technological framework on the SWH approach to distinguish the degree to which the SWH approach be effectively integrated with technology within a 6th grade classroom, and how this affects the class from a teachers' perspective.

This study used classroom observations, personal interviews, teacher reflections and lesson plans to observe different behaviors and thought processes a 6th grade teacher has in terms of technology use to promote the SWH approach's form of inquiry through one unit. Once a framework was applied to the data different behaviors were parsed out to answer the questions:

- How does a 6th grade middle school science teacher conceptualize the use a TELE to support students' argumentation within the Science Writing Heuristic approach?
- What are some ways she supports the Science Writing Heuristic approach with technology, in her classroom?

Study Overview

Chapter 2 is a literature review. This Literature Review will focus on Technology's role in Science education and trends that are occurring as well as Inquiry, Argumentation and Technology as tools in Science Classrooms from theoretical and practical perspectives.

Chapter 3 will discuss the design and methods used. An in-depth explanation of data collection and the technology and inquiry analysis will be given as well as thorough descriptions of each behavior item to filtered level.

Chapter 4 will organize the data and describe the findings

Chapter 5 will answer the researcher's questions and lead to a discussion dealing with the limitations and implications this study has.

CHAPTER 2: LITERATURE REVIEW

This chapter will address how current literature mediates argumentation and technology within a science classroom, with specific focus on the Science Writing Heuristic (SWH) approach as an argument-based inquiry approach. The purpose of this study is to apply a technological framework on the SWH approach to distinguish the degree to which the SWH approach be effectively integrated with technology within a 6th grade classroom, and how this affects the class from a teachers' perspective. To accomplish this task it is important to first understand how the literature depicts argumentation as an important force in the science classroom, especially with reference to the 8 core practices established by the National Research Council's (NRC) 2012 document, the Next Generation Science Standards. Second, the researcher will discuss the SWH approach as a tool for engaging students in argumentation that has resulted in positive returns. Third, attention will be given to the union of both technology and argumentation literature and how research depicts their combination. Finally, this chapter will discuss the framework which will be used to examine the extent to which technology can be integrated within the SWH approach.

The Focus on Argumentation and Technology in the 8 practices

Inquiry based science education has taken a spotlighted role in the American educational system, with the goal of scientific literacy in mind, for the better part of a decade (American Association for Advancement in Science [AAAS], 1993; National Research Council [NRC], 1996, 2000) A major emphasis has been placed on argumentation being one of the center pieces of inquiry because it not only mirrors many of the ideas of authentic science practices; such as engagement in community knowledge, but also allows for the articulation of understanding through data, evidence, and analysis, essentially improving science literacy. (McNeill, 2011; Berland & Riser, 2009; Duschl, 1990, 2000; Duschl & Osborne, 2002).

In 2012 the National Research Council attempted to create a bridge between content and skill emphasis. They created a list of eight practices which they considered imperative for K-12 students to engage in to further their understanding of science as an interaction between both science content and science community. These eight practices attempt to expand on inquiry by focusing on one of its major concepts, student learning, and developing individual ideas within that concept. Along with expanding the literature and activities within a concept, the eight practices seek to extend a connection between how scientists practice and teachers design, but without loosening focus on student learning (Bybee, 2011). While one practice explicitly deals with argumentation, all of the practices deal with different aspects of argumentation such as gathering data, constructing explanations and evaluating and communicating information, once again emphasizing the importance of argumentation in science education and literacy.

Almost in tandem with a focus on science literacy and argumentation, the NRC (1996) also began acknowledging other tools of science education such as technology, as did other major constituents such as the American Association for the Advancement of Science (AAAS, 1993.) Nearly two decades later national programs such as STEM (Science, Technology, Engineering, Mathematics) make technology a major focus for the growth of American culture and economy (Bybee, 2010). Technology's role in education is well documented in terms of "drill and practice", however, literature has begun to indicate roles for technology outside the frame of simple rote learning and expanding into inquiry based science classrooms (Means &Olson, 1995; Brush & Saye, 2004; Dornisch & Sperling 2006). To further this point, throughout the NRC's (2012) documentation about the 8 practices, ideas of technology's role is hinted at or spoken about very generally. Because of the NRC's (2012) placement of importance on argumentation and technology, it is important to first discuss argumentation as a core practice and second, technology as a tool to enhance argumentation.

Argumentation as a Core Practice

In 1996 the National Research Council (NRC) produced science standards which they hoped would produce a more science literate society and expanded their definition to include more than content knowledge but also, reasoning and communication, essentially argumentation (AAAS, 1993).

Because of the importance of the concept, clarity must be brought to the idea of argument based inquiry. Cavagnetto (2010) explains the fundamental role of language and argument in science practice and the lack of this leads to science education purporting science practice as a static endeavor rather than dynamic and community driven (Driver et al., 2000). Driver et al. go on to explain, in their own work, there are two different types of argument typically represented in educational literatures; rhetorical and dialogical. The former, rhetorical argumentation, is very singularly minded in presenting a consolidated body of work with the express purpose of persuasion; where the latter focuses on a more multi perspective approach, with a body of work to be explored and gaining its' persuasion traits from engagement rather than structure. This section will focus on the dialogical perspective because it is more representative of the NRC's (2000) vision of inquiry, argument, and negotiation. Finally Osborn et al. (2004) drew delineation between argument and argumentation by noting "The former we see as a referent to the claim, data, warrants, and backings that form the substance or content of an argument. The latter in contrast, we see as a referent to the process of arguing (p 998)," once again pointing out the importance of the engagement process to argumentation. Indeed the nature of argumentation as a social practice, where individuals engage with others through bodies of work or through pure interaction, is the bases of the science community at large. Argumentation in this form develops a group of skills for students such as data collection, evaluation, evidence construction, and critiquing, (Berland & Reiser, 2009; Chin & Osborne, 2010) that is represented in the NRC's 2012 documentation of the 8 practices.

In creating the 8 practices the NRC dedicated Practice 7 specifically to argumentation and its subsequent components such as claims, evidence, and data. The use of claim and evidence style justification is an idea the NRC (2012) would call essential to the advancement and elaboration of ideas or explanations. They acknowledge this can take place in a formal and informal setting, from presentations to conversations students have with one another and their teacher. Progression of this practice is necessary for younger students to have more guidance in order to derive evidence from their data and like the evidence to their claims; while more experienced students will need more support critiquing their own and others' works and creating more complex arguments with multiple sources of evidence. Engagement of science through experience e.g.) talking about, writing about, and defending ideas is important to true science literacy (Driver et al, 1996)

While Practice 7 focuses specifically on "Engaging in argument from evidence" the other practices tangentially focuses on argumentation as well such as constructing explanations, analyzing and interpreting data, using models, obtaining, evaluating, and communicating information. Obviously, the NRC intends on having argumentation play a great role in the future of science education and science literacy for future generations. One approach to introducing argumentation into a science classroom environment is with the Science Writing Heuristic approach.

The Science Writing Heuristic Approach

The Science Writing Heuristic (SWH) approach (Keys et al; 1999) attempts to seamlessly integrate scientific argumentation within inquiry based learning activities shifting away from traditional teacher centered classrooms. The SWH approach focuses on helping students talk, think, express, and negotiate meaning from lab based science investigations (Hand et al. 2004). In creating an arena for scientific argumentation, it mirrors how real scientists read, write, and reason about ideas and concepts. The SWH approach has students turning traditionally stagnate information, which would typically be memorized, into a dynamic conversation, in which students must present claims and evidence. By using the SWH approach's templates and dialogical procedures students are able to negotiate their way to creating valid claims that are supported by evidence as well as defending claims by using evidence, which according to the NRC (2012) document is essential to argumentation.

Two templates are involved in the SWH approach, one for the student and one for the teacher. The student template helps guide students through their own activities. Students use argumentation as a way to navigate content, negotiating a shared understanding with peers by going through multiple stages of research, using the template as a guide. The teacher template helps direct teachers to better guide their students through the negotiation process. While the template exist in parallel, the teacher template gives guiding prompts and approaches to enable teachers to ensure each student is participating in the authentic science practices. For the purposes of this study only the teacher template was be used. Table 1 describes the teacher template for the SWH approach (Hand, 2004).

