The Pennsylvania State University
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STUDENT USE OF WEB 2.0 TOOLS TO SUPPORT
ARGUMENTATION IN A HIGH SCHOOL SCIENCE CLASSROOM

A Dissertation in
Learning, Design, and Technology
by
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ABSTRACT
This ethnographic study is an investigation into how two classes of chemistry students (n=35) from a low-income high school with a one-to-one laptop initiative used Web 2.0 tools to support participation in the science practice of argumentation (i.e., sensemaking, articulating understandings, and persuading an audience) during a unit on alternative energy. The science curriculum utilized the Technology-Enhanced Inquiry Tools for Science Education as a pedagogical framework (Kim, Hannafin, & Bryan, 2007). Video recordings of the classroom work, small group discussions, and focus group interviews, documents, screen shots, wiki evidence, and student produced multi-media artifacts were the data analyzed for this study. Open and focused coding techniques, counts of social tags and wiki moves, and interpretive analyses were used to find patterns in the data. The study found that the tools of social bookmarking, wiki, and persuasive multimedia artifacts supported participation in argumentation. In addition, students utilized the affordances of the technologies in multiple ways to communicate, collaborate, manage the work of others, and efficiently complete their science project. This study also found that technologically enhanced science curriculum can bridge students’ everyday and scientific understandings of making meaning, articulating understandings, and persuading others of their point of view. As a result, implications from this work include a set of design principles for science inquiry learning that utilize technology. This study suggests new consideration of analytical methodology that blends wiki data analytics and video data. It also suggests that utilizing technology as a bridging strategy serves two roles within classrooms: (a) deepening students’ understanding of alternative energy science content and (b) supporting students as they learn to participate in the practices of argumentation.
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Chapter 1

Introduction

Reform movements in the science education community (Bell, Lewenstein, & Shouse, 2009; Duschl, Schweingruber, & Shouse, 2007; Quinn, Schweingruber, & Keller, 2011) argue that science education for American youths needs to include not only the development of scientific knowledge, but must also provide the opportunity for youths to participate in science practices. In fact, the current framework for K-12 science education (Quinn, Schweingruber, & Keller) emphasizes the importance of youths’ participation by listing scientific practices as a major dimension of science education.

One science practice advocated as essential is argumentation (Bricker & Bell, 2009; Duschl & Osborne, 2002; NRC, 2011), designated in the K-12 Framework for Science Education. Argumentation is considered the dialogic process by which knowledge is produced. Scientific arguments are a means by which scientists, and learners of science, explain scientific phenomenon as well as convince others’ of the soundness of the logic of their conclusion (Duschl & Osborne).

Research has shown that the use of computers and technology by students can support their participation in science practices (Smith & Reiser, 2005), including argumentation (Linn, Clark, & Slotta, 2003). Specifically, research indicates that student use of Web 2.0 technologies can support student engagement, communication, and collaboration (Cress & Kimmerle, 2008; Larusson & Alterman, 2009; Peters & Slotta, 2010), which are necessary for participation in science practices like argument and explanation building.

Emerging Web 2.0 tools and applications such as social bookmarking, wiki, and video-production have become freely available over the past decade. Presently educators at
all levels are incorporating technologies into their classrooms. Teachers and schools adopt these Web 2.0 tools to facilitate experiences for a variety of reasons: communication, collaboration, and construction of knowledge artifacts in ways that support learning across a multitude of settings. However, these advances in technology have occurred at a pace much faster than the development of both research on effective classroom practices and findings on technologically enhanced learning in science education. This study addresses this gap between technology, classroom practices, science practices and learning theory through the investigation of one technology-supported unit focused on students’ participation in argumentation related to the adoptions of alternative energies.

**Research Purpose**

In this dissertation I examine of how students’ engagement in argumentation can be supported in schools through the use of Web 2.0 technologies. I investigate technologically supported argumentation in one high school science unit on alternative energies through analyzing students’ use of Web 2.0 technologies to

a) support making sense of new information with social bookmarking,

b) articulate their understandings of alternative energies as they co-construct a wiki, and

c) create a persuasive multimedia artifact to sway an audience to their viewpoint.

I posit that this Web 2.0 supported participation allows for not only appropriation of science practices but also provides enhanced opportunities for science learning. My study considers one setting in which I believe this supported participation occurred.

I used video-based research with an ethnographic design to examine students’ engagement in the alternative energies unit. The result is a thick, rich description of cultural
patterns of tool use within the classroom setting to support participation in science practices and to support their learning, and design principles for use of Web 2.0 tools within high school classrooms. The following are my research goals:

- Describe the student use of Web 2.0 tools to support participation in argumentation as they construct collaborative knowledge artifacts,
- Describe the student learning about alternative energy resources over the course of the technology-enhanced, collaborative unit, and
- Describe the emergent design principles for classroom use of Web 2.0 tools to support participation in science practices.

**Conceptual Framework Overview**

As stated above, I focus on the scientific practice of argumentation, specifically the goals (Berland & Reiser, 2009) of sensemaking, articulating, and persuading. To accomplish this work, I adapted a theoretical framework to allow me to examine the social and cognitive elements needed to support students’ engagement in science practices within this technologically enhanced classroom (see Figure 1-1).
Figure 1-1. Theoretical Framework.

Alignment of the goals of argumentation, student actions, and supporting Web 2.0 technologies (based on Berland and Reiser, 2008).

Within this framework, I use sociocultural learning theory to conceptualize how students learn alternative energy concepts and participate in science practices over the course of a technology-enhanced, collaborative project in a high school chemistry class. I study how learners facilitate interactions with Web 2.0 tools to understand how they support and appropriate practices of argumentation (see Table 1-1 for a summary of the concepts and theories that comprise my study’s theoretical framework). To this end, I take learning as a process that is constructed socially as learners participate in practices. In this sense, science can be taken as a compilation of practices with theory, reasoning, material procedures and models as essential components (Lehrer & Schauble, 2006). Research (Kuhn & Udell, 2003) indicates that engaging in argumentation not only improves the quality of student arguments,
but also improves student learning of content (Zohar & Nemet, 2002). Although argumentation is an important science practice, Newton, Driver, and Osborne (1999) state that student engagement in argumentation within science classrooms is uncommon. Often teacher driven interactions dominate the classroom discourse (Lemke, 1990); fostering student engagement in argumentation has proven difficult (Driver, Newton, & Osborne, 2000). Because of this, attempts have been made to incorporate a variety of learning experiences and environments in classrooms to support the practice of argumentation.

Table 1-1. Theoretical Framing for the Study

<table>
<thead>
<tr>
<th>Theoretical orientation</th>
<th>Concept used in dissertation to understand Web 2.0 tools as learning resource</th>
<th>Selected references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sociocultural learning</td>
<td>Everyday understandings and strategies</td>
<td>Rose and Barton (2012)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stahl (2007)</td>
</tr>
<tr>
<td>Science practices (as a specific form of cultural practices)</td>
<td>Argumentation</td>
<td>Newton, Driver, &amp; Osborne (1999)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Osborne &amp; Patterson (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Berland &amp; Reiser (2009)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zohar &amp; Nemet (2002)</td>
</tr>
<tr>
<td>Argumentation sub-practices</td>
<td>Sensemaking</td>
<td>Heer &amp; Agrawala (2008)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Golder &amp; Huberman (2006)</td>
</tr>
<tr>
<td></td>
<td>Articulating understandings</td>
<td>Weinberger &amp; Fischer (2006)</td>
</tr>
<tr>
<td></td>
<td>Persuasion</td>
<td>Berland &amp; Reiser (2009)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zohar &amp; Nemet (2002)</td>
</tr>
</tbody>
</table>

The practice of argumentation is social and occurs within the scientific community where members “make sense of the phenomena under study proffering, evaluating, critiquing, challenging, and revising claims through discourse” (pg. 192, Berland & Reiser, 2009). A similar science practice is explanation. Although Osborne and Patterson (2011)
make a deliberate distinction between argumentation and explanation, others (Berland & Reiser; Bielaczyc and Blake, 2006; Hogan, Nastasi, & Pressley, 1999) have treated these terms as a combined unit because of the overlapping pedagogical goals. I choose the term argumentation within this dissertation, adopting Osborne and Patterson’s (2011) use of “argument” as “a claim to be justified” (pg. 629), along with the elements of an argument being a claim supported by justifications (data, warrant, and backings), counter-arguments, and rebuttals (Toulmin, 1958; Zohar & Nemet, 2002). In addition, I take Berland and Reiser’s (2009) three goals of explanation (argumentation and explanation are viewed as one combined practice), which are (a) making sense of phenomenon, (b) articulating understandings, and (c) persuading others, as also applicable to argumentation.

To promote student participation in argumentation within a technologically enhanced classroom setting, I designed an intervention that utilized Web 2.0 technologies as supports for these practices. After considering the affordances of the technologies, I aligned each goal of argumentation, sensemaking, articulating, and persuading, with a Web 2.0 tool or technology: social tagging using social bookmarking (via Delicious.com), co-authoring a document to display understandings using a wiki (via wikispaces.com), and designing and creating persuasive videos (see Figure 1-1). The Web 2.0 technologies function as tools to support student meaning-making (Robbins, 2005) and mediate learning (Nasir & Hand, 2006) about alternative energy.

**Sense-making**

Sense-making includes behaviors such as organizing, authoring, deciding, or acting, foraging for data, looking for patterns, and problem-solving (Heer & Agrawala, 2008). As
such, “Tagging is fundamentally about sensemaking” (Golder & Huberman, 2006, pp. 200). Social bookmarking is a platform that provides a collaborative interface where individuals can save bookmarks of online resources and apply keywords in the form of social tags (or tagging) to organize, annotate, or summarize the information found within the webpage links (Golder & Huberman). These organizational strategies provide students with a way of making sense of the found information about alternative energies, as well as sharing the resources with others within their group.

**Articulating Understandings**

Articulating understandings is an integral part of learning (Sawyer, 2006), particularly where students use representations to make their thinking visible. Bell (1997) proposed using an argument map where students could investigate all possible knowledge and information before determining what evidence to select to construct their arguments, as well as allow other students to examine the evidence chosen by others in order to compare differing viewpoints about the same situation or claim (Bell, 2013). A wiki is a Web 2.0 tool that supports user interaction for creation of content (Rollett, Lux, Strohmaier, Dosinger, & Tochtermann, 2007). This differs from the typical web page that hosts predetermined information. By students gathering information and synthesizing it to form a non-biased wiki about an alternative energy resource, I posit that the wiki functions as an argument map. Thus, the practices of argumentation can be supported in the classroom through wikis (Larusson & Alterman, 2009; Peters & Slotta, 2010) as students articulate their individual understandings of alternative energies and communicate these to others. Through creating a
knowledge artifact about their group’s assigned alternative energy, students are able to later examine all the available information and select the evidence that helps build their argument.

**Persuading**

The third goal, persuasion, engages students in argumentative discourse by providing a medium for students to reconcile ideas, critique those of others, and revise their ideas by moving beyond selecting evidence (Driver, Newton, Osborne, 2000; Duschl & Osborne, 2002). In addition, designing the script collaboratively in order to construct video artifacts supports engagement in the learning processes (Zahn, Pea, Hesse, & Rosen, 2010) as students negotiate meaning for themselves and the audience. Video was chosen as a technology to support the argumentation; it functions as a medium to convey ideas and arguments to an audience. As such, it supports persuasion by communicating the group’s collaborative argument without requiring the face-to-face presence of the participants.

Through the student use of Web 2.0 technologies as a support for each sub-practice, student participation in the practices of argumentation and also deep engagement with the content will be facilitated.

**Research Questions**

1) How do students use the social bookmarking tool? How do they use it to support (or not support) argumentation? Specifically, how do students use the social bookmarking tool and tagging to support their individual sensemaking (a sub-practice of argumentation) about alternative energy resources?
2) How did the students use the wiki in the completion of a group project? How do they use the wiki as support for jointly co-authoring shared publications about alternative energy asynchronously? In particular, how do students use the process of co-authoring in a collaborative online environment such as a wiki to support articulating and communicating their understandings?