The SWH approach encourages students to use their language, writing, talking, and modal representations, to negotiate with their peers a shared understanding of a topic or concept. Research on SWH indicates the use of this argument based approach to learning has improved students understanding of science concepts resulting in improved science literacy (Keys, 2000; Hand et al. 2004, Burke et al., 2006). To date the SWH approach has no documentation in technological interventions, thus leaving a research opportunity. Within the NRC documentation of the 8 practices (2012) they also refer to the use of technology to aid integration of the practices into the science classroom, therefore it is important to explore the relationship of technology and argumentation within the science classroom.

Table 1. Teacher Template for the Science Writing Heuristic Approach

Segment	Description of Segment
Exploration	Teacher uses strategies to engage students and access pre knowledge of the topic within a science and laboratory frame. Mapping is typically used
Pre-Laboratory Activities	Teacher design investigations to engage students pre-knowledge and expand upon it into the current topic. Brainstorming, question development, group revisions of concept mats, all are way to have students express and expand on prior knowledge
Participation	Teacher guides students through a laboratory investigation, showing samples getting students invested on the topic. Data collection occurs.
Negotiation Phase I	Teacher guides students thinking through activities such as journal writing and exploratory
Negotiation Phase II	Teacher supervised student's negotiations of their understandings of the data with other students in the class. They are encouraged to make claims which are supported by their data
Negotiation Phase III	Teacher guides students to access different data sources including experts and expert texts
Negotiation Phase IV	Teacher guides discussion on students current understandings, creates finalized report or document
Exploration	Teacher uses strategies to help students reflect on their understandings and the actions they took throughout this experience

Technology as General Practice within Argumentation

In the last quarter of a century technology has made great leaps and strides in the classroom environment trending in two ways. Linn (2003) suggests that there are specific and generic tools that can meet the needs of students. Specific tools have become more tailored to detailed topics and have led to the development of more customized applications. More tailored tools are represented by specialized devices or applications that allow students to spend more time utilizing the tool than modifying it, much like modifying a car to drag race, performance might be lacking or subpar in amenities, but for the single purpose of drag racing the car is outstanding. The second trend in educational technologies is a more customizable application where students and teachers are given more generic tools and able to utilize different applications to their own need. This trend is creating an application that acts more like a Swiss army knife where individuals can use only the pieces they need.

Both of these trends can be seen in how technology is being used to aid argument construction and engagement. Research has shown great advantages in the use of technology to aid students understanding of how argument construction occurs, allowing students to more easily engage in conversation and present evidence for their claims (Barab et al., 2000; Eslinger, et al., 2008; Frailich et al., 2009; Hoban et al., 2011; Lin et al., 2011 Varma & Linn, 2011). One example would be FossilSim. One of the research goals for this project was to decrease the difficulty of data organization and interpretation by eliminating extraneous cognitive load. By allowing students to create personalized side by side comparisons of different natural phenomena students are able to collect data and more easily write up explanations for why or why not a geological feature was present using the data they collected, and eventually presented to the class (Lin et al., 2011). The scaffolding present in these works not only helps students organize materials but also promotes the development of argumentation skills as students are able to prepare their data as evidence to present. Tools assist students in argument construction, help integrate new and old ideas, and allow them to re-organize their thoughts in more structured ways (Duschl & Osborn 2002; Linn, 2003). FossilSim is not alone in its attempts to integrate technology with argumentation; other products offer all-in-one applications for students, adhering to Linn's (2003) first trend of tailored tools. The second trend, dealing using different general applications to meet the different needs of students can be represented by the Mac suite of applications such as Pages, Keynote, and Numbers. These applications are very generic but can also be used to create arguments as well. Either or both types of tools are present in TELEs.

Both specific and general technological advances create the opportunity for technology integration into science based argumentation and this opportunity directs attention towards how this integration may occur.

Integration of Argumentation and Technology into the Classroom

In their research, Clark et al. (2007) describe a framework for thinking of how technology should be used to support students' argumentation in a science classroom and the benefits of doing so. The focus of their research is to explore TELEs and parse out important constructs within the technology that support argument creation within the science classroom and argumentation among the students. They present two main categories: facilitating collaborative argumentation and facilitating the construction of individual arguments and contributions. Both of these categories have subcategories.

First when dealing with the concept of facilitating collaborative argumentation Clark et al, (2007) describe four subcategories: a) modes of communication, b) group composition, c) co-creation and sharing artifacts, and d) awareness tools. Within these subcategories the researchers describe different features, and how each feature, when used, might have a different impact on argumentation.

First, when considering modes of communication the authors depict two types of learning environments, asynchronous and synchronous. The former, asynchronous, allows students to work at their own pace, on different parts or aspects of a project differently than their peers, supplemented with online resources or technology guided science lessons. This process is either structured by the program the students are working in or by the teacher creating guidelines for students work. This asynchronous style allows students to reflect and analyze data and evidence in their own time, allowing for a deeper understanding of their arguments and the potential of creating a more equitable environment for argumentation construction. This method also allows students to delve into science content to whatever extent they deem necessary to answer their question. There are, however, many drawbacks to this environment involving teacher, student, and curriculum time management. The latter, synchronous, offers different remuneration, in students' ability to jointly construct arguments, manage resources, and negotiate ideas. This synchronous communication requires technological scaffolds to aid in group construction, so students can spend more time focused on argumentation and less time focusing on menial tasks such as combining different student's evidence or being able to read another classmates handwriting. Perhaps one of the greatest benefits of synchronous communication is the immediate feedback and response loop that can be documented using technology. A drawback of this method is the ridged nature of how students must progress together.

The next subcategory discussed by Clark et al, (2007) is group composition, in which different technologies may group students according to their opinions or skills, or helping assign roles and reminding students of tasks. The authors claim these types of technologies impact engagement.

The third subcategory is co-creation and sharing of artifacts. The authors claim it is important for students to "create, modify, and share permanent external representations of their ideas and arguments with one another," (p219) to engage students in evaluating and critiquing each other and also as a motivation to refine and correct misunderstood concepts. This creation of artifacts also allows students to identify gaps or missing pieces in their understanding, within themselves and others. Collaboration to make arguments, presentation of arguments, and eventually defense of arguments is the point of creating artifacts. Student will have a better idea of where to go next with tangible artifacts in hand.

Finally the authors describe the last subcategory under facilitating collaborative argumentation, to be an awareness tool. Much like co-creation and sharing of artifacts, this awareness is to help students self-regulate the need for modifications and advancement. Students can use technology to help track how other students are doing, or their own progress over time, and in tandem with self-reflect can help guide students to be more aware of different science skills they need to work on.

The other category in Clark et al.'s framework deals with facilitating the construction of individual arguments and contributions. This concept deals with specific scaffolds for students as they construct arguments and are categorized as a) access to data, b) evaluation of data, and c) argument construction.

First when dealing with access to data, technology can provide information that is not typically accessible to students while still providing an authentic learning environment. Information that is typically not accessible, except through technology, might include content videos, government data sets, pictures, Skyping with experts, interactive texts, and scientific models and applications. This assists argumentation by creating rich and varied data sources in which students may collect and organize from, eventually turning this information into evidence for their claim. Collection and organization are also areas where technology can help argumentation. With access to a plethora of different types of data, technologies can help students store data in text form to pictorial representations.

Second, technology can also help with the evaluation of data. By creating technological scaffolds that allow students to compare conflicting data and data sources students are more able to construct valid arguments. Also different types of technological modeling tools allow for students to better describe phenomena and identify items of conflict, through organization and the creation of artifacts.

Finally, technology can directly support students' argument construction by creating scripts and blanks for students to fill in their claims and evidence. Some models of this technology are so sophisticated they allow room for counter arguments and evidence disproving those. Some models are so simple they require a word processer and a form document, helping students outline their ideas and to ensure the students have enough evidence, which could be done with a paper and pencil. Either way, technologies can be used in directly helping students construct a claims and evidence based argument.

After constructing this framework the authors use it to analyze and discuss 4 different technologically created argumentation tools. Each of these 4 tools attempt to teach general or specific science concepts through argumentation to varying degrees of effectiveness. In their concluding comments the authors call for research to be done focusing on the core framework of argumentation and technology interaction within a science context rather than on the creation of more technologically advanced argumentation managers, commenting there is little value to be gained if students do not understand the construction. Heeding these authors call to arms the time has come to look at the Science Writing Heuristic approach, an argumentation approach to students learning claims and evidence based negotiation within their technological frame.

In this chapter the researcher first discussed the importance of argumentation within the frame of the NRC (2012) 8 practices and the Science Writing Heuristic approach as a tool to engage students and teachers in argumentation, justifying the combination of the two ideas with resources from a peer reviewed body of literature. Secondly, the researcher looked at ways technology and argumentation can have a synergetic interaction as described by different frameworks. Currently, the Science Writing Heuristic does not explicitly engage or encourage the use of technological interventions, but rather exists as an approach to argumentation, either within or outside of technology, however the opportunity has arisen for the SWH approach to be supported by a TELE. Thus, a framework for analyzing technological use in argumentation was presented. The use of this framework, when applied to the classroom of a 6th grade science teacher, will allow for the researcher to observe how a TELE supports the SWH approach.

CHAPTER 3: DESIGN AND METHOD

The purpose of this chapter is to describe the methodological framework used to collect, organize, and analyze the data collected for this qualitative case study and to justify why those methods combined with a qualitative approach are the best choices to explore how a Technologically Enhanced Learning Environment supports the Science Writing Heuristic approach. This chapter first discusses the qualitative design of this study and how it emerged from a constructivist view point and purpose before going on to justify and detail the methods of data collection. Finally, the organization of data and analysis approach will be explored.

Research Design

The purpose of this qualitative case study (Creswell, 2006) was to look into how a 6^{th} grade teacher uses the Science Writing Heuristic (SWH) approach supported by a Technologically Enhanced Learning Environment (TELE). A qualitative approach was chosen for its affordance for thick descriptions of contextual stations and rich examinations into those contexts. As an exploratory study, the sample size was limited to one teacher at the recommendation of the administration of the technology-immersive school. By using a qualitative case study approach (Merriem, 2006); a frame could eventually be developed to study a larger sample in future research. As the study was done in the natural setting of a teacher's classroom, this accorded the most authentic view and interaction with the teacher, an essential factor when considering the complex and detailed understanding required in interpreting the interplay of all the component parts. The level of detail needed could only be established by an in-depth qualitative case study.

This qualitative design also emerged from a constructivist vantage point. The SWH approach is designed to focus on the individual student participant’s construction of knowledge, while the teacher, acting as a guide, is also learning and constructing ideas based on students' understandings and misconceptions (Hand et al, 2004). As the students construct their individual realities, they must negotiate a common classroom consensus.

This consensus, in turn, is mediated by the TELE in order to help both the teacher and student meet mutual goals. A generic qualitative case study approach was used for this study because the goal was not to create theory but rather to identify patterns and themes that occur throughout the data. Using this method permits the researcher to understand how a 6th grade middle school science teacher use a TELE to support students' argumentation within the Science Writing Heuristic method. Using this approach allows me to weigh the consistency in which I talk about and implement technology to support SWH, and more importantly, it helps me understand why the participant made the choices they made

Context

Setting. To approach this question a single teacher from Washington School in the Washington Community School District was chosen (all names within this project have been changed). Washington is the ideal bed for study due to its attitudes toward technology and education that is reflected in its science classrooms. This school has instituted a 1:1 iPad ratio among its ~600 students and 50+ teachers and staff, boasting more than 25Mb of internet access, and Apple TVs in all of its classrooms. Abeling (2012) interviewed faculty at the school and quoted administrators insisting "We don't have a technology initiative, we have a learning initiative." Teachers at the school also declared "The iPad won't transform education, I have to, it's up to the teacher." One of the broader goals of this school is to give everyone technology so they can take the focus off of technology acquisition.

Washington has created an ideal situation to research how teachers integrate technology into a classroom. The resources available to the teachers, such as media specialists and professional development allow Washington Middle School teachers to work with a unique skill set. The teachers at this school are not hindered by the immense amount of digital technology they have access to; rather they are limited by their knowledge of how to use it. Teachers at Washington Middle School are not only actively learning and developing their content knowledge but also their technological expertise with the school's support and encouragement. In this exceptional situation the teachers are more equipped to integrate technology into their classrooms. Because of these reasons, Washington Middle School is ideal to study.

There are some drawbacks to choosing Washington Middle School as a site for research. This school is not reflective of Iowa School districts. According to their district report card (2011) within the middle school alone, students scored at minimum 3 points higher than their 6th grade equivalents across the state of Iowa, their student to teacher ratio for the 2010-11 school year was 10:1, and approximately 27% of their student population is economically disadvantaged compared to 34% state wide (Chen, Sable, Mitchell & Liu, 2011). Because of these factors research done at Washington Middle School may not be generalized for all schools. These advantages allow educators at this school to place less focus on state standards, class size, and social economic disparities, and focus more on integrating their technology into authentic learning opportunities.

This study was piloted in a sixth grade science classroom taught by one white female teacher in a suburban elementary school in the Midwest. This school has specifically categorized itself as a middle school institution serving grades five through six. During the 2011-2012 school year, the student population was 665 students. According to the school's deistic report card, approximately 27% of the student population qualified for free and reduced lunch the previous year (2011). This report card, put out by the district to highlight certain key factors in the associated schools, also showed 15% of this middle school was eligible for Individual Educational Programs (IEP). The ethnic diversity of the school was reported as 94% Caucasian, 3% Hispanic, 1.5% Asian, 1 % African American, and < 1% other.

Teacher and Instruction. In this study, reputational case sampling was used to select the teacher (Creswell 2006). According to the administration at the school, this teacher had a positive reputation for embracing new educational interventions which would include new technologies and the SWH approach. This teacher was also chosen specifically for traits the administration valued, e.g., multiple decades of teaching experience between homeschooling and public school, 7 years spent specifically with middle school students, and 5 years spent teaching science specifically at the 5th and 6th grade level. Another reason this teacher was chosen was because she was in the first year of implementing the SWH project into her middle school classroom.

While some teachers at her school had experience with the SWH approach from previous districts, this was the first year of participation for the teacher I was studying. She had just finished participating in a professional development (PD) workshop for SWH. This PD workshop was focused on aiding teachers with regards to integrating instructional units from their school mandated curriculum around big ideas through the use of the SWH argument-based inquiry approach. Purposeful reputational case sampling was used because the administration, who had known her for many years, deemed her one of the best candidates for integrating technology with new curriculum and lauded her work with students and science.

Part of the theoretical framework guiding this study is the constructivist theory that student's best learn science concepts within a preconceived frame developed before instruction, which emerges from their own personal experiences over their lifetime (Duit & Treagust). Because these personal conceptions are not necessarily in line with actual science concepts, students are more likely to stay with their own personally-developed conceptions, and as a result, resist change. This resistance to change, even in light of a more promising science view, is combated in the SWH approach by the persistent need for students to develop more and more sophisticated evidence to support their claim, creating dissatisfaction with a student's personal conceptions if it is not aligned with the science concept. Eventually, this dissatisfaction elicits a conceptual change in the student's understanding. While students are developing arguments and gathering evidence, the role of the teacher is critical. She must use her knowledge of the science content, the affective domain, and the relevant technology to support her students' understanding while at the same time engaging in the teacher portion of the SWH approach.

Site Description. Upon initially entering the school, the first impression was how new the site was. The old middle school, having been flooded two years prior, had been recently torn down, and this facility built with a new technological focused infrastructure in mind. The floor plan of the school was uncluttered and exposed with large wall-length windows in the cafeteria and entry hall which allowed in copious amounts of light. There were wireless access points placed inconspicuously along the ceiling at 40 yard intervals with cords running unobtrusively into the ceiling. I was taken around by the gatekeeper, Becky. Becky was in charge of creating a highly technologically-infused curriculum for the students at this middle school. As we walked, she told me the library had approximately one iPad cart for every two classrooms and that each teacher had a Dell work station and an apple TV. We paused briefly in front of the informational technology office where iPads and other devices were repaired and technical concerns were dealt with. She informed me that this professional's time was split between their location at the middle school and the high school. Eventually Becky took me to the classroom I would be observing and introduced me to the teacher I would be working with.