3) How do students use multimedia technologies to persuade others (a sub-practice of argumentation) towards their viewpoint about alternative energy resources? How does student participation in the video design process support (or not support) the practices of scientific argumentation?

These questions were developed with the aim of generating an analytical account of students’ science discourse and design moves that can inform theory, instruction, and curriculum development.

**Problem Statement**

With research on argumentation in the classroom growing and technologically enhanced environments expanding exponentially, more research on how high school students can support their participation in argumentation with the use of Web 2.0 technologies is needed. Therefore, the central problem of my study is researching the role of student use of Web 2.0 technologies as support for participation in argumentation. To facilitate my analysis of student learning, I align the affordances of the web 2.0 tools with the intended science practices targeted by this intervention.
Social Significance

With adoption of national standards that advocate for youths’ engagement in science practices, educators appear to be searching for learner-centered pedagogies that engage students in science activities, but also fit within the limitations of their school budget. Given the low cost of Web 2.0 tools, teachers are implementing their use in classrooms as a cost effective way to engage students in learning activities. Although the affordances of many Web 2.0 tools have positive pedagogical implications for classroom use, research cannot keep up with implementation within actual practice given the speed with which new Web 2.0 tools are developed. With this study, I provide empirical evidence that shows how learners can engage in the practice of scientific argumentation with the assistance of tools such as social bookmarking, wiki, and video and multimedia production.

The findings of this study speak to the interest of individuals, organizations, and groups that examine how technology can support science content learning as well as participation in science practices. This study contributes to the science education field through refining theory about how youths learn to participate in scientific practices of argumentation. It also adds to the body of knowledge about the use of audience in students’ work in science, particularly as students are engaged in socioscientific argumentation. In this work, I also develop design considerations for environments that support student participation in science practices and advance perspectives on the role of Web 2.0 technologies in classroom settings to support student learning.
Chapter 2

Theoretical Framework and Literature Review

As the present research seeks to understand student use of Web 2.0 tools as a support for the scientific practice of argumentation, I draw on three principle bodies of research for my theoretical framework:

1. the scientific practice of argumentation, specifically the three sub-practices:
   a. sensemaking,
   b. articulating understandings, and
   c. persuading,
2. Web 2.0 technologies that are used to support learning, and
3. the use of technology in high school science classrooms.

Using literature from the fields above, I build a theoretical framework from which I analyze student use of Web 2.0 tools to understand how it hindered or improved students’ scientific argumentation. First the scientific practice of argumentation is defined and empirical findings related to its use in classroom are discussed. Next, I discuss the research on the use of Web 2.0 tools to influence students’ learning. Finally, a summary of research findings on how emerging technologies have been used within educational settings related to supporting scientific practices is presented.

Argumentation in Science Education

The [USA] National Research Council’s (NRC) K-12 Framework (2012) emphasizes the entwining of the practices of science and understanding of science content to afford all students a more complete understanding of science. Specifically, Duschl, Schweingruber,
and Shouse (2007) state that learning science must include learning science facts and learning to participate in scientific activities. Duschl and colleagues assert that including science practices in science education is needed to create informed citizens who are able to continue learning about science (NRC), build upon their science skills within the workforce (Hilton, 2010), and communicate on scientific issues that have importance to their daily lives (Zimmerman, 2012). The current movement in the science education community emphasizes students’ participation in the practice of argumentation as a key factor when students are learning science (Duschl & Osborne, 2002; NRC). It is through engaging in argumentation that students are able to make sense of the scientific ideas, co-construct knowledge, and learn to persuade others of their viewpoint (Berland & Reiser, 2009).

Research (Sampson & Clark, 2008) in science education on argumentation has focused on the artifacts and processes of argumentation. Research on the artifacts that have been created by students as products of arguments has examined argument maps (Bell, 2004), warrants to support claims (Sandoval & Millwood, 2005), and justifications (Zohar & Nemet, 2002). Others have examined the processes in which students engaged during argumentation: selection of data to use for claims (Kuhn & Reiser, 2006; Ryu & Sandoval, 2012), constructing arguments to support a claim with the goal of improving the quality of discourse (Kuhn & Udell, 2003), and facilitation of the social interaction of argumentation (using the TAP framework) as well as the quality of the discourse (Osborne, Erduran, & Simon, 2004).

To accomplish this, science schoolteachers are urged to incorporate science practices into their classrooms to support students’ understanding of science. Once such practice is argumentation. In science education, argumentation has been viewed as discourse in which
participants use collaborative discussion to persuade peers (Driver, Newton, & Osborne, 2000) or resolve issues (Andriessen, Baker, & Suthers, 2003). However, research (Newton, Driver & Osborne, 1999) has shown that in science classrooms, students’ participation in science practices such as argumentation is rarely present, with the majority of interactions within the classroom being teacher-driven (Lemke, 1990). It is important to provide students with opportunities for deeper engagement in argumentation through adequate time to discuss issues in class and participate in argumentation (Duschl & Osborne, 2002) in order to improve students’ understandings of science content and allow them to better understand the process by which scientific knowledge is generated (Sampson & Clark, 2008). Although research (Osborne, Erduran, & Simon, 2004) indicates that scientific argumentation is challenging to support within a classroom setting because of the difficulty of providing appropriate evidence, providing students with opportunities to participate in the practices of argumentation is paramount.

**Socioscientific Issues**

For this dissertation, I utilize research in socioscientific issues within the classroom to situate my study. For several decades, science education classrooms have incorporated socioscientific science curriculums to help students learn skills necessary to make decisions about social issues forming on the science, technology, and society interface (Tal & Kedmi, 2006). Sampson, Simon, Amos, and Evagorou (2011) differentiate between socioscientific argumentation and scientific argumentation by defining their scope; socioscientific argumentation supports consideration of “different courses of action related to a complex problem from multiple viewpoints…[where] a wide range of reasons are viewed as an
acceptable way to support challenge the viability of a course of action” (pg. 194). Because of the challenges of implementing scientific argumentation, research has suggested that the use of socioscientific issues would address the discourse, considerations, and connections of science through deeper engagement of the students (Zeidler, Sadler, Simmons, & Howes, 2005). Student use of evidence for socioscientific issues has contained everyday knowledge in such fields as economics, experiences, moral values and ethics, and social constraints that students bring into the classroom to use as data and form warrants (Osborne, Erduran, & Simon, 2004; Sampson, Simon, Amos, & Evagorou, 2011).

Studies of socioscientific issues within classrooms have focused on increasing the complexity of asked questions (Dori & Herscovitz, 1999) and analysis of complex case studies to promote more sophisticated questioning (Dori, Tal, & Tsauchu, 2003). Others have examined patterns of argumentation and their relationship to content learning (Zohar & Nemet, 2002). Several lines of research have also examined how students utilized materials that were provided to them during instruction for argument construction and participation in argumentation. Tal and Kedmi (2006) presented case studies about environmental issues to lower achieving high school students who analyzed the cases and presented decisions. Through analysis of the discourse, decisions, and reflections, Tal and Kedmi found that students increased the number of justifications that they used, improved scientific knowledge, and wrote more complex value considerations after completion of the unit. In a similar vein, Simon and Amos (Sampson, Simon, Amos, & Evagorou, 2011) found that students engaging in socioscientific argumentation gave preference to information provided as evidence by the instructor; the students utilized the provided information over their personal beliefs and ideas, indicating that quality of arguments is linked to the available
evidence. By providing the students directly with materials on which to focus, the students were able to create more connections and utilize more scientific evidence within their arguments.

Often students perceive science as being disconnected from their experiences, values, and beliefs (Rose & Barton, 2012); by understanding how students make sense of socioscientific issues, we gain insight into understanding what evidence they choose to foreground in their decision-making process. Past experiences, values, and beliefs of students have been found to be integral aspects of their understandings about science (Sadler, 2004). These are embedded within the students’ cultural resources and impact the student decision-making processes, more so than scientific knowledge (Rose & Barton). Unlike Simon and Amos (Sampson, Simon, Amos, & Evagorou, 2011) where teacher-provided evidence was preferred over personal beliefs, Simonneaux and Simonneaux (2009) found that closer ties between the student’s identity or beliefs and the socioscientific issue make it more likely that students will base their justifications and selection of evidence on personal values instead of scientific data. Concerns within the learners’ household can also impact the selection of evidence used in other settings. Rose and Barton (2012) found that students in low income or high unemployment areas exhibited tension when choosing between finances and environmental concerns; students prioritized economic concerns over other factors. Additional research on teaching socioscientific issues within the classroom echoes these findings: youth value emotion and personal beliefs as legitimate factors in decision-making (Ekborg, 2005; Zeidler & Sadler, 2007).

Several lines of socioscientific research have focused on the content area of alternative energy. Again, the connection between the convergence of scientific knowledge
and everyday understandings of values, beliefs, and experiences and the impact on decision-making was evident. Kolsto et al. (2006) investigated 22 college age students and their decision making process about an issue linking power lines and leukemia. Group discussions and a presentation of their decision, as well as interviews, were the primary data collected. Students were found to make decisions based on the information provided within the course or underlying personal values; even when given opportunity, students did not investigate the issues further on their own. Most of the students made decisions that were focused on provided scientific information or personal values without making connections to the science content presented in class. Two suggestions for improving the quality of arguments constructed are to create connections between school science and “real science” and utilize pedagogy to produce student subject experts within the classroom in order to provide different viewpoints.

In a second study, Rose and Barton (2012) focused on the Green Club, an after-school, community-based youth club focused on green energy that provided opportunities for students to participate in place-based, science inquiry within their community. Twenty 6th and 7th grade students participated in a 13-week unit focused on possible local construction of a hybrid power plant. The students investigated alternative types of energy, interacted with simulations of energy production, and surveyed experts and the community members; the unit’s activities culminated in presentations to a community forum and participation in a debate. Rose and Barton used interviews, multiple sources of data, and a case study of two urban students’ justified decisions and constructed stories to explain the students’ support for hybrid power plants in their area. For these middle school students, major areas of focus within their decision-making process were global warming, cost, jobs, and pollution. Rose
and Barton found that both youth in the case study came to the same decision by using many of the same facts, but positioned the information differently based on their perspectives. Rose and Barton advocated both students and teachers becoming ‘critical consumers’ by asking questions in order to make visible how people understand and interpret assumptions, different meanings of terms, and scientific concepts in order to make justifiable decisions.

Research on the use of socioscientific issues within high school settings is limited. In Australia, Dawson and Venville (2010) investigated the effect of whole class discussion and the use of writing frames on student argumentation about genetics on 10th grade students. They found that the role of the teacher and student, the use of writing frames, and context of the issue all positively affected the student argumentation. Felton, Garcia-Mila, and Gilabert (2009) examined how 100 7th grade students in Spain constructed arguments about the effect of alternative energy resources on climate change. Students constructing arguments in which the focus was on the fundamental processes in argumentation such as claim, counter-argument, and rebuttal scored higher on post-tests about content issues as well as had improved argumentation scores. Felton, Garcia-Mila, and Gilabert recommended that teachers use caution with assigning activities centered on the goal of persuasion and instead provide opportunities for students to voice opinions, understand opposing viewpoints, and work towards collaborative solutions instead of competing.