When I walked into Lisa's (names have been changed) room, the first things I noticed were the desks. This room had three different types of desk arranged in different ways. The first and most predominate were dry erase desks, organized into pods of 4. The second group was made up of standard flat-top desks with book racks under the seat, which were arranged facing forward. These desks were in a single row spanning the back right half of the room. The final desk area was simply a table with chairs, located along the back left side. I would later find out Lisa had purposefully arranged her room in this eclectic fashion in order to accommodate different students' needs. Her desk was neatly organized in the front right corner of the room. Her Dell station was situated off to the side, along with a document camera that seemed to be gathering dust. When asked about her document camera, she discussed how the school was trying to go paperless and how the document camera seemed to be a remnant from an earlier time. She had only used it once since she started teaching in this classroom a year ago. A projector hung from the ceiling in the classroom as a permanent feature with an attached Apple TV. After the appropriate discussion and signing of paperwork, we discussed how the data collection for this project would be handled.

Data Collection

Data collection for this project took place in the fall of 2012 with the approval of the Institutional Review Board (id # 201207799) . This was an ideal time to try to find out how a 6th grade teacher uses the Science Writing Heuristic (SWH) approach supported by a Technologically Enhanced Learning Environment (TELE) because this was the first year of SWH implementation but the second year of the school's technological initiative. As the teacher had already been in a TELE for more than a year, she could focus on the implementation of the SWH approach. Ten observation sessions took place in the teacher's classroom over the period of the study, occurring approximately every Monday, and six interviews with the teacher were collected evenly throughout the process, including a pre-unit and post-unit interview. The teacher was also very methodical and suggested that Mondays would be the best days to visit because the students would start on a new topic within the unit while the rest of the week was focused on that topic.

The data collection for this project took place over 3 months and included 10 observations. Each observation lasted approximately 1 hour. The data collection also included 6 semi-structured interviews which varied in length. 3 months was a necessary time period due to length of the unit taught. Lisa was planning on covering all the stages of the SWH approach during this unit, and I wanted to observe the technology usage throughout. The class period I observed had the unique case of being broken up into two parts by a gym class. The students would receive instruction for half an hour, go to gym, and return to continue their science lessons. During this break, while the students were in gym class, we conducted our semi-structured interviews while Lisa set up anything she needed for the rest of science lesson or the rest of the day. The class period was in the afternoon, which the teacher often attributed to adding to the class's restlessness. Lisa chose this class period for observation because it was the first science period of the day. As a result, I could see any problems that could arise naturally, and she could show me how she dealt with them. She informed me that due to her long tenure in teaching, she had stopped making lesson plans for daily events and instead made outlines. I collected two of these outlines she had made for the unit. Observations were taken by hand, and interviews were audio-recorded and transcribed. Journaling was also done throughout the course of this research to capture my feelings and biases and occurred typically after an observation had occurred. Limited artifacts were also collected for this study, at the discretion of the teacher. No identifiers were given with the artifacts.

Triangulation for this project was derived from these sources of data.

The Unit

The unit Lisa was teaching focused on Newton's three laws of motion. Lisa described these laws as, "… lay[ing] the ground work for everything that came after. So it's okay if they're like turtles right now. Slow and steady as long as they're moving… [i2p1l24]." She explained that this unit usually took longer than other units because she not only focused on the content but also laid the ground work for students to develop experiments and to write up lab reports. Lisa noted that with the incorporation of the SWH approach, she expected the unit to take longer and was happy with the arrangement. Lisa's primary goals were for her students to be able to construct knowledge and to communicate with each other through the use of this construction. Her big idea was based on the Iowa Core Curriculum for Science, National Science Education Standards (NRC, 1996) and the Benchmarks for Science Literacy (1993). The Next Generation Science

Standards had released their initial guidelines, but this district chose to align with the state standards until an official release had been made. Lisa tried to use these standards to guide the classroom activities and discussions while still considering the technology she had accessible and the SWH approach. She commented that the SWH approach of using of big ideas to help guide students' inquiries fit well into this unit. For example, the students were asked to develop hypotheses to test any of Newton's laws of motion. The students then individually came up with many different questions about the big idea, such as "why did Newton like apples so much?" and "how does a car go?" These questions were critiqued and vetoed by other students as not aligning closely enough with the main idea. Eventually, through group discussion, each student developed a personal investigative question. The next steps in the unit had students designing and implementing an investigation to collect data and to create evidence to support their claims, all dealing with the big idea. This unit did not have any pre-developed lessons incorporating technology, and all technology usage was implemented solely at the teacher's discretion. When discussing this unit in terms of technology, Lisa seemed enthusiastic. She compared this lesson to her experiences more than a decade prior:

> [This lesson is] so different now, kids don't make charts with graph paper they use...um... the iPad. Everything is on [the iPad] nowadays, there's no messing around with papers getting lost or ruined or me not being able to read their writing… [i1p2l4]

This unit would provide the basis of all the data I would collect and eventually code over the next three months using the framework outlined by Clark et al. (2007). Once the coding was done analysis would begin.

Data Analysis

Observations and interviews were coded using Clark et al.'s (2007) framework was developed from their extensive research focused on technology and argumentation driven environments. The breakdown of observed subcategories can be seen in Table 2.

Table 2. Technology Supported Argumentation Code Book

Code	Subcategory	Description
Asynchronous	Individual reflections (1)	Students use technology to view and change their own arguments without outside feedback.
	Individual analysis of data (2)	Students use technology to view, manipulate, and document their own findings as data, without outside feedback
	Individual analysis of evidence (3)	Students use technology to help organize data and derive evidence, using writing, pictures, and video without outside feedback
Synchronous	Group construction of arguments (4)	Students use technology to connect evidence and claims as a presentation for other classmates
	Group negotiation of ideas (5)	Students use technology to help guide discussion about students; work and present alternative solutions, allowing time for all parties to participate
	Group feedback (6)	Students use technology to critique and evaluate each other's work
Group Composition *		Teachers use technology to group students according to different factors, ability, interest, roles, etc. (*Not used in the context of this study)
Creation of artifacts	Individual (7)	Students individually create artifacts with technology

Table 2. Continued

	Group (8)	Students create artifacts in small groups with technology
	Modification of artifacts (9)	The initial students involved in creating an artifact are allowed to go and modify the artifact using technology
Sharing of artifacts	Evaluation (10)	The teacher or student gives a final evaluative score on another student's work with little room for revision
	Critiquing (11)	The teacher or student or group of students give feedback for changes or clarity needed to improve an artifact with room for the initial student to make changes either through technology or the use of technology
Awareness	Monitoring Self (12)	Students are able to look at their own work and change their work according to new data and outside sources using technology
	Monitoring Others (13)	Students are able to look at the work of others and to critique the work based on the evidence and claim, giving helpful feedback using technology
Access to data	Unique sources of data (14)	Students are able to access data through the Internet and other sources that would not normally be accessible to them

Table 2. Continued

	Collection (15)	Students are able to collect data and store data more easily using technology
	Organization (16)	Students use technology to record and organize data in multiple ways
	Evaluation of data comparison (17)	Students can use technology to easily compare their data with other sources
	Modeling (18)	Students are able to use technology to model their data in different ways. Student might be able to use this information to predict or to display
	Description (19)	Students use technology to describe data within their frame of understanding by incorporating pictures or graphs or text. Typically a statement describing the medium is also inserted e.g. a caption might be included
Argument Construction	(20)	Students are given examples and templates to guide their argument development and scaffolding is slowly decreased incrementally with the use of technology
Environmental integration	Curricular (21)	The technology is built into the curriculum or is purposefully placed into curium settings by the teacher
	Organic (22)	The teacher chooses when to use technology to enhance student learning.

Clark et al.'s (2007) coding scheme was gradationally refined for the purposes of this study through re-readings of the transcripts, eventually settling on 7 main codes and 22 sub categories which were used to code the transcripts.

The researcher also used the framework as a lens to view the observation and field notes. However, only the transcripts were coded strictly by this framework. A full description of the Clark et al.'s framework used to view all documents can be found in Table 3. The interviews acted as the best representation of the teacher's ideas, while the observations and field notes simply represented my interpretation of the technology use. There were three levels of data analysis.

Level I: Sectioning Technology Use within the Science Writing Heuristic. As seen Table 1, the linear-type progression of the SWH approach allows for the segmentation of this method into 8 parts for the teacher. During the course of this study, 4 segments stood out from the others. Pre-laboratory activities, participation, negotiation phase II, and negotiation phase IV had a very high amount of technology use. While technology was still used during the other 4 phases, it use was not as prevalent or diverse. Once this trend was identified in the data, each SWH segment was assigned the label "high technology" or "low technology" to indicate how much or how often Lisa chose to use technology during that particular phase of SWH. This delineation between high and low technological sections allowed me to ask Lisa follow-up questions about her ideas between different segments of SWH and her technology use. Technologically- rich segments tended to focus on the different applications and technological tools that were available to the students as they worked with the content. Technologically-low SWH segments typically used a presentation tool and a word processor.

Level II: Coding the Information. After delineating different levels of technology use within the SWH approach, the next level of analysis focused on coding all the segments. This experience proved difficult because many of Lisa's actions fit into multiple categories due to multiple interpretations of artifacts. Clark et al.'s framework allowed for no overlap between the codes, and as a result, the inter-rater reliability was insufficient. Once overlap was allowed, an external 3rd year graduate student auditor was able to rate samples of transcripts with .7 reliability. The external auditor was given the framework, and there was a discussion of each of the categories and subcategories. She was then given one interview to score, and the number of matching codes was compared to the total number of codes provided. The greatest discrepancy of inter-rater reliability occurred when dealing with feedback and evaluation. For example, part of the transcripts involved Lisa discussing student revision of data organization:

> … and the charts those kiddos make. They do some fancy things to them, but don't always... um…kinda get what others will understand until someone says something. Then they're like OH! It should look like this, not that. Using pages, they can do it like that [snaps fingers] when before they would roll their eyes and groan, but now they hear that from another student, and they're even um… kinda excited to change it, give it a new look. It's just so fast! [i4p1l15]

The researcher coded this as Synchronous-Group Feedback and Creation of Artifacts-Modification of Artifacts because Lisa expected the students to use a technology to share and give feedback to one another while the technology also allowed them to modify their artifact in a way that would be impossible without the relevant technology. My auditor felt similarly, and used both of those codes but additionally added Evaluation of Data-Describing because she felt the initial student would only change their work if they had evaluated the critique and felt the new graph would provide a better description of their data and ideas. While this might be true, it is not clear within the transcript whether this is a concept that occurred to Lisa. Because she did not articulate this idea and because the purpose of this research was to gain a better understanding of her conceptualization of technology within the SWH method's frame, we discussed how that code did not fit.

During this level of coding data, the external auditor was shown the field notes/observations and the journals already coded. Upon reading through a sample of the data, she approved the codes as being appropriate to the artifacts. This method of verification, rather than inter-rater coding, was chosen because the field notes/observations and journal already expressed my bias when collecting and documenting. For example, one observation included Lisa organizing all the students to collect data. The students used different technological data collection methods, including video recording, audio recording, word processors, and traditional pen and paper. During the interview, Lisa discussed all of these methods as having equal and valuable weight when questioned, but during the observation, it was clear she was encouraging video and word processor usage. The auditor pointed out that while my coding for this section seemed reasonable; she could not glean that from the observations herself.

Level III: Groupings for Analysis. Once coding was finished, the data was counted and sorted. The data derived was analyzed in multiple ways. The data was examined as a whole conglomerate to examine how technology use occurred across the SWH approach, the data was segmented according to the different stages for the teacher within the SWH approach, and groupings of different codes were bundled to see how their usage transpired throughout the SWH approach. This final level of analysis directly led to the themes which were member-checked with Lisa once all coding was finished. Her response is noted in the findings.

Table 3. A Description of Clark et al.'s 2007 Framework for Technology Supported Argumentation

Category	Code	Description	Example within SWH
Facilitating collaborative argumentation	Modes of communication	Synchronous/Asynchronous: Technology allowing students working together on similar events or working individually on different events	Students can use technology to collaborate and join ideas, or are able to work at home on different parts of their experiments and construct their own ideas and meaning from an experience at their own pace
	Group composition	Technology helping group students according to interest or other affective domain categories	The teacher was able to group the students depending on which stage of the experiment they were on by quickly looking at their electronic work
	Co-creation and sharing artifacts	Technology would help create, modify, and share permanent external representations of their ideas and arguments with one another. The technology also allowed for students to monitor themselves and others	Students were able to create documents, images, and video, to support their claims, and quickly send these artifacts to other student in order to be critiqued. This is also when students would write their own personal meaning into an activity.

Table 3. Continued

Facilitating the construction individual arguments, contributions	Access to data	Technology allowed students access to different sources of data as well as allowed them to easily collect and organize their own in different ways for easy interpretation	Students were able to collect raw data in the form or video and documents and able to transform that raw data into different charts and graphs to assess what might be the best presentation tool for others to show the evidence
	Evaluation of data	Technology is able to help students help students compare their information with other sources, help them create models, and allow them to develop descriptions and evidence from their findings.	Students are able to critique each other's work easily with fast feedback and are also presented with data collected by someone else and try to follow someone else's line of reasoning. This is also an opportunity compare their ideas to internet or e-book sources
	Argument construction	Technology provides templates for fill in the black type activities that go from very scaffold to students creating their own.	The teacher was able to show students many different example projects for students to base their work off of.
	Environmental integration	Technology can be more seamless when it is built into a curriculum but is not necessary for all cases	In our case the teacher did not have a curriculum that is technology immersive; rather she is left to her own devices.

CHAPTER 4: FINDINGS

This chapter offers the outcomes from qualitative analysis of the data collected during the course of this study. While these outcomes are up to interpretation it is my opinion these themes are the most supported with the data collected and are reasonably corroborated across the different types of data. First, we will approach the data from a holistic level, looking at the technology use throughout the SWH approach as a whole, and then look at different segmented parts of the SWH approach and the technology usage within those areas.

Holistic Findings

When looking at the data as a whole entity, a technological sequence emerged dealing with how the teacher used technology to present the various SWH components (see attached table.) This technological sequence represents how the teacher used different technologies in her class, such as projectors, videos, word processors, media editors, image creators, idea organizers, cameras, iPads, different applications, and the internet to achieve her goals for the students. The sequence is: Large Group Activity, Individual Creation, Small Group Activity, Individual/Small Group Revision, and Evaluation. Each part of this sequence is marked by a shift in how the teacher uses technology or in how she expects her students to use technology. While not all parts of the sequence occurred, the parts that did emerge occurred in the same order. The technological sequence, both whole expressions and partial expressions were also repeated multiple times within her teaching of the SWH approach.

The repetition of technological use throughout this unit was not a pattern she noticed when asked to member check the data. However, upon reflection the teacher concluded there was a sequence and hypothesized she might have conducted her class in such a sequence to reduce the stress of using unfamiliar technology. The teacher also informed me she wanted to leave some technological choices up to the students. Lisa's technological sequence repeatedly occurs within each different component of the SWH approach rather than adhering to the larger unit. This indicates she is using the TELE to support the SWH approach and has structured her classroom to allow content material; in this case Newton's 3 laws of motion, to act as a foundation for her students to explore, derive arguments from, and participate in argumentation using the SWH approach, supporting each section with technology.

In order to see how this teacher supports the SWH approach with different technologies from her TELE we must understand individual parts of the sequence.