**Defining the Terms Argumentation and Argument**

Argumentation and argument, although similar, do not refer to the same concept. Argumentation is the process; the argument is the product produced (Driver, Newton, & Osborne, 2000; Kuhn & Udell, 2003).
Argument

Often an argument is identified and analyzed for effectiveness using Toulmin’s (1958) *The Uses of Argument*. Toulmin’s framework asserts that an argument can be recognized by the presence of key elements: argument, claims, data, warrants, qualifier, rebuttal, and backing. Many researchers (Bell & Linn, 2000; Erduran, Simon, & Osborne, 2004; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000) have utilized this framework for analysis of arguments’ effectiveness. Although Toulmin’s framework provides insight into the structure of arguments, issues with reliability, justifications, and assessment of the content (Sampson & Clark, 2008) have lead current researchers to often simplify these components. For the reason of simplification, I adopt Osborne and Patterson’s (2011) definition of argument as a “claim to be justified” (pg. 629) for this dissertation study. Based on the definition of Zohar and Nemet (2002), I reduce the structure of argumentation to these four components: a claim supported by justifications, counter-arguments, and rebuttals (Zohar & Nemet, 2002). I later elaborate and define these four components of an argument in further in this chapter. This argumentation component framework was chosen for specific affordances: by condensing the elements of data, warrant, and backings into the category “justifications”, I am able to foreground the content and quality of the student-produced arguments and minimize issues with reliability and validity (Sampson & Clark; Zohar & Nemet).

Argumentation

Argumentation is a core disciplinary practice of science according to the [USA] National Research Council’s (NRC) K-12 Framework (2012). As stated above, it refers to
the process of making an argument. In science classrooms, according to Berland and Reiser (2009), the practices of argumentation and elaboration are entwined and complementary because of the overlapping pedagogical goals. When used as a pedagogical strategy, argumentations’ goals are sensemaking, articulating, and persuading. Although Osborne and Patterson (2011) deliberately distinguish between argument and explanation, other researchers have also combined the two elements when examining student reasoning (Hogan, Nastasi, & Pressley, 1999) and building knowledge through negotiation of understandings (Bielaczyc & Blake, 2006). In addition, McDonald and Kelly (2012) examined discourse within a chemistry classroom and found connections between argumentation and sensemaking: “arguing to learn can only happen in the larger context of science sense-making discourse that occurs around and within the arguments” (p. 274). Following these lines of thought, for this dissertation I view argumentation and explanation as one practice. I take Berland and Reiser’s (2009) three goals of explanation,

   (a) making sense of phenomenon,

   (b) articulating understandings, and

   (c) persuading others,

as being sub-practices inherent within argumentation as well. I utilize these three sub-practices as the theoretical principles of design for facilitating argumentation and construction of arguments within a classroom environment.

**Three Sub-practices of Argumentation**

I consider the three sub-practices of elaboration (Berland & Reiser, 2009), sensemaking, articulating understandings, and persuading other’s to one’s view, as sub-
practices of argumentation. Although I examine these individually, they are interwoven in practice and are not to be considered steps in a sequence or to be followed in a linear progression. Second, I will explore the affordances of Web 2.0 tools and then examine how the Web 2.0 technologies could be used as tools to support student participation in these sub-practices of argumentation.

**Sensemaking**

Golder and Huberman (2007) defined sensemaking as “a process in which information is categorized and labeled and, critically, through which meaning emerges” while examining collaborative tagging systems. Sensemaking, defined in this way as meaning making from information, has been examined in many contexts: information systems, medicine, data visualization, and science education. In medical fields, Weick, Sutcliffe, and Obstfeld (2005) interviewed nursing staff to determine how they made sense of the chaotic environment. From these interviews, they simplified the definition to state, “sensemaking and organization constitute one another” (p. 410). Weick, Sutcliffe, and Obstfeld elaborated on this definition by describing behaviors of sensemaking: labeling, categorizing, noticing, and classification. In computer science fields, Heer and Agrawala (2008) examined visualization software users for sense-making behaviors; these behaviors were also primarily organizational and included labeling, authoring, deciding or acting, foraging for data, looking for patterns, and problem solving. In both groups (Heer & Agrawala; Weick, Sutcliffe, & Obstfeld), sensemaking was conceptualized as being social in nature and often focused on communication of the participants’ understandings. Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) noted social sensemaking with 86
students in 7th grade who used the Zydeco mobile platform to conduct an inquiry in a museum. The students in this study took photographs and used Zydeco as a support when discussing and proposing annotations for these photographs before applying tags. Cahill et al. concluded, “Collaborative sensemaking through discussion is a powerful way for students to learn during field trips” (p. 27).

Sensemaking in science education has often focused on aligning evidence and claims, making it discipline specific (Berland & Reiser, 2009; Duschl, 2000). Researchers with a sociocultural perspective (Rose & Barton, 2012; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001) also noted that students drew upon informal, everyday strategies and talk to make sense of science content in addition to using disciplinary lenses. Often students utilized a diverse array of tools in unique ways in order to make sense of science content and communicate their understandings. Rose and Barton (2012) examined how appropriation frameworks such as cultural tool kits, genres, and everyday sense making work together to explain how urban youth appropriated and assimilated science content. They found that the students actively engaged in scientific sensemaking, but often through tools, genres, gestures, and examples that were atypical of a science classroom. Teacher recognition of the frameworks that students utilize as they make sense of science content can support this learning within the classroom. Utilizing frameworks that bridge between the students’ scientific and everyday sensemaking strategies to support students’ active engagement in scientific sensemaking can help them develop a deeper understanding of the content (Berland & Reiser, 2009).

One aspect of sensemaking within groups that is evidenced across all fields is rendering the abstract concrete (Weick, Sutcliffe, and Obstfeld, 2005) by making thinking
visible (Bell, 1997). Two recognized social sensemaking behaviors that support making thinking visible are organizing and annotation. Organizing occurs as students recognize patterns and classify information in ways that integrate scientific knowledge and discourse with their everyday ways of knowing. Annotation not only comprises labeling, which is a strategy of applying words to objects, artifacts, or actions to create organizational structures that tie new knowledge to existing understandings and allow for retrieval (Kuhn, Cahill, Quintana, & Schmoll, 2011), but also encompasses summarizing where users reflect on the information in order to explain how it fits into their inquiry process or to synthesize content for later use.

Articulating Understandings

A second goal of argumentation is articulating understandings. Articulation is putting ideas, feelings, or actions into words; however, this is not a simple process. The intricacies of what counts for a well-articulated understanding in science is specific to the domain. This practice of articulation is separate of theory and requires specific supports in order for students to be successful (Ohlsson, 1992). Ohlsson advocates that students be taught articulation in science classes and not simply the theoretical content; knowing the components of a theory is not enough for students to construct explanations or apply principles of it.

In order for students to make their thinking visible (Bell, 1997), they must first articulate their understandings to others. The process of articulating is an integral part of social learning (Sawyer, 2006) as students express their own understandings and make sense of other student’s interpretations in order to create shared understandings (Berland & Reiser,
Students make these shared understandings visible through social interactions (Chu & Kennedy, 2011) and during co-construction of collaborative knowledge artifacts as small groups of students work together to solve problems (Alavi, 1994) and create materials. One example of student use of a tool to support their articulation of understandings is ExplanationConstructor. Students have used this epistemic tool for support (Sandoval & Reiser, 2004) as they articulated their understandings and constructed explanations about natural selection. This tool provided support for their social communication by asking questions as they constructed explanations and arguments.

There are issues as well with students articulating their understandings through co-construction of knowledge artifacts. Although collaborative learning has been linked to construction of shared knowledge, often outcomes are not as effective as desired because of lack of quality interactions and issues with the tools used for communication (Chu & Kennedy, 2011).

**Persuading Others**

Persuading others has often been considered an integral part of science. Persuasion is a complex, social process of knowledge building fashioned by connecting evidence and claims (Scardamalia & Bereiter, 1994) and creating valid justifications for the claims that are supported by evidence (Zohar & Nemet, 2002). Students negotiate understandings by constructing explanations and persuading others of the correctness of their explanation (Berland & Reiser, 2009). Research (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000) indicates that attending to the persuasion goal of argumentation can help shift students from “doing school” to “doing science”, leading to greater participation in science practices.
As students participate in the discourse of argumentation, persuasion requires anticipation of challenges by other students and preparation of counter-arguments and rebuttals to address the challenges. The goal of persuasion is central to not only practices of argumentation, but also to scientific inquiry; without the ability to challenge evidence and explanations, individuals lack the power to engage in scientific discourse. Student participation in practice of persuasion contains both a defense of a claim as well as social engagement with the ideas or challenges of their classmates. This participation often requires considerations for the intended audience: probable facts that will be used to support the other’s argument, counter-arguments or rebuttals that they may choose to employ. Studies have fostered argumentation in classrooms by pairing students with opposite viewpoints and having them persuade each other of their position (Bell & Linn, 2000). Berland and Reiser (2009) found that students were able to construct claims and support them with evidence. However, students often failed to persuade the audience of their claims, most likely because of the students lacking a clear understanding of the goal for each activity.

Several studies (Ferretti, MacArthur & Dowdy, 2000; Nussbaum & Kardash, 2005) have indicated that student activities with the goal of persuasion have lead to student production of weaker arguments than activities with goals specifically targeting elements of arguments such as counter-argument or rebuttal. Nussbaum and Kardash (2005) found that groups focusing on persuasion used fewer counter-arguments in written essays than groups focused on argumentative elements. This has implications as well for student construction of knowledge – Sampson and Clark (2008) stated that the use of counter-argument and rebuttals were linked to students’ understanding of the content.
Using Technologies to Support Science Learning in Schools

Technology has great potential in enhancing student learning and achievement (Bransford et al., 2000). Often, technology in the classroom can be found in the form of software that guides and scaffolds students in discourse, knowledge building, and argumentation (Bell, 2004; Linn, Davis, & Bell, 2004; Slotta, 2004). In other formats, technology facilitates connection and communication. Several ways that this occurs is by providing connections to environments outside of the classroom, connecting students with real-world scientists or other professionals, and facilitating visualization of data (Bransford et al). Connecting students to other people or settings can allow learners to not only build upon their prior knowledge and later transfer this knowledge to other situations, but also provides the learners with a way to extend and enrich their learning (Linn, 2006). Software, applications, and devices can facilitate students’ construction of joint knowledge. By allowing learners to make their understandings visible to others, misconceptions and preconceptions can be addressed even as new information is integrated.

Students continually rely on a variety of tools, technologies, and resources (Ash, 2003; Ash & Wells, 2006) to make sense of information, experiences, or actions collaboratively (Ash, 2004) within their social groups. Many of these technological tools provide affordances that foster communication and collaboration (Stahl, Koschmann, & Suthers, 2006) in ways that other tools cannot. One technological advance is the facilitation of learning that takes place in student-to-student interactions that are supported by computers. Lonn and Teasely (2009) researched Learning Management Systems and found that many students considered efficiency to be an affordance of technology. In addition, research (Baker, Corbett, and Koedinger, 2007) on 70 students using online tutoring software
indicated that some students possessed a “gaming mindset”. Students with this mindset valued the affordance of entertainment (Kay, Meyer, Wagoner, and Ferguson, 2006) of technology; in this case, they tried to ‘beat’ the tutoring system without actually completing the tasks.

The field of computer-supported collaborative learning investigates how students learn collaboratively in small groups using a social constructivist framework (Stahl, 2007). This work focuses on providing opportunities for students to learn together via discourse as they construct shared knowledge artifacts. This can occur either virtually with student interactions and communication completely supported by computers or face-to-face (F2F) with the students’ focus on exploring simulations or collaboratively gathering and discussing information (Stahl, Koschmann, & Suthers, 2006). In addition, when co-constructing meaning online, Stahl (2007) found that students used multiple methods of responding, making suggestions, posting questions, and referencing objects, incidents, and other actions in an obscure fashion. The students creatively invented new practices of meaning making and interspersed them with traditional methods, particularly with new or different medias.

Numerous studies have identified how designed learning environments and software can facilitate collaboration and creation of knowledge. Case-Based Reasoning (Kolodner, 1993) allowed students access to past cases that provided support in developing solutions for the current issue. The WISE online environment promotes student integration of knowledge through supporting ideas, exploration, and discussion (Linn, 2006; Slotta, 2004). Another online environment, CSILE, supported student knowledge building (Scardamalia & Bereiter, 1994). The Knowledge Forum was specifically designed to support both knowledge building and collaboration within a virtual, multimedia database and work-space (Scardamalia, 2003).
Computer mediated communication has had success in engaging students in authentic activities (Bruckman, 2006) without the support of a designed environment. Although several studies have investigated the use of wikis in science education, little analytic attention has been focused on the student use of Web 2.0 tools to support the goals of argumentation: sensemaking, articulating, or persuading others. As such, this study provides additional insight into facilitating students’ collaborative learning and participation in science practices when supported with Web 2.0 technologies.