First, she uses a technology to introduce new topics or content during a large group time. This technology is focused primarily on presenting information to the whole class. The second time she implements technology in her lessons she has individuals create artifacts. The next time she uses technology within a SWH segment is to have students critique each other's artifacts and revise them. The final time she encourages technology usage in this sequence is during an evaluative process. This sequence can be seen in detail in Table 4 and a flow chart is depicted in Figure 1. Lisa discussed how she thought each of these parts were important in their own way. During the large group sequence Lisa said:

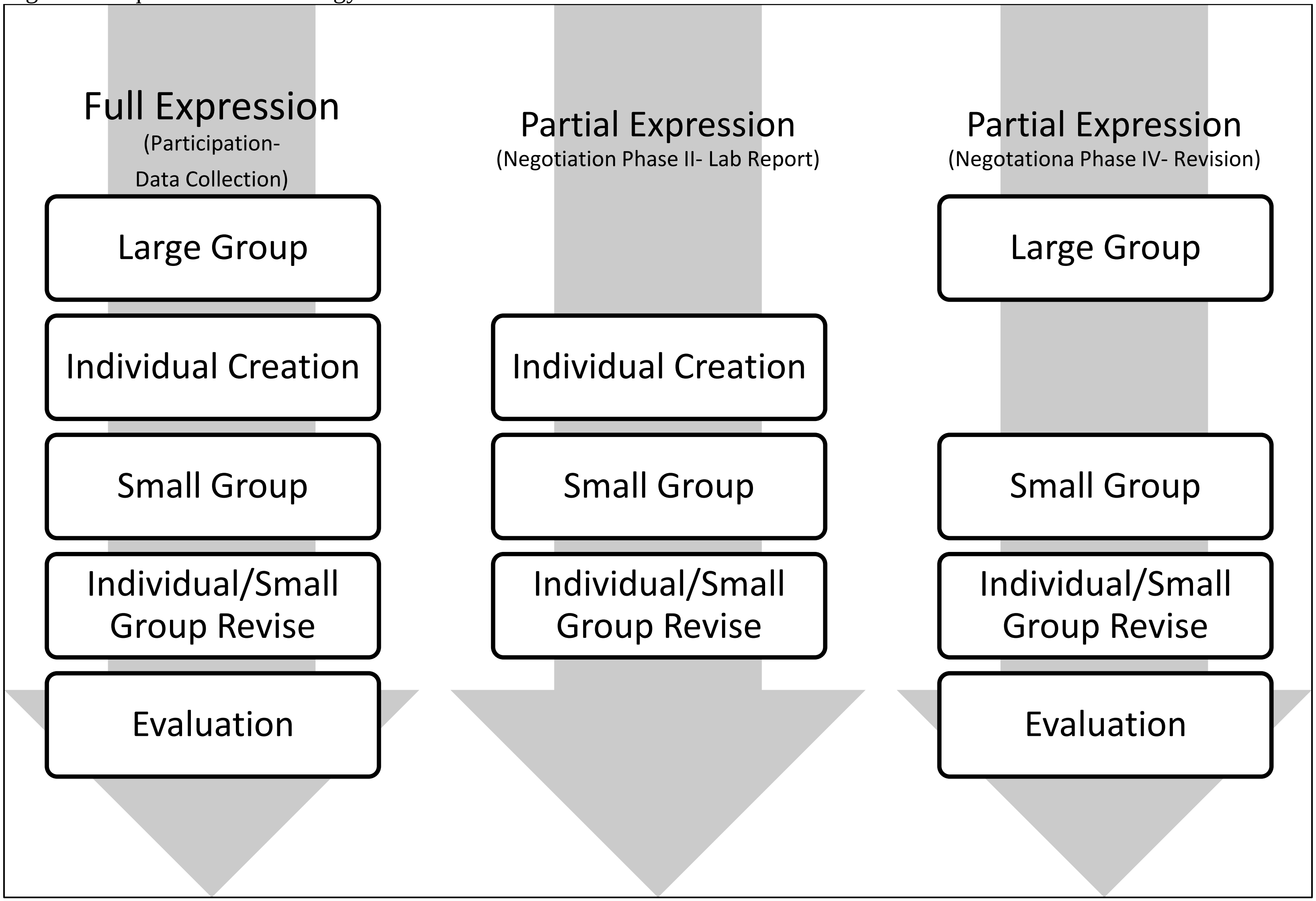
> I just like knowing my kidder-roos are on the same page. This way they can see me working with Jennifer and see how they should do it but also how um... really they also see how to help and talk to others, which is the later part of this [lesson]. [i2p4l9]

Table 4. Sequence of Technology Usage

Sequence of Technology Usage	Whole Sequence Expression (Participation-data collection) *high technology use*	Partial Sequence Expression (Negotiation II-Lab report creation) *low technology use*	Partial Sequence Expression (Negotiation IV-revision) *high technology use*
Large Group	The teacher showed the students a toy car experiment and had the class develop data collection methods using different technologies including video and word processors	Not Expressed	The teacher gathers the class together and reintroduces how to critique peer work, what criteria students should look for, and shows different methods to accomplish this.
Individual Creation	The teacher asked students to develop data collection techniques. Students created these in a word processor but had to consider and test multiple types of technology.	The teacher has the students look at individual components of their data and begin writing links between their evidence and their claim.	Not Expressed
Small Group	The teacher assigned students into small groups of 3 and 4 to share their methods and critique each other's work.	The teacher assigns small groups to read each other's work	The teacher organizes small groups of students to discussed individual students work and commented on how the evidence supported the claim and what is missing from the report
Individual Small Group revise	The teacher directs the students to work individually to correct any issues brought up previously	The teacher directs the students revises their work according the peer critique.	The teacher directs the individual students re organizes their evidence and/or presents it in different ways to support their claim.
Evaluation	The teacher has the students e-mailed their methods of collecting data to the teacher	Not Expressed	The teacher has the students email their work to a peer for evaluation.

On the left is the order of technology use. The second column gives an example of when the sequence fully expressed itself within a lesson, while the third and fourth columns represent lessons where there was partial express. The events still occur in sequence.

Figure 1. Sequence of Technology Use Flow Chart



This quotation shows how Lisa thinks about technology during the large group as a scaffolding tool for multiple SWH activities and setting rules for peer interaction. While observing this task the researcher often noticed Lisa commenting aloud how students shouldn't get defensive when people question their work or doubt their findings. She had a student make a note of things to remember when discussing someone else's work and email it out to the class. This list consisted of items like "be respectful," "argue the science not the person," "It's okay to be wrong, it's not okay to be stubborn." This list was derived from the large group discussion and was referenced by the students once they started working in groups to modify their work.

The second time the teacher would typically introduce more technology into her lesson was when students were making or modifying individual artifacts. "..it doesn't matter what they use now, I just want to see them do it, so they can get it, got it, good! [i4p1013]" In this phase technology use is not very structured. Lisa gave students goals more aligned with the SWH approach and the unit content and left the choice of technology use up to the students. During this sequence students would often use their iPad's, or computers to help generate artifacts, but some students would draw, write on paper, or use dry erase boards. Lisa did not discourage these creation processes but did require the students to document their work by taking a picture of it or recreating the final product digitally. Often the students working in these non-device oriented mediums would transfer their ideas to a technological format with the help of their teacher and peers. For example one student developed her mind map about Newton's 1ST law on a dry erase board; she took a picture of the map and moved it into an app on her iPad, for working in a small group. Other students in her group had developed their mind map with pictures they had gotten from the internet and by photographing her image the student was able to combine different elements of their mind map with hers. When asked about the student's transitions between mediums Lisa discussed how some students think in words, but other students want to think in pictures. She was adamant that technology is a way for students to express themselves more naturally but also to understand students work differently and there are benefits to different approaches.

The third and fourth sequence would often happen together. The students would meet in small groups and present their work to their peers. During this time they were constructively critiquing each other's work and revisions simultaneously. Lisa talked about these times during sequences as one of the reasons she felt passionate about technology. For instance she commented:

> I love, love love this part. They're all working together and talking and arguing in a good way. It's super telling about what they um...really think about their own stuff and explaining it to someone else who doesn't get it can be a new experience. Then when that student tells them it doesn't work, they can change it right then and there if they agree. You've never seen them get so much done before. It shows them spell checkers are the greatest after all too [i5p2l20]

She emphasized the speed multiple times during the interviews. Lisa shared many of the frustrations students used to encounter pertained to the rewriting lab reports and making corrections. She said the use of technology alleviated that frustration allowing students to focus more on if the critiques were valid rather than the work involved in making the changes. She expressed that, from her personal experience, students were more willing to listen and take input from other students knowing that changing their project wouldn't be as hard, where before students "would be super stubborn and not want to listen to anyone's opinion because they meant they might have to re-write. [i6p6l13]" This statement seemed to indicate Lisa felt the students were less personally attached to their document when using technology and more attached to scientific negotiation. While there are other factors likely at play, which might influence students' willingness in altering their work, observational logs [7,8,10] indicate the teacher would transition the students into small group and pair negotiation with verbal directions like "change your work as needed," "correct things as they come," and "edit, edit, edit." Once again this indicates the teacher relates specific components of the SWH approach to explicit editing technology such as word processors, and video and image editors.

The final stage to this sequence dealt with the evaluation of an artifact. Lisa would have students send her emails of their project when they were ready to receive a grade and move on to the next parts of their projects. She asked for the data to be sent in a single email with the final artifact as well as any other materials they thought she should be aware of, such as previous drafts, internet articles, videos they had collected as well as other artifacts. If they sent extraneous documents she required a written blurb about each additional item. These items would help inform her before she graded them, and according to her many students took advantage of this. She saw this collection as a way to ensure the students were using appropriate sources to guide them. She posted some of these to a class website so other students could use them as resources, depending on what stage of investigation they were on.

This sequence of how Lisa used technology in her classroom remained constant but not unaltered through each segment of the SWH approach, and different parts of the sequences were emphasized more than others during different SWH components. For example, during Negotiation Phase IV, where students were finalizing their entire research report on the experiment they conducted pertaining to one of newton's laws, the sequence still happened in order but did not include individual creation. This phase also emphasized revision above the others. During the Participation component of the SWH approach, Lisa highlighted individual creations and small group sequences most. When this was brought to her attention during the member check, she commented, she might use technology to bring out elements she considers more important and letting unimportant elements fall away. She discussed one example as data organization. The teacher described student data collection before technology as "messy" and sometimes lost or missing by the final submission. Lisa describes current, technology infused, data collection as a more streamlined process, videos and pictures can be taken and data can be written down neatly all in one device. Files and folders can be made immediately to store the data, and the data can be found simply by using the search bar. She goes on to comment how there needs to be a "flow" in how technology is used as to not disrupt the class environment when students use it.

This "flow" in the classroom environment was expressed by a holistic view of the technological sequence. In order to look more deeply in to how technology is used to support the SWH approach within Lisa's classroom a compartmentalized view be used to tease out other important ideas.

After looking at the holistic technological sequence developed by a 6th grade teacher attempting to support the SWH approach with a TELE, it is important to view how when different sections of the SWH method are viewed another pattern develops focusing on high and low technology usage.

Sectioned Finding

When examining technology within the different components of the SWH approach, some components had lower or higher usages of technology. Lower usage is being defined as having only one or two codes being represented within that component and higher usage as having multiple codes represented. It was discovered upon re-reading the observational field notes, higher usage segments also seemed to have more diversified technologies used as show in Table 5.

The use of Clark et al.'s (2007) framework signifies how technology can support students' construction of arguments and actual argumentation. They discuss higher representations of technologies used in specific ways lead to a technology-enhanced learning environment which would support student's argumentation. The representation of technology occurred frequently in some components of the SWH approach and was underrepresented in other areas. This deviation justified investigation. When examined further, students working as individuals seemed to generate the most codes for technology, while during group work students were more relegated by the teacher to use the specific applications such as Pages, Keynote, and Numbers to present and defend their work. Interestingly, lower technology segments of SWH received a larger time allocation within the unit as a whole. This occurrence can be summed up in a point Lisa made early in our interviews:

> I think one reason to use technology is to get rid of all those little things that get kids frustrated and angry for no good reason, and let them get frustrated an angry about the actual science. [laugh] but honest, it make the parts that don't matter as much easier for kids so we can spend time on things the computer can't do, like think [i1p5l15]

Table 5. Description of Sectioned Findings in Terms of the Science Heuristic Writing Approach

Component	Description of Segment
Exploration	Lisa allows students to work with low and high tech mediums, while some students chose to use a concept mapping app on their iPads other students chose to use dry erase boards or paper and pencil. These eventually had to be turned into an electronic format (low technology)
Pre-Lab Activities	Lisa guided students to engage in many different types of technology within this segment including internet investigations, online experiments, hands on experiments filmed with iPads (high technology)
Participation	Lisa guided students through the different experiment stages, using many types of technology. The technology was primarily used to collect different types of data and organize it (high technology)
Negotiation Phase I	Students used a word processor and documented their experiment (low technology)
Negotiation Phase II	Students discussed their documents with peers using programs to share (low technology)
Negotiation Phase III	Students researcher online, through e-texts and regular texts and emailed experts (high technology)
Negotiation Phase IV	Students revised and edited each other's work finishing their data organization and evidence claim presentations (high technology)
Exploration	Teacher uses strategies to help students reflect on their understandings and the actions they took throughout this experience (low technology)

What Lisa is describing in this quotation is that technology is able to reduce student's cognitive load allowing them to engage in authentic science and inquiry. She gave examples such as students not being able to read their own or other students' hand writing, losing papers, and not having access to resources, as time wasting activities, when really they should be working on developing critical thinking skills. Students who must use cognitive ability to decipher handwriting and thinking about lost documents are not giving their full attention to the process of developing arguments. This quotation also explains why longer periods of class time were allotted for lower technologically infused segments; the time was used for students to critique, negotiation, and revise. TELE do not typically focus on technology and what the technology can do, but rather try to focus on the purpose for using the tool. In these cases the SWH approach did not benefit from large amounts of technological support and because of that less technology was used. While building and constructing artifacts were important, the time used for their creation could be expedited with technology, also making the artifacts more easily accessible. This ultimately causes the majority of technology to be represented during data collection and presentation phases, which are primarily individual student work, in which students use the technology to aggregate as much data as possible and create initial artifacts. Group work and critiquing segments focus more on student's interactions and negotiation, causing the technology simply to be a platform for student discussion and revision.

This idea of lessening the amount of student time spent on non-essential work also generated two other finding. Lisa claimed students were producing higher caliber work than before she entered a technologically immersive environment and. She also discussed how evaluation was made easier for her as a teacher through infrastructure. First, she discussed how student's professionalism was better and their lab reports were cleaner and had more information.

> …you should see some of the stuff these kids are doing. I've never been prouder. They make movies, and YouTube things about the stuff we cover, and the reports they make? Forget about it! They care that their pictures aren't aligned and titles aren't bolded. I'm not saying they don't care about the science, but they care the science is presented nicely and orderly, and I LOVE that it... it's great to see kids taking pride in their work and honestly it's easier to grade for that matter... [i3p2l18]

During classroom observations the students were very engaged in making their reports look professional, while still paying attention to the content. During a revision phase of one of the lab reports the researcher observed a conversation between Lisa and a group of students. Lisa was asking many questions about their content and probing them to go further in questioning of each other to relate their claims and evidence. The students in that group eventually decided to reorganize their data and rephrase the statements about their evidence to better align and support their claims. As the students rearranged their data in different graphs and charts Lisa pointed out different ideas could be said about the data when presented differently as the students wrote the appropriate sentences. When asked about interaction, Lisa discussed how "Students talk for the data [i6p7l3]" going on to discuss how students often do not know what to say about the data they collect. Lisa claimed by using different graphic organizers, graphs, and charts, the students are able to more clearly understand the data they want to represent and technology allows them to do so easily so they can focus more on interpretation then recreation, and structured her class accordingly.

Lisa also claimed, as a teacher, she was more able to clearly follow students' trains of thoughts and notice misconceptions because they sent her weekly emails with their drawings, writings, pictures, and video. During my first observation at Lisa's school she showed me the school's database and infrastructure in place to help organize the student's data. Administrators developed complicated folder systems that would file student email in personal folders for teachers to review by class. The technology organized all the students' work for her so she wasn't spending time organizing or deciphering it, and rather allocated the time to assess the work. Lisa's claim was partial supported by the coding scheme. Clark et al.'s (2007) framework categorized organization data explicitly, while other codes also have elements of organization built in. By using technology to support the dynamic structure of the SWH approach, Lisa could be helping to add organizational elements to students output. By using technology to create the artifacts she knew where students were in the unit content when they sent her artifacts to evaluate every week. Students were using technology to review and revise each other's work so that also cut down on the time she spent editing and thus could spend more time on the arguments students were making.

During an observation [9], Lisa was very explicit in stating the need for students to create clear arguments that were easy for readers to follow, much like these findings should allow for a discussion of the researcher questions and their resolutions.

CHAPTER 5: DISCUSSION

The purpose of this chapter is to answer the researcher question proposed in chapter one, delve into the implications that arise from that answer, as well as to discuss the limitations of this study. This section ends by calling for further research to more closely scrutinize some of the questions that were raised by this study.

Answering the Research Question

- How does a 6th grade middle school science teacher conceptualize the use a TELE to support students' argumentation within the Science Writing Heuristic approach?
- What are some ways she supports the Science Writing Heuristic approach with technology, in her classroom?