**Web 2.0 Technologies**

Web 2.0 technologies are similar to software, applications, and devices that can facilitate students’ construction of joint knowledge (Cradler, McNabb, Freeman, & Burchett, 2002). By allowing learners to make their understanding visible to others, misconceptions and preconceptions can be addressed even as new information is integrated. By leveraging the unique opportunities of these media, users and researchers alike can not only create collaborative work, but also have access to a history of the collaboration. The use of Web 2.0 technologies such as social bookmarking and wiki supports social acts that constitute group learning and leads to individual learning.

**Social bookmarking.** The annotation of resources through application of social tags provides support for reflecting on and summarizing information and organizational strategies that facilitate later use and retrieval. Research into annotation has focused on tagging dynamics in social bookmarking (Golder & Huberman, 2005), influences on tagging behavior, informal annotations while reading (Marshall, 1998), and categories of tagging systems to construct a taxonomy (Marlow, Naaman, Boyd, & Davis, 2006). Ames and
Naaman (2007) examined the attitudes and motivations of 13 participants’ annotation of photographs through interviews. Primarily the participants tagged photographs to organize for others to understand the context or search, with retrieval and communication (about context) with friends and family second. Although the users perceived benefits in annotating the photographs, the investment of time and effort outweighed the benefits for most individuals.

In a review of research on Web 2.0 applications that support collaboration, researchers (Hsu, Ching, & Grabowski, 2008) found that through the creating and sharing of social tags, individual knowledge through summarizing the site as well as social knowledge was constructed through sharing the tagged sites with others. Other researchers (Levin & Wadmany, 2006; Or-Bach, 2005) indicated that construction of knowledge was improved through the creation of tags as individuals summarized the information. Farwell and Waters (2010) studied how 59 higher-education students utilized an online bookmarking program. Organizing the bookmarks, particularly through sharing, was shown to provide a more complete understanding of the material in a study because of increased interaction with the information and between students. Additional interaction was supported with social bookmarking websites through the use of networks; because new information from other users was easily added, collaboration and sharing of resources occurred, along with the validation of the materials through a rating system formed by the number of people choosing to bookmark the link (Farwell & Waters). Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) found that this social interaction extended beyond online sharing of bookmarked links or tags already applied; discussion face-to-face about words to be used as tags for student-taken photographs in the museum helped students connect their prior
knowledge to new understandings. The social tags applied by students were used as a means of organizing their information found online. In addition through the application of keywords in the form of social tags, the search function on the website worked much like a database (Jonassen, 1996), affording students a method of searching and sorting the gathered information as well as making visible previously unseen connections.

Delicious.com is an online social bookmarking, also called metadata tagging, site (Hsu, Ching, & Grabowski, 2008) that has been utilized in several fields for organization of resources and professional development. Delicious has been shown to function well as a folksonomy, or social bookmarking tool, by allowing sharing and collaboration of bookmarks, tags, and annotations.

Wiki. A wiki can be defined as a website designed to permit several authors to add, edit, delete, or otherwise modify content (Engstrom & Jewett, 2005) quickly and collaboratively (Forte & Bruckman, 2010). Because several authors are able to contribute to the wiki content, wikis are often used for collaborative documents or projects, knowledge management, or project development (Goodwin-Jones, 2003). Wikis have been utilized in in education in writing based courses (Lamb, 2004), project-based learning (Byron, 2005), online learning courses (Byron), creating textbooks (Evans, 2006), and for auxiliary activities such as clubs, job postings, and career development (Lamb). Specifically in classrooms, wikis have been used primarily for collaborative writing and project-based learning in science (Peters & Slotta, 2010), math (Zinn, 2006), and design engineering (Chen, Cannon, Gabrio, Leifer, Toye, & Bailey, 2005).

Fostering collaboration. Computer-mediated communication on the wiki allows a record of interaction and collaboration to be maintained (Bruckman, 2006). Larusson and
Alterman (2009) advocate that wikis best support collaborative student learning. The shared space of the wiki can be considered a representational system that can be shared among members as they work and allows for collaboration to occur in a timely manner (Cress & Kimmerle, 2008). In a study of 54 high school math students, researchers (Fong & Wang, 2007) have shown that wikis can foster collaboration online by providing a space where students were able to interact about their math work after school, thus connecting their knowledge and practice. In addition, they found that the number of posts made by a student and the student test scores were positively correlated. Another common feature of most wikis is the edit trail. The edit trail functions as a version history, allowing changes to the content to be logged and then returned to that version, especially in the case of an accidental change (Engstrom & Jewett, 2005). Wikis afford the collaborative generation of knowledge because of their ability to support hyperlinks, addition and revision of content, creation of artifacts, and clarification of understandings. In addition, wikis are considered a rich online space where complex learning activities may occur, providing students with a common ground in which to collaborate (Gutiérrez, Baquedano-Lopez, & Tejada, 1999).

**Pedagogy of wikis.** Wikis support learning along the tenets of Scardamalia and Bereiter’s (2006) knowledge building society. They provide an online space that facilitates collaborative knowledge advancement through creation of a shared artifact. The wiki page and discussion page provide opportunity for shared discourse. The wiki pages that the students construct are considered a knowledge artifact and support the collaborative generation of knowledge through creation of hyperlinks and artifacts, addition and revision of content, and clarification of understandings. The wiki also supports student engagement and collaboration between members (Larusson & Alterman, 2009). As the knowledge is
created from individuals’ experiences and understandings of information, and then is diffused through the structure of the wiki, students improve the artifact through edits and additions. By production of the artifact, not only is student understanding made visible, but the wiki also provides affordances for the generation of collective knowledge, leading to greater insights than students alone may produce. Thus collaborative learning through the wiki allows for extension of learning and creation of emergent knowledge (Fong & Wang, 2007).

Investigation into collaborative knowledge construction through the use of a wiki has great importance in the technologically rich environment of many educational programs today. The wiki affords a space in which student and group understanding can be made visible, but as the wiki content is created, knowledge can be constructed individually and collectively (Cress & Kimmerle, 2008). This occurs when a contributor puts forth their personal understandings onto the wiki, where it then exists independently as a created artifact. This process typically requires one to clarify their understanding while making their thinking visible, often leading to deepening the individual’s knowledge as well (Bell, 1997). According to Cress and Kimmerle, as students work on the wiki, they process the information and internalize it, expanding their knowledge both directly from the wiki content and from emergent knowledge. The emergent knowledge, aligning with the tenets of Scardamalia and Bereiter (2006), is considered to be the creation of connections between their personal knowledge and the information on the wiki leading to insights that were previously part of neither: collaborative knowledge building.

Several lines of research have focused on the use of wikis in science education. In biology, Peters and Slotta (2010) used wikis as a support for collaborative knowledge building focused on biodiversity within a 10th grade biology class. The students were placed
into Biome groups and given a template page on the wiki. This wiki repository held pages from all four classes, allowing students to add and edit their page and others’ pages. Following construction of the wiki pages, students constructed articles that drew on their subject expertise. Students who were actively engaged in the wiki project were found to have improved test scores after the project. In graduate-level chemistry, Moy, Locke, Coppola, and McNeil (2010) examined 30 students’ use of Wikipedia.org over 14 weeks as they created Wikipedia articles on chemistry topics for the general public. The students in this study reported taking into consideration the audience when writing, as well as indicating that working on Wikipedia page prompted deeper learning of the content.

**Issues with the use of wikis in classrooms.** Problems have been noted in the use of wikis or other Web 2.0 tools within the classroom. Although the wiki can be analyzed to determine contributions to the artifact, assessment of student individual learning through the group work cannot be directly measured through work on the wiki alone (Trentin, 2009). This issue aligns with other research utilizing jigsaw pedagogy (Brown & Campione, 1994) in determining how to ensure that students learn from artifacts on which they did not personally contribute to the content. Although the wiki provides evidence of collective understanding, what each student understands remains unknown. One suggestion for resolving this issue is to integrate the wiki information into other activities within and outside of the classroom (Wheeler, Yeomans, & Wheeler, 2008) to situate the learning via produced artifact within a larger contextual setting of the classroom and community.

Another problem within wiki learning can be the lack of communication and coordination between members (Cress & Kimmerle, 2008). Research (Liccardi, Davis, & White, 2007) with 30 professionals involved in online collaborative projects found that
although many wikis contain discussion tabs or pages to support and track conversation, communications was difficult because of misinterpretation of comments, difficulty in connecting the comments or suggestions to changes within the document, and unawareness of how to communicate (Liccardi, Davis, & White, 2007). In addition, participants exhibited characteristics of ownership on the page that contributed to conflicting results: sometimes leading to higher standards for the page but lower participation by other members. Thom-Santelli, Cosley, and Gay (2009) interviewed 15 Wikipedia author/editors who participated as a Maintainer (someone who volunteers to take primary responsibility for the upkeep on a specific Wikipedia page). These editors, although not owners, felt responsibility for and expressed territoriality, “ownership towards an object” (p. 1481), of the wiki page, by editing others’ work to maintain personal standards. These Maintainers demonstrated defense of the wiki page by protecting it from substandard editing and exhibited a more hierarchical collaboration than expressed by the stated intent of Wikipedia. These behaviors were found to be beneficial in maintaining quality of the wiki page over time, as well as providing support for new members by allowing incremental participation in editing. However, edit wars and defensive discussions discouraged attempts at outside participation, limiting the breadth of knowledge available. Thom-Santelli, Cosley, and Gay (2009) suggested identification of primary participants in wiki construction to recognize sustained efforts as well as encourage others to join the community.

**Student Produced Video and Multimedia**

Video is often used passively as a presentation medium in educational settings as a method of enriching lessons or supplementing lectures. When used as such, video has been
found to enhance student comprehension of complex systems (Park & Hopkins, 1993).

Video has also been used as an interactive tool for “anchored instruction” (Barron, Schwartz, Vye, Moore, Petrosino, Zech, & Bransford, 1998). Utilizing the “Jasper Woodbury Series” (Cognition and Technology Group at Vanderbilt University, 1997), students watched the videos, posed questions about the content, and found answers independently; students interacting with the video outperformed stagnant video watchers. A third use of video or multimedia in the classroom (Zahn, Hesse, Finke, Pea, Mills, & Rosen, 2007) was through the use of student-created media projects within the context of project-based learning (Bereiter, 2002). In this case, the student design and construction of the video was the culminating product for the project, conveying not only information or understanding of the topic, but also serving as the solution to the problem.

Student-production of multimedia artifacts within classrooms facilitated student acquisition of multiple skills in addition to creation of the actual product. Zahn, Hesse, Finke, Pea, Mills, and Rosen (2007) compiled a list of skills developed through the creation of a video or multimedia project in response to an assignment including content, technical skills, and social skills, as well as design elements such as visualization and argumentation techniques of articulation and persuasion. Through designing and creating multimedia projects, students engaged deeply with the content and the processes as well as developing social skills. Examples of projects included interactive game design (Kafai, Franke, Ching, & Shih, 1998), hypermedia design (Stahl, 2003), and mini-documentaries (O’Neill & Calabrese Barton, 2005).

New media literacies require learners to attain “capacities of decoding and encoding of print, image, and audio, and composing involves a broader template of design”
According to Hoechsmann (2008), this new, active audience is “intimate … and immediate” (p. 62). In addition, different conceptions of audience produce different outcomes when creating media; these are dependent on the cultural aspects of media practice. This media practice has evolved into a fluid pedagogy used by creators who utilize just in time learning (Gee, 2003) available through online resources to gain needed information when it is necessary in order to continue creating.

Alignment of the Sub-practices of Argumentation and Technologies

Alignment of theoretical principles, technology, and student actions (based on Berland & Reiser, 2009).

Technology has the ability to enhance student learning and achievement, as well as facilitate communication and collaboration (Bransford, Brown, & Cocking, 2000). The use of Internet based technologies, particularly Web 2.0 technologies such as social bookmarking
and wiki (Cradler, McNabb, Freeman, & Burchett, 2002) as well as those supporting the production and distribution of multimedia products, are well suited to supporting participation in science practices (see Figure 2-1 for the alignment of sub-practices and technologies used in this dissertation). Social bookmarking through the saving of links, creating of tags, and sharing of information can lead to greater understanding of the information (Farwell & Waters, 2010). Even more so, the technology of social tagging supports the crucial sensemaking process necessary within scientific argumentation by distributing cognition between students and artifacts, mediated by the adopted tools (Lemke, 2001). Wikis, with their ability to foster collaboration and communication, allow for connection of content and practice (Fong & Wang, 2007) because students can articulate their understandings while collaboratively creating knowledge artifacts. Through creation of multimedia artifacts, students deeply engage in a myriad of social, technological, and design skills. They also create a knowledge artifact that can be used to inform and persuade others of their perspectives and understanding of the content (Zahn, Hesse, Finke, Pea, Mills, and Rosen, 2007).

It is in this intersection of education, science practices, and knowledge, facilitated by technology, that I apply the above theoretical framework within two classrooms. I use the framework to understand how learners with technological supports engage in their classroom learning community infused by argumentation practices. Through application of this framework, I elucidate where students can best appropriate the content knowledge and science practices to become scientifically literate citizens of the future.
Chapter 3

Methods

In this section, I describe my research methodology. I first describe the pilot project that motivates the present study. Second, I detail strategy based on Zohar and Nemet (2002) for data collection, analysis, and addressing ethical constraints within my video-based, ethnographic design that examined students’ participation and engagement in the alternative energies unit.

Pilot Study

This dissertation builds from my pilot study (see Appendix A for complete details) that was conducted in 2009. The pilot project investigated how student use of Web 2.0 tools could support content learning in science and appropriation of the practices of argumentation. Specifically, two research questions guided the pilot study:

1. How can social bookmarking and videos be used to support youths’ construction of group and individual scientific content knowledge?
2. How can social bookmarking and videos be used to support students’ selection and use of evidence when constructing scientific arguments?

To answer these questions, this study was structured as a static group comparison. Four intact classes – two academic and two general classes – were chosen; one academic and one general were randomly assigned to both the control and treatment group. All participants were given the task of researching an alternative energy source (i.e., wind, hydroelectric, solar, nuclear, and geothermal) online. Students next created a video. The video was to sway
a “town council” to vote for their position either for or against having the energy source in their town.

The control group researched and organized Internet resources through traditional methods of bookmarking on their computer, taking notes, or printing out the webpages to annotate by hand. The experimental group used a social bookmarking website (delicious.com) to organize their websites and annotate them with key terms intended to summarize the content. Following their participation in the treatment or control condition, all students were required to use a storyboard as a support for the design of their video; this storyboard provided support for the students to be able to follow the patterns of scientific argumentation. The students then used their research notes and the storyboard to construct a video that presented an argument either for or against the energy source. All students in the classroom watched all the student-produced videos. A discussion followed in each class about the strength and structure of the arguments presented as well as the content material. Both conditions were given a content assessment that included an open-ended response in which students were required to read a scenario concerning their town, make a decision about “building an alternative energy source” near the town, and construct an explanation supported by evidence. In both conditions, participants were allowed to access their collected research materials and all videos during the construction of the essay.

For the pilot study, the following data were collected:

(a) digital artifacts from the learners’ social bookmarking accounts including students’ networks, links, and tags,

(b) student-produced persuasive videos about alternative energy,
(c) students’ individual written essay presenting an argument for or against an alternative energy plant being built locally, and
(d) students’ individual reflections about their learning process written at the end of the unit.

Three analyses were performed on the data. First, I counted the number of links and social tags for each student account on delicious.com. Second, I used the argumentation framework based on Zohar and Nemet (2002) to analyze the persuasive videos for claim, justification, counter-argument, and rebuttal. Finally, the written documents were analyzed using open coding to examine for themes related to student feelings related to the project. The findings were used to inform the second iteration of the study (Brown, 1992).

The findings from the pilot study suggested that using social bookmarking techniques and collaborative construction of a persuasive video helped students learn content and construct an argument. However the connections documented did not exhibit differences that were statistically significant at the p= 0.05 level, although they indicated that further study could be warranted (Cohen, 1994). In addition, examining only the differences in scores for pre- and post-tests and scores from the student created videos did not allow investigation of the actual processes of student learning of science content and collaborative science practices.

Therefore, I posit that more investigation into the use of social bookmarking (Delicious.com) and other Web 2.0 tools as technologies to improve content knowledge and participation in scientific practices of argumentation is warranted. In addition, to truly examine how the knowledge was constructed, the supports for practice provided by the tools, and how collaboration occurred online and in the classroom setting, the study needed
increased methodological diversity. This allowed me to investigate more deeply the learning phenomenon of interest: how students collaborated and used the technological tools in support of their engagement in science practices.

Present Research

Setting and Participants

The pilot and the current study were conducted at the same small, rural, public high school located in Northeastern United States. The school was impacted by poverty at a rate higher than the state average, being classified by the U.S. Department of Education (2011) as a rural, poverty-impacted school. It was a one-to-one laptop school district; the district provides students grades 9 through 12 with an Apple MacBook to be used in and out of school over the school year for their high school career. The one-to-one laptop initiative was implemented initially to provide equity in technological access across socio-economical boundaries. The majority of the youth participating in both studies were white and of European origin, which reflects the demographics of the school district and region in which they reside.

Context

The facility with technology for both the teacher and students was a unique factor for this study. The researcher was the teacher for both studies and had taught high school chemistry for 21 years. As the researcher-teacher, I received training on computer use, software, and applications for the school where I taught, as well as on learning and design of constructivist learning environments during my studies. The students received training on use
of the computer, software, and applications in required technology classes as well as within core subject area classes on an as needed basis. In addition, the other teachers at this district were highly qualified instructors within their field of study, as well as having received additional training on the use of technology within the classroom setting.

The rich technological context of this high school setting provided a unique vantage point for this study in that the students were well versed with use of the laptop and most software before the start of my dissertation project. Although most students had not heard of social bookmarking prior to this study, many had used an online wiki product during their previous year biology class. Most students had used wikispaces.com during the previous year and for some projects earlier during the school year, as well as other wiki products that were provided by the school that functioned in a similar manner. The students in both classes were very facile with technology, having had access to a laptop for over a year, as well as having taken a class during eighth grade on basic use of the software included on the laptop such as iPhoto, iTunes, iMovie, GarageBand and other commonly used applications. In addition, several of these students enjoyed using the wiki as a tool for group projects and self-selected this format to use when completing a group project earlier this year. Therefore, the novelty of computer use was not a factor for the students. Thus, the previous technology training received by the facility and the students in this school provided additional validity for the study.

**Participants**

For this present study, I observed thirty-five youth in two academic chemistry classes as they participated in a three-week unit on environmental chemistry, specifically alternative
energy resources, during late spring of 2011. All names of students and places used are pseudonyms.

**Morning class.** The morning class contained 15 students, all consented: 5 boys and 10 girls aged 14-17 and in grades 10 and 11. Two consented students were absent for the majority of the project (without internet access) and were therefore excluded from the data set for portions of the project. Of these students, 4 are identified as gifted students. There were no special education students in this class. The demographics of this class are representative of the school district and area in which they reside and are predominately of White ethnicity. The students meet nine 40-minute periods per six-day cycle with every other day (either even or odd) having two periods together to accommodate an extended lab time.

**Afternoon class.** The afternoon class contained 20 students consented into the study. Of these 20, 12 were male and 8 female. All students were between the ages of 14 and 17 and in 10th or 11th grade. Five students in this class were identified as gifted students. The demographics of this class were predominately White, which is representative of the school district and region in which they live. The classes met for nine, 40-minute periods in a six-day cycle with lab periods every other day (even), which allowed for a double period lab to accommodate extended lab time.

**Positionality of the Researcher**

In both studies, in addition to being the teacher for these classes, I functioned as the primary researcher, practitioner, and designer for the pilot and dissertation study. Because of this entangled relationship, I carefully described the context, document the design of the
implementation and changes, and detail steps for the analysis, as recommended by Joseph (2004). This dual role held many advantages. As the teacher, I had a prior relationship with the students that provided me an understanding of the culture and norms of the classroom (Brown, 1992) as well as knowledge of the local curriculum content. This position also allowed me to refocus the timeframe or modify the study design in a timely manner when needed (Joseph) without having to confer with others.

**Research Design**

I conducted a 3-week ethnography (Spradley, 1980) of a single community of learners in a high school chemistry class during an alternative energy unit. I used an ethnographic design, as defined by Spradley (1980, p.31), “to discover the cultural knowledge people are using to organize their behavior and interpret their experience.” Ethnography allowed me to better understand the roles of the students within the small and larger groups, as well as how they functioned, by providing a way to look at the relationships within this setting (Wolcott, 1999). Because I was interested in how the students used Web 2.0 tools within this setting as well as how they specifically targeted the tool use to support their participation in the practices of argumentation, I examined the cultural patterns of use within the classroom as a way to better understand these actions. This allowed me to connect the data files from Web 2.0 tools, video recordings, field notes, reflections and interviews, and documents within each class and across asynchronous classes. Using multiple levels of analysis allowed me to better understand meanings produced by the students participating in their classroom activities and make cultural inferences about the group by using three types of information:
(a) student discourse,
(b) student behaviors in class and online, and
(c) the cultural artifacts that they used and produced (Spradley).

I was able to provide a thick description of the community by using these ethnographic methods to examine the student behaviors, discourse, and use of the Web 2.0 tools within the classroom setting.

In addition, I used video in my study as a way to capture and analyze the students’ discourse and actions as they worked. In order to fully analyze the construction of content knowledge, practices, and negotiation of meaning, the use of video is imperative as a data collection method (Sherin, 2004). This allowed me to examine the students’ shared discourse in and perspectives on the learning environment (Angelillo, Rogoff, & Chavajay, 2007; Barron, 2007; Hmelo-Silver, Katic, Nagarajan, & Chernobilsy, 2007). The video was especially useful as the project had a discontinuous timeframe with the groups’ work stretched across two class periods, as well as the project being spread across nineteen class periods over three weeks (Ash, 2007). Although collection of video data was still mitigated by the researcher (i.e. the direction in which the cameras are pointed, when to begin taping and stop, who wears the microphones) within the context provided, video provided a method of data collection that could then be analyzed as fine-grained as needed to answer the research questions (Sherin).

Using both of these research methodologies allowed me to analyze the large corpus of data collected for this study. By incorporating video and ethnographic methodologies, I was able to best examine the student use of tools to support their practices. This allowed me to
better understand how students used Web 2.0 tools as a support as they participated in the practice of scientific argumentation.

**Design of Implementation**

The design of this unit utilized Technology-Enhanced Inquiry Tools for Science Education as a pedagogical framework (Kim, Hannafin, & Bryan, 2007) to support and explore the interactions among the macrocontext (educational standards), the teachers’ community, and the microcontext (classroom) as shown in Figure 3-1.

![Figure 3-1. Framework for teaching and learning with inquiry tools (theoretically ideal framework). (Kim, Hannifin, & Bryan, 2007).](image)

To address the curricular goals and objectives about alternative energy resources (NRC, 2012) and support student participation in the practice of scientific argumentation
(NGSS, 2012), I utilized the framework (Kim, Hannifin, & Bryan, 2007) to design a unit in which students participated in the three goals of argumentation, sensemaking, articulating, and persuading (Berland & Reiser, 2009) while they researched and designed knowledge artifacts about alternative energies, all supported by Web 2.0 technologies. The project was guided by the question (Krajcik & Blumenfeld, 2006; Sadler, 2009): “What would you need to know to make an informed decision about an alternative energy resource plant being built near your town?” I chose the question to be “educationally rich” enough to function in such a way that it will “marshal, generate, and sustain student…thoughtfulness” for the course of the project (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). I based the classroom intervention design on the microcontext portion of this framework (Kim, Hannifin, & Bryan, 2007); focusing on the interactions between

a) teacher and tool while selecting the inquiry tools,

b) teacher and student through the creation of project guidelines, deadlines, and other requirements, and

c) student and tool as the youth utilized the Web 2.0 tools to create artifacts and solve problems.

To provide ample time for the students to answer the overarching question for this project, the initial timeframe for the total project was 15 class periods; as students worked and encountered technical difficulties, as well as working around field trips and sports dismissals, the timeline was extended to 19 class periods (see Table 3-1). First, students in two asynchronous classes were given six periods in the classroom to research an alternative energy, bookmark and create social tags for these pages, and construct group wiki pages, as well as to read and critique two other pages. The wiki pages were to be non-biased and
present all aspects of the energy resource, akin to an argument map displaying all evidence available (Bell, 1997). Second, the students were placed in small groups within their intact classes and assigned a second (different) alternative energy for their video project. Third, the students then used the wiki pages as a classroom knowledge resource (Kali, Levin-Peled, & Dori, 2009) to design and construct videos over six periods that were intended to sway the "town council" to vote for or against an alternative energy plant being built in their town. Student-designed videos were chosen as the culminating artifact to engage the students more deeply in the content as they collaboratively designed for an audience (see Figure 3-2), therefore involving both content and form in their design process (Zahn, Krauskopf, Hesse, & Pea, 2009). These videos were displayed on the class web page, which was open to the public, as well as being watched by the students in class and discussed as a large group. Finally, students completed open-ended reflections about the project. Two small focus groups (Morgan, 1997) of students were interviewed about their tool use, understandings about the practice of scientific argumentation, and overall insights about the project.
Figure 3-2. Model of collaborative design activities (Zahn et al., 2009). The computer-mediated interaction between the students, content, and form while designing multimedia products.

**Timeframe**

The timing for the studies, mid May, was designated because of the school curriculum and required testing. The timeframe of just over three weeks (19 class periods total) was required because of end of the year collection of the laptops by the school district (see Table 3-1). In addition, the laptop collection constraints made the ‘teacher functioning as researcher’ more necessary because the pace of the project required quick responses to changes in schedule, issues with software or equipment, and design changes. Coordinating these changes with an outside research team could have required more time than the students had been allotted for the project because of end of year collection of the laptops by the school district.
## Table 3-1. Overview of the Project Timeframe, Activities, Technology, and Summary.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Activity</th>
<th>Technology Used</th>
<th>Action/Outcome</th>
</tr>
</thead>
</table>
| **Period 1** | Large group discussion led by teacher | Whiteboard | • Teacher and students discussed factors needed to evaluate an energy resource.  
• Overview of project and timeline.  
• Overview of delicious.com |
| **Period 2-5** | Research and construction of knowledge resource | Social bookmarking (delicious.com) and wiki (wikispaces.com) | • Students researched online their alternative energy resource.  
• Students saved links and annotated with social tags.  
• Students co-created a public wiki page containing the information the students felt was needed to evaluate the resource. |
| **Period 6-7** | Critique and revision finished | Wiki discussion boards | • Students critiqued a wiki page of their choice, leaving constructive criticism.  
• Students responded to the questions or comments and either rebutted the criticism or added/clarified information in response. |
<p>| <strong>Period 8</strong> | Overview of next segment of project | iMovie and Garageband | • Students were instructed on how |</p>
<table>
<thead>
<tr>
<th>Schedule</th>
<th>Activity</th>
<th>Technology Used</th>
<th>Action/Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 9-10</td>
<td>(video design and construction). Discussion of what &quot;makes&quot; a good argument.</td>
<td></td>
<td>to use the technology to construct a video.</td>
</tr>
<tr>
<td></td>
<td>Storyboarding and scripts</td>
<td>Word or paper and pencil</td>
<td>• Students chose a “perspective&quot; for their video.</td>
</tr>
<tr>
<td>Period 11-15</td>
<td>Design and construction of videos</td>
<td>iMovie or Garageband</td>
<td>• Students created videos.</td>
</tr>
<tr>
<td>Period 16-17</td>
<td>Watch videos in large groups. Discuss use of facts and other factors to create a convincing argument. Complete reflections.</td>
<td>Projector</td>
<td>• Students discussed videos.</td>
</tr>
<tr>
<td>Period 18-19</td>
<td>Test on unit/essay Focus group interviews</td>
<td>Evaluation</td>
<td>• Teacher evaluation of student’s content knowledge.</td>
</tr>
<tr>
<td>Schedule</td>
<td>Activity</td>
<td>Technology Used</td>
<td>Action/Outcome</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>-----------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>understandings, and design moves.</td>
</tr>
</tbody>
</table>

**Selection of groups**

Small groups of students were self-selected by the students *within* each classroom and were based on lab groups chosen earlier in the year (Crawford, Krajcik, & Marx, 1999). Small groups have been recommended to best examine collaboration as they mediate between individuals and communities, as well as allowing group cognition, shared meaning construction, to be visible (Stahl, Koschmann, & Suthers, 2006). The teacher purposefully selected the groups *between* the two classes. The group selections were based primarily on the size of the self-selected groups in order to allow each alternative energy resource to have a small group in each classroom, as well as being a part of a group that was separated by a time constraint (see Table 3-2). This design choice was made to build upon research (Stahl, Koschmann, & Suthers; Fields & Kafai, 2009) concerning facilitating collaboration within the classroom and over Internet environments; this research prompted the decision to examine not only collaboration within the classroom, but also collaboration facilitated by the technologies without a face-to-face component. In addition, the teacher’s purposeful selection of groups between classes allowed all non-consented students to be grouped into one area, protecting the identity of the non-participants. Because participation in the study was confidential, only the non-consented students and the teacher knew which students were not consented. Topics for each of the groups were randomly selected by drawing the type of alternative energy out of a container.
Table 3-2. Distribution of Groups for the Project

<table>
<thead>
<tr>
<th>Assigned Energy</th>
<th>Research and Construction of Wiki</th>
<th>Topics for multimedia presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>Sharon, Missy, Andrea</td>
<td>*** , Erica, Ally, Craig</td>
</tr>
<tr>
<td><strong>Geothermal</strong></td>
<td>*** , ***</td>
<td>Colin, Emma, ***</td>
</tr>
<tr>
<td><strong>Hydroelectric</strong></td>
<td>Mandy, Susie</td>
<td>Gary, Tom, Ben</td>
</tr>
<tr>
<td><strong>Nuclear</strong></td>
<td>Matt, Merle, Andy</td>
<td>Molly, Luke, Shelly, Ethan</td>
</tr>
<tr>
<td><strong>Solar</strong></td>
<td>Tammy, Lori, Shawn</td>
<td>Dane, Timmy, John</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>Brandy, Elise</td>
<td>James, Tanner, Tracy, Anna, Fredrick</td>
</tr>
</tbody>
</table>

*** non-consented students within this group

Data Gathering Methods

I employed various ethnographic methods of collecting data throughout this study to answer my research questions. In Table 3-3, I map the research questions to the data collection methods for this study.

Table 3-3. Research Questions and Data Collection Methods.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do students use the social bookmarking tool? How do they use it to support (or not support) argumentation? Specifically, how do students use the social bookmarking</td>
<td>• Participant observation</td>
</tr>
<tr>
<td></td>
<td>• Discourse analysis from video transcripts</td>
</tr>
<tr>
<td></td>
<td>• Ethnographic interviewing</td>
</tr>
<tr>
<td></td>
<td>• Document analysis (student)</td>
</tr>
<tr>
<td>How did the students use the wiki in the completion of a group project? How do they use the wiki as support for jointly co-authoring shared publications about alternative energy asynchronously? In particular, how do students use the process of co-authoring in a collaborative online environment such as a wiki to support articulating and communicating their understandings?</td>
<td>delicious accounts including tag words, links, and networks and reflections</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>How do students use multimedia technologies to persuade others (a sub-practice of argumentation) towards their viewpoint about alternative energy resources? How does student participation in the video design process support (or not support) the practices of scientific argumentation?</td>
<td>Participant observation</td>
</tr>
<tr>
<td></td>
<td>Discourse analysis from video transcripts</td>
</tr>
<tr>
<td></td>
<td>Ethnographic interviewing</td>
</tr>
<tr>
<td></td>
<td>Document analysis (wiki pages, discussion boards, wiki history and reflections)</td>
</tr>
<tr>
<td></td>
<td>Video analysis</td>
</tr>
</tbody>
</table>

**Participant Observation and Interviews**

I acted as participant observer within the classroom because of my role as both teacher and researcher (Jacobs, 2004). I primarily functioned within the teacher role with the students, allowing the researcher role to be as unobtrusive as possible. As the teacher-researcher, I participated in class discussions and classroom procedures, as well as positioning cameras during class time. I also asked questions and prompted for responses during class time to better understand student thought processes and insight into tool use while they were working on the projects. Classwork for each consented group was video recorded for the duration of the project beginning before students walked into class and continuing until the students walked out. Although students complained occasionally about being videoed, they never requested the recording stop. In fact, several times students left
video messages for myself in a joking manner that they expected to be viewed at a later date. Field notes (Rossman & Rallis, 2003) were used to document basic information about the events during each class period. I relied primarily on the video to document each class because the constraints of the dual teacher/researcher role.

I used semi-structured interviews (Rossman & Rallis, 2003) as a method of deepening my understandings about the student experiences with the tools, their perceptions about the support that the tools provided, and overall insights into the practices of argumentation. All students wrote reflections on the project based on prompts that aligned with the interview questions to gain insight into all student thought processes. The focus group interviews allowed me to probe more deeply their thoughts and provided validation of my interpretation of their actions and reflections.

**Use of Video Recordings of Classwork and Interviews**

For the present research, I video-recorded all class time, interactions, and interviews that occurred during scheduled courses within the school setting. I used a total of four cameras positioned to capture as much group work as possible in each class. Microphones were used when possible to enhance audio quality of the video recordings.

In order to analyze the video, content logs were developed for all video (Jordan & Henderson, 1995). All video was examined and critical events were identified. Critical events are defined as discourse or actions related to participation in the practices of argumentation, collaboration, communication, or tool use. These critical events are most likely small segments of video taking place over short periods of time, according to Stahl,
Koschmann, and Suthers (2006). The transcripts for all critical events and the focus group interviews were coded using both a priori and open-ended, emerging codes.

**Document Analysis**

I analyzed the written student reflections using open-ended coding with initial codes based upon ideas from the content and usage analysis on the tags, wiki, and videos. In addition, several codes were added based on literature pertaining to each technology. Other codes were added as needed to address ideas emerging during the analysis and combined to form themes. The written reflections and transcripts were imported into Atlas.ti and coded, utilizing codes from each section of the project or technology discussed. In addition, the student discourse, video, and other work were aligned to examine how the students used the tools to support their learning and triangulate findings.

**Design Elements and Procedures for Analysis**

**Social bookmarking**

Delicious is an online social bookmarking, or metadata tagging, site that allows users to assign keywords to websites and organize them into groups or “bundles”. All groups were instructed to use the website [www.delicious.com](http://www.delicious.com) to collect and save website links as they researched their project, as well as annotate their saved links using keywords (or social tags). To ensure that all students were familiar with use of the social bookmarking site, a review of its use was provided for the students by the school technology coach. Specifically, students were provided information on how to bookmark resources and create social tags, as well as
the ability to create networks. Figure 3-2 displays a screenshot from a delicious account showing bookmarked links and metadata tags.

Figure 3-3. Screen shot of student delicious.com account.
Student selected links and keywords chosen during research on alternative energy.

The students were given directions on how to research online about their specific energy resource and to bookmark the websites that they found using delicious.com. They were instructed that the information found on these websites was going to be used to construct a wiki page. They were given suggestions and requirements for researching their information about alternative energy resources. At least 10 viable websites were to be bookmarked on delicious.com for each student, as well as keywords or social tags created for each website. The social tags allowed for personal construction of knowledge as students summarized content to formulate the keywords (Hsu, Ching, & Grabowski, 2008). Each website was to be summarized using at least one social tag. The tags were self-selected by
the student either through creation of the keyword or choosing words populated by the website from previously generated words. Procedures for connecting via networks were discussed by the instructor, but were not required and left up to each individual student. Creation of networks within the small groups followed the recommendations of Bryant (2006) in that organizing the bookmarks through sharing promoted more complete understanding. Figures 3-3 and 3-4 show snapshots of a [researcher annotated] student delicious.com account tag cloud (see Figure 3-3) and bookmark list (see Figure 3-4).

Figure 3-4. Social tags applied by students as a tag cloud.

The size of font indicates that the words were applied more often during the tagging process; words not included in the analysis are noted.
Procedures for data analysis. While the criteria for the in-class project required that students use delicious.com while conducting their online research, not all students chose to complete these requirements. During the unit, all students (n=35) created accounts on a social bookmarking site, delicious.com. Of these created accounts, two students had extended absences during the project and did not bookmark or annotate any links. An additional two students did not use their created delicious.com accounts in any way. These four students are not included in this analysis. The remaining 31 students saved (bookmarked) a total of 339 links in delicious.com, and 28 students applied 655 words as social tags to the links (three did not apply any tags on their
links); see Table 3-4 for a summary. Repeated words for individual students were counted as many times as they appeared on the students’ unique links, but the same word in any form used on the same link was counted only once (e.g., ‘job’ and ‘jobs’ were counted as one word). Twenty-seven students created 110 connections to classmates to form networks.

Table 3-4. Summary of Students' Overall Social Bookmarking Use.

<table>
<thead>
<tr>
<th>Type action</th>
<th>Number students contributing</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Created account</td>
<td>35</td>
<td>35 accounts</td>
</tr>
<tr>
<td>Researched in the project</td>
<td>33</td>
<td>33 researched to create the wiki</td>
</tr>
<tr>
<td>Bookmarked links</td>
<td>31</td>
<td>339 links saved</td>
</tr>
<tr>
<td>Social tags applied</td>
<td>28</td>
<td>655 words applied</td>
</tr>
<tr>
<td>Networks created</td>
<td>27</td>
<td>110 connections</td>
</tr>
</tbody>
</table>

For the social bookmarking documents, two analyses were performed on the social bookmarking and tagging data. To find evidence of the sense-making practice, I first analyzed the delicious.com links and social tags created during research activities and the students’ reflections about the bookmarking. I used two coding schemes for the analysis of tags. First, I coded the tags for sensemaking using annotation and support (Golder & Huberman, 2007; Heer & Agrawala, 2008; Kuhn, Cahill, Quintana, & Schmoll, 2011) by comparing tags to website title and content shown in Table 3-5. The tagging strategy analysis examined the tags for alignment with the title of the website that the students bookmarked in delicious. The social tags applied to the websites were identified as support (duplicated from words found within the title), or annotation (summarized from information in the title or found on the website). In addition, I analyzed the social tags for content, shown
in Table 3-6, to examine how the students used the tags specifically to organize the information for later use on the wiki, as well as for communication and evaluation of the websites. I imported the social bookmarking website pages into Atlas.ti to code for content. Codes used were both pre-determined and emerging. Initially, codes from the literature (annotation and support) as well as topic, type, position, quality, picture, and communication were used. Refer to Table 3-6 for the lists of codes, definitions, and excerpts. Several codes were added during the analysis to address emergent themes: organization, collaboration, and time-saver.

Table 3-5. Coded Tag and Interpretation for Social Bookmarking.

<table>
<thead>
<tr>
<th>Link title</th>
<th>Social Tag applied by student</th>
<th>Coded tag and interpretation</th>
</tr>
</thead>
</table>
| Susie: Hydroelectric Energy Advantages and Disadvantages « Green World Investor | advantages | Support (found within the website title)  
Topic (pertains to the section on the wiki for advantages and disadvantages) |
| Susie: Profiles--Hydropower » Explore More: The Future of E0nergy | limitations | Annotation (not found in website title, but content in website supports the use)  
Topic (pertains to the section on the wiki for advantages and disadvantages) |

Second, I analyzed the video records of small group discussions during work in the classroom to examine how students made sense of the information and how social tagging was used as a support during the alternative energies unit. I used focus group interviews to better understand the tool use, and interviews and reflections to triangulate the video data. At the conclusion of the unit, prompts were provided in the form of open-ended questions for
students’ written reflections to elicit ideas about the use of social bookmarking and tagging for research. I analyzed the written student reflections using open-ended coding with initial codes based upon ideas from the content and usage analysis on the tags. In addition, several codes were added based on the social bookmarking/tagging and sensemaking literature. Additional codes were added as needed to address ideas or themes emerging during the analysis (See Table 3-6).

Table 3-6. Summary of Codes, Explanations, and Results of Reflection Analysis.

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Data excerpt</th>
<th>Frequency of code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beneficial</strong></td>
<td>Tags/tag use positively affected the student’s work on project</td>
<td>Connie: “The tags were helpful because they gave more in depth information”</td>
<td>51</td>
</tr>
<tr>
<td><strong>Difficulties</strong></td>
<td>Tags/tag use negatively affected the student’s work on project</td>
<td>Brenda: “I don’t think that the tags helped at all with research”</td>
<td>12</td>
</tr>
<tr>
<td>associated with use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organizational</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>Arrangement of ideas, organization, put things in order</td>
<td>Marcella: “They [the tags] helped pull the pieces together”</td>
<td>20</td>
</tr>
<tr>
<td><strong>Keeping track</strong></td>
<td>Keeping track of information, finding resources</td>
<td>Carol: “I knew where all my info was so I didn’t have to search”</td>
<td>6</td>
</tr>
<tr>
<td><strong>Time-saver</strong></td>
<td>Made it possible to complete the work faster</td>
<td>Molly: “[Tags] helped us look up research faster”</td>
<td>11</td>
</tr>
<tr>
<td><strong>Collaboration</strong></td>
<td>Working with the creator as well as using their resources</td>
<td>Andrea: “they [the other student’s tags and resources] were helpful because there were links to different information”</td>
<td>3</td>
</tr>
<tr>
<td><strong>Sharing information</strong></td>
<td>Working together, sharing resources</td>
<td>Ericka: “[Delicious.com] could help us collaborate”</td>
<td>1</td>
</tr>
<tr>
<td><strong>Collaborate</strong></td>
<td>Working together</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using others’ work

| Using others’ work | Referring to tags or links bookmarked and tagged by others | Ellen: “Use other people’s [tags] to help find good websites to use” | 9 |

Wiki

Most students were familiar with the use of a wiki, specifically wikispaces.com, an online Web 2.0 application that is intended to be used as a collaborative space for construction of knowledge artifacts (Trentin, 2009), from both biology the previous year and a project in chemistry earlier in this year. I created groups of 5 to 7 students within each classroom using pre-existing lab groups. The groups were formed with members of both the morning and afternoon classes to promote collaboration and prompt students’ making their thinking visible as they co-authored the wiki pages asynchronously across the classes. Each group of students was randomly assigned an alternative energy by drawing the type of energy out of a hat; the types of energy included solar, biomass, hydroelectric, nuclear, geothermal, and wind. Non-consented students were members of two groups: Biomass and Geothermal, therefore only four group’s wiki pages were analyzed for this study.

After being placed in a group that was comprised of students from both classes and being assigned a type of alternative energy, all students were instructed to create a shared classroom knowledge artifact in the form of a wiki page (Scardamalia & Bereiter, 2006). Students participated in a large group conversation prior to the project to decide information that would be needed to make a decision about alternative energy. The student-generated list of categories was provided as the guideline for content to be included on each groups’ wiki page about alternative energy. Based on this conversation, students were given requirements about the content to be placed on the page such as name and description, advantages and
disadvantages, costs, impacts, and pictures or graphics. Each student was required to post at least five significant contributions to the wiki as a classroom grade. This page was to incorporate both pro- and con-aspects of their assigned alternative energy resource in order to present a non-biased view akin to an argument map (Bell, 1997). A screenshot of a portion of the solar wiki page is inserted below (see Figure 3-6). The groups’ constructed wiki pages were to present evidence for and against the energy. (See Appendix B for the initial written project specifications). The teacher provided verbal instructions as well:

Teacher: Make certain that you present both sides of the picture on the wiki. It should show the pros and the cons of the resource. Unbiased. Not slanted.

The importance of the wiki to the students was that they were told that later they would use the wiki pages as a knowledge resource for a final, graded project. It was emphasized to the students that these wiki pages would be used as a classroom knowledge resource at a later time for another project. All students were informed that at this time each group would use another group’s wiki page to complete a second project. To make sure that all students understood the basic operation of the wiki, the technology coach for the high school provided an overview for the students of the use of wikispaces.com at the start of this part of the lesson.
Figure 3-6. Wiki screen shot.
A section of the solar group’s wiki page.

Students were required as a part of their course grade to evaluate the wiki pages created by other groups and post self-generated questions on the discussion pages of the wiki for those pages. Each student was required to post two questions about another groups' page on the discussion board that asked for clarification or contributed material to aid in the page construction. Furthermore, the students were required to respond to two questions or comments posted on their page’s discussion. Each post was to be a significant contribution: answering a question, elaborating on a response, or rebutting a response. Through these requirements, students commented and responded to comments, creating a form of scholarly discourse around the topic of their created resource; this was intended to create an environment in which students were responsible for the content of their wiki page as well as being responsible for helping the other groups create a complete and well-balanced wiki page.
**Procedure for wiki analysis.** Two analyses were performed on the wiki data. First, I analyzed the wiki data to examine how students used the wiki over the course of the project, particularly how they used the wiki to support the articulation of their understandings of alternative energy (See Table 3-7). Second, I examined more closely the interactions and patterns of the small groups of students researching and constructing the wiki both face-to-face and asynchronously through case studies of two small groups of students who constructed two wiki pages, Solar and Nuclear.

To examine the student use of the wiki, I analyzed both entries and transactions on the wiki. I considered an entry to be the time stamped notation within the wiki history; entries can consist of one or multiple additions, edits, deletions, or moves on the wiki. The entries are generated automatically by the wiki and displayed in the history. Transactions are also captured by the wiki history, but are compiled within an entry. One or more transactions can comprise a wiki entry. Transactions are viewed by clicking through the track changes function within each wiki entry and are not individually displayed. Transactions show not only the overall changes that were made, but also the order in which the changes were made.

To examine how students articulated their understandings of alternative energy on the wiki, I used the four dimensions of argumentative knowledge construction (Weinberger & Fischer, 2006), participation, epistemic, argument (not found in the wiki document analysis), and social mode of co-construction, to analyze the wiki transaction history, discussion boards, and student written reflections as initial coding categories for analysis. Emerging codes were added as needed, as well as several codes being combined or deleted. See Table 3-7 for the final codes utilized in this analysis.
I measured student *participation* by counting number of entries for each student as well as number of transactions within each time-stamped entry. Although simply logging in to the wiki could be considered latent participation, the wiki used did not record this. The participation dimension was analyzed by counting the number of entries (addition of content and edits) for each student; the quality of each entry was not examined. In addition, the heterogeneity of participation within each group was analyzed by comparing each student’s number of entries to others in their group and with the other participants.

To look at *co-construction*, I examined how the students entered their information, whether it was entered as stand alone sections, added to other student’s work, and their editing of their own and other student’s work. I utilized transaction analysis with several units of analysis (Peters & Slotta, 2010) to examine how students added and edited information when constructing the pages. Changes were coded as addition or edit. More specifically, changes were identified as addition of photo, edit or move of photo, addition or edit of text, and deletion of text or photo. Furthermore, codes were used to identify the edits, moves, or deletes as the author’s work or that of another student (Peters & Slotta). The number of additions and edits were counted as well as the actual actions performed for each. These codes used as guides when analyzing the transcribed dialogue and interviews for evidence of co-authoring as the students articulated their understandings on the wiki.

Table 3-7. Codes, Explanations, and Examples for Wiki Analysis.

<table>
<thead>
<tr>
<th>Code</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemic dimension (Initial code)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>Students select, evaluate, or relate components of the problem but do not involve</td>
<td>On the wiki page: “<em>We need captions under the pictures to explain them.</em>”</td>
</tr>
</tbody>
</table>
| Concept | Students summarize, rephrase, and/or discuss theoretical concepts and content material. | In the wiki:  
Initial: “animals because the turbines are noise outside of the water...”  
Final: “animals due to the noise created by the turbines which is amplified by the water...” |
|-----------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Relationship | Students discuss the relationship between the problem and concepts in order to determine how to approach the content in view of the problem or apply the knowledge. | From classroom discussion:  
Ethan: “I think that that [paragraph] should be under advantages not science.”  
Molly: “But its how it works.”  
Ethan: “But we need more advantages, and it fits too.” |
| Off-task | Student discussion not related directly to the task of creating the wiki page content, i.e. formatting, colors, discussion of personal issues or information | Removing Tanner’s name from the wiki page. Changing colors back and forth. |
| On-task | Student work or discussion related to the problem, the concepts, completion of the task | Adding information to a section on the wiki page. |

**Social mode of co-construction (Initial code)**

| Elicitation | Student use of learning partners or their created materials as resources, for example discussion within class, referencing their work, or elaborating on other student’s work. | From classroom discourse:  
Tammy: “What’s the word for that?”  
Shawn: “I don’t know.”  
Lisa: “Turbine.” |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Externalize</td>
<td>Students contribute information or explicate understanding without referencing other contributions (stand alone contributions).</td>
<td>Adding a paragraph of information to a section that does not connect to material before or after the segment by referencing or elaborating directly. Adding statements that could stand alone.</td>
</tr>
</tbody>
</table>
| Quick | Students accept critique quickly to continue, a coordinating discourse move. | In the discussion boards:  
James: “We need more advantages.”  
Tamera: “Ok.” |
| Integrate | Students change views through persuasion of | Erika: “Under cost, you need more information...” |
partners or by synthesizing information.

Susie: “It's lacking.”
James: “Will try to find more things.”

Conflict

Students use critique, multiple perspectives, and point out aspects of peer’s contributions in order to modify them or present alternatives.

Sara changes Evan’s information in the wiki by modifying his statement. “Wind turbines have had minimal health problems over the years, but even newer ones still have complaints of dizziness, vertigo, nausea, anxiety, and sleep loss.”

Additional emerging codes used in wiki analysis

| Communication | Students utilize the wiki to communicate with other members. | In the wiki: “I’m working on paraphrasing the information on our wiki page. don’t be afraid to help me :)” |
| Delete | Students delete section or segment, not just revise or rearrange. | Remove segment of text, picture, comments, communication, or other information without replacing. |
| Management | Students use the wiki to monitor progress, assign tasks, or direct arrangement of sections on the wiki. | Written on the wiki page: “DO NOT DELETE THIS!” |
| Organization | Students rearrange, format, or move sections on the wiki, or discussion about how to arrange sections on the wiki. | On the wiki page: “I'm making a table of contents” and then the student created the table of contents, moving segments to make the page flow. |

Following the transcription of selected instances of video of student work on the wiki, I aligned face-to-face and online participation via timestamps (Fields & Kafai, 2009) as a way to analyze face-to-face video and work on the group wiki. I looked at the in-class discourse in synchronization with the work on the wiki to examine the instances of collaboration, practices of argumentation (specifically articulation of understandings), and learning face-to-face and on-line.

Multi-media Artifact Design

Prior to this alternative energies project, students were familiar with the use of video production software. The school-wide technology training for students includes training on
the use of the video software; students had produced videos for this science class and other classes as well. The students were instructed to design a video arguing for or against a proposed alternative energy plant to be built close to their town. The goal was that their video would sway an audience of “town council members” to vote for their proposal.

Students participated in a teacher-led group discussion about the structure for argumentation. In addition, students brought up other factors such as music and pictures that they felt impacted an argument that would sway them to a decision. Students were reminded, however, that as instructor for the class I would be using the scientific argument structure of claim, evidence, counter-argument, and rebuttal when grading their projects. Following this discussion, students were given a story-board handout as a support to help align photos and script along with a suggested structure for their video. The storyboard was considered a visual organizer for their information to help structure the video design; it included stating the point of view, facts/justification, impacts, evidence to support the justifications, counterargument with supporting evidence, and conclusion to provide a suggested structure for their video design. After being provided with a storyboard and suggestions for structure of arguments, I created small groups of 2-3 students within the classes to create persuasive videos to sway “town council members” to vote for or against an alternative energy. The students were randomly assigned an alternative energy different than that of their wiki page. Students discussed the advantages and disadvantages of the energy resource with their partner(s), and then selected which side they felt they should represent.

Thirty-four students participated in the construction of 12 persuasive multimedia presentations. Within these 12 multimedia artifacts, 11 artifacts consisted of static photographs, graphics, and charts that were found on the Internet with students providing
voiced-over scripting. One persuasive multimedia artifact was constructed with live video recorded with the students as actors as well as several static photographs.

The students used the class-created wiki as a knowledge resource when creating their script. In addition, they chose pictures from the wiki and from other online resources to supplement their voiced script. Finally, the groups exported the video as a QuickTime movie that was then shared with all classes. The videos were posted to the teacher's school webpage and viewed by the class in large groups. A large group discussion about each video followed the viewing with the teacher facilitating a critique of the structure of the argument(s) used in each video, as well as student responses to each video. Following all videos, students discussed in a large group setting which features in the videos felt more convincing overall to them.

**Design of the multimedia artifact analysis.** Three analyses were performed on the persuasive multimedia presentations: one on the artifacts themselves, the second on how the students created the artifacts, and the third on the students’ reflections. First, to find evidence of argumentation, I analyzed the student-produced persuasive multimedia artifacts with a framework modified from Zohar and Nemet (2002). In Table 3-8, I provide definitions of each code utilized in the analysis. The second analysis focused on the recordings of both classwork and focus group interviews; these data were analyzed through development of content logs (Jordan & Henderson, 1995) to identify critical events; critical events were transcribed and examined using an interpretative analytical approach. Finally in the third analysis, I analyzed the written reflections using coding categories developed from the prior two analyses; these reflections were used to triangulate and provide additional evidence for the findings related to the construction of the students’ artifacts.
Table 3-8. Framework Used for Analysis of Argumentation in Student-produced Multimedia Artifacts (based on Zohar & Nemet, 2002).

<table>
<thead>
<tr>
<th>Argumentative moves</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Argument</td>
<td>Claim and justifications.</td>
</tr>
<tr>
<td>Justification</td>
<td>Collapses several of the components of an argument (data, warrants, backings) into one category.</td>
</tr>
<tr>
<td>Counter-argument</td>
<td>Presents a claim that is in opposition to the original argument.</td>
</tr>
<tr>
<td>Rebuttal</td>
<td>Justification that counters the counter-argument.</td>
</tr>
<tr>
<td>Non-argumentative moves</td>
<td>Questions, coordinating moves, and meta-statements on argumentation</td>
</tr>
</tbody>
</table>

I examined the argumentation within the student-produced videos using a framework based on Zohar and Nemet (2002). This framework condenses the strategies used in argumentation into claim, justification, counter-argument, and rebuttal. By consolidating warrants and backing into the category of justifications, the reliability and validity of the analysis are improved by simplifying the structure (Sampson & Clark, 2008). A claim was required to have a valid justification to be considered an argument. Scores were assigned (See Table 3-9) based on number of justifications, counter-arguments, and rebuttals and were used to determine the quality of argument (Zohar & Nemet; Samson & Clark). Scores of 0 - 2 were assigned for each category based on the number of valid justifications, counter-arguments, and rebuttals; scores of 0 – 2 were also assigned based on the argument structure, giving each argument a possible total of 12.
Table 3-9. Scoring System for the Student-produced Persuasive Multimedia Artifacts (based on Zohar & Nemet, 2002).

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Justification</td>
<td>Reasons or supports for a conclusion.</td>
<td>No valid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>justification</td>
</tr>
<tr>
<td>Counter-argument</td>
<td>Argument contradicting the original argument.</td>
<td>No valid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>justification</td>
</tr>
<tr>
<td>Rebuttal</td>
<td>Argument used to refute the counter-argument.</td>
<td>No valid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>justification</td>
</tr>
<tr>
<td>Structure</td>
<td>How students chose to support their argument.</td>
<td>No valid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>justification</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition, the videos of student discussion leading to the script and construction of the video were examined. Transcripts of all video were coded focusing first on argumentation structures and then using open coding to allow for generation of themes. Emerging themes were centered on how information was used within the video, procedures for creating the video, persuasive techniques using scientific argumentation as well as everyday ideas of persuasion, and the importance of audience on the scripting.

**Focus Group Interviews**

Following the study, 13 students participated in focus group interviews. These students attended one of two group interviews, based on their schedule. One group of seven students met during 2 non-consecutive periods (about 60 minutes total), and the second group
of six students met for about 60 minutes during a double class period. Because not all students could participate in the interviews because of time constraints, the questions used as a foundation for this interview were the same as the open-ended questions given to all students the final day of the study in written format. The small group interviews allowed me to probe the student answers more deeply. Discussion following the questions changed as needed to better understand the nuances of the student participation in the project, tool use, and supporting construction of knowledge as well as participation in the practices of argumentation.

**Reflection**

All students completed the open-ended reflection the final day of the project. Their answers provided insight into the students’ prior use of the Web 2.0 tools, how the tools were used, and how the student felt that the tools supported their collaboration, learning processes, and participation in argumentation.

**Tool Use**

I observed student use of technology while researching, constructing the wiki, writing the script, and constructing the podcast, which provided information about how the students actually used the tools as supports (or distractions) over the course of the project. Student reflections and interviews provided additional insight into how the tool use supported sensemaking, articulation of understandings, and design of persuasive videos from the students’ perspective. In addition, the interviews allowed me to fact check with the students
about my interpretation of their understandings of alternative energy, appropriation of the practices of argumentation, and tool use.

**Trustworthiness**

I triangulated data from multiple sources to ensure that the analysis was trustworthy (Rossman & Rallis, 2003). Data from the classroom video, wiki and social bookmarking data, interviews, reflections, and student-produced videos were all utilized to further establish validity and reliability of findings. In addition, the focus group interviews were used as a method of verifying my interpretation of the students’ understandings and use of the tools as supports.

**Personal Biography**

Presently, I am both a graduate student and employed by a public school district in Northwestern Pennsylvania. I have been employed at the high school within this district for 21 years as a chemistry teacher, Keystone Integrator, and technology leader. As my high school supports a one-to-one laptop initiative to help mitigate the inequity observed in socio-economic status, I was interested in how students used the technology to support their learning. I designed this unit to help meet the Next Generation of Science Standards within the classroom, as well as examine how the students used the tools to construct knowledge, communicate and collaborate, and support their participation in science practices. In addition, I was more broadly interested in how the students chose to use the tools; while teaching, I had noticed that often students found uses for tools that were not teacher directed or intended. Finally, although software exists that could have been used, I was interested in
how free Web 2.0 technologies would function as supports for this project, particularly because of budget constraints within a typical school district.

**Ethical Considerations**

The Penn State University Institutional Review Board approved this study. All participants provided