To answer the first question, this 6th grade middle school teacher conceptualizes technologies role within the SWH we must look back to the pervious chapter dealing with segmented findings. In analyzing how Lisa breaks up technology for each of the different segments of the SWH approach we find Lisa describes that technology helps her in three ways. Technology cuts down on wasted time for the students, allows students to create better more complex explanations, reasoning, and understandings, and reallocates her time as teacher to better focus on student's content.

First, she feels technology helps cut down the amount of time students spend on non-essential work so they may focus on the more important ideas such as sense making, negotiation, and critical thinking. She said:

> …iPads have really changed what their turnaround can be. One student makes a comment, the other student likes it, backspace backspace, write, write, write, boom it's done! They don't have to make a note, or cross something out, they change it and it looks perfect. A lot of the kids like that, it looks perfect again. It's a lot less work so they're more willing it to do it. I see the drafts almost every week so I know their thoughts are changing and evolving and growing what do I care if they don't rewrite it?[i5p3l8]

Conceptually, this is consistent throughout the interviews Lisa talked frequently of using technology as a time saving tool during data collection, artifact creation, and evaluation. Lisa explained that she has been a Science teacher "on and off" for more than a decade. Because she is certified in many areas she is often asked to teach English as well Science. During multiple interviews she often spoke of past issues students had writing and rewriting. She described the difficulties involved to convince them the importance of doing so. She suggested science having the same issues. Students used to be bogged down with editing for grammar and punctuation and lose sight of the purpose and content. Lisa saw technology as how students could move past the tedious part of writing, and focus on the purpose they were pursing; making coherent arguments by connecting their evidence together and supporting the claims they made.

Second, Lisa believes the use of technology allows students to develop more nuanced complex concepts and presenting their ideas, data, evidence, and claims in a plethora of different ways. She discusses one of the codes, "access to data," regularly without knowing it exists.

> I love when kids put pictures in to their [lab reports] I was afraid they'd put doodles and weird cartoons, and sometimes they do, but you can tell when they take time and choose good ones. Then I use the captions to tell if they get it or not or if they're just using it because it's pretty...one student, he linked a bunch of spectacular YouTube videos about newton's cradle, they were so go I had to show [them] to the class. You never got this before the iPads kids wanted to do the minimum amount of research and now they're going above and beyond because it's only one click away… [i6p1l12]

In this interview excerpt Lisa is very excited about how technology allows students to express their understanding of content at a new level. She conceptualizes technology as a portal, giving students access to new form of communicating their knowledge to themselves and to others. She finds this type of pictorial and video usage as engaging and expresses later on, she believes it is a reason students are more willing to engage in each other's works for review and discussion.

Finally, Lisa thought her responsibilities as a teacher had shifted with the use of technology, dealing with less administrative issues and focusing more on student understanding. She commented that "click, click, click, and I have their work right in front of me, convenient and easy to read, in barely no time at all![i1p5l4]" She only commented on this idea of her work load shifting twice during our time together, and I never actually observed her looking at the students work. During one visit she did show me the how easily she was able to give students grades and attach examples of their work for parent to see it electronically.

To answer the second question, "What are some ways she supports the Science Writing Heuristic approach with technology, in her classroom?" Lisa has allowed technology to organically and systematically develop into her curriculum to support SWH. Her approach can be considered organic because it is not dictated into the curriculum nor does she set rigorous lesson plans which demanded the inclusion of technology. Her approach however, does have structure. Unbeknownst to her at the time of this study, according to the member check, the techniques she uses to incorporate technology within her classroom did have a sequence of events. This sequence of events cycled once every segment of SWH, without the intent of incorporating technology, but rather with the purpose of using all the resources at hand to assist in the implementation of SWH. We find that it is a purposeful use of resources, rather than a purposeful use of technology, that motivates Lisa to use technology in her classroom.

Within the technological sequence she developed, Lisa was able to use technology to embody different parts of the Clark et al (2007) framework, which show how different technologies support argument based learning environments. For example during the course of this unit students were developing questions, claims, and evidence for an experiment dealing with one of Newton's 3 laws of motion. One student, Emi (names have been changed), conducted her experiment and, with Lisa's encouragement, video recorded the data collection process. In a large group review of her work many of her peers noticed a discrepancy between the data she collected and the question she was asked. Lisa then guided a class negotiation on what Emi should do next. Some students suggested to redo the experiment, some students recommended changing her question, while Emi argued the question and the data aligned. After a class negotiation Emi changed her research question to more appropriately reflect the data she had collected. Without the video, and simply hearing Emi describe her experiment, the students wouldn't have been able to give as through of a critique. This episode, which lasted less than 10 minutes of class time, encompassed 3 major codes, Creation of artifacts, Sharing of Artifacts, and Evaluation of data, and multiple sub-codes within our technological frame. In this scenario Lisa used technology to provide additional information for students to develop critiquing skills, as well as used technology to enhance the level of data collection. Another example of how Lisa used technology to the advantage of her students was during "Negotiation phase 3." This phase has students compare their ideas about science to expert sources and texts. With the use of the internet students were open to many different "expert" sources. Within this school' technology curriculum, discerning creditable internet sources is introduced in the 4th grade, and every subsequent grade does a refresher course for the students, so Lisa did not have to worry much about students using poor sources. She did allow her students to attempt to contact experts in the field to gain more insight in their personal experiments. This activity engaged 2 codes, Asynchronous communication, and access to data, and multiple sub-codes within those.

By providing, opportunities, rather than forcing situations, for technology to enhance different aspects of the SWH method, such as during pre-activities, participation and all student negotiation phases, Lisa is able to incorporate technology within the SHW method seamlessly.

In summary, this study has discussed how a 6th grade elementary teacher conceptualizes the use of technology within the SWH framework and described different ways she supported that integration within her classroom. This teacher showed great knowledge about the SWH method, technology, and the integration of the two.

Limitations

During the course of this study I have run in many limitations that can be reduced to 4 categories, the inexperience of the researcher, complications with the instrument used for coding, problems with the participant, and issues with preforming a case study.

I, as a new researcher, have many limitations in my understanding and expertise of research and specifically as a qualitative researcher. There are likely nuances and gradations within the data I am not equipped to detect. Because of that, themes might have gone unnoticed or artifacts that could have added for a more robust understanding have gone uncollected. Along those lines, due to my inexperience with semi-structured interviews, may first two interviews with Lisa ended being much shorter than the last 4. While this could be due to rapport, my inexperience certainly contributes.

Another limitation deals with the analytical frame chosen to examine the classroom. This frame was developed from analyzing technologically immersive environments implementing technological argumentative frames as software intervention. The SWH methodology is not a software intervention but rather teaching intervention conducted by a teacher rather than a program. The authors analyzed 4 different successful argumentation interventions and parsed out different aspects of technology that assisted students in actively engaging in argument construction and engagement. Within in the scope of the study the teacher was in charge of integrating the technology and SWH to actively engage students in argument creation and negotiation and I used the frame work to see if it was done successfully. In hindsight I might have let the codes from Lisa's interviews occur more organically and then compared the codes I developed to the other instrument.

The participant in this study was very enthusiastic in contribute to the research. There are however major issues with only looking at a single individual. To provide better fidelity between what the participants was saying more observations should have been done within the classroom, spaced closer together, and more interviews should have been taken during the project. In retrospect I should have had the participant reflect more on her actions within the classroom, and would have performed the interviews after the lesson rather than during the middle break. Lisa also proves to be a unique individual; I am not sure how transferable her data is to other teachers between her enthusiasm to learn new technology, and her background of decades teaching at this grade level

Finally there are limitations of doing a case study. There is no generalizability of this study. This is not truly a limitation because generalization was never my intent. However the usefulness of this information to is limited due to the single participant and her unique circumstances. Very few schools have access to the level of technology and technological support Lisa has. Typically, single, standalone case studies, such as this one are collected by a sole researcher; this introduces biases into the research. While there was an external auditor of my data, they only coded samples of the transcripts with me. This biases the research to my personal lens.

Implications for Further Research

Ideally more research will be done on the topic of teacher conceptualization of technology to support argumentation. To effectively use technology in the classroom to support argumentation teachers will have to develop its integration organically or technology will have to be placed into classrooms through curriculum and software interventions. Strategies could be developed to help integration at different levels, depending on schools access to technology and this could also be explored at different grade bands. Would technological integration with argumentation, within science look different at the secondary level?

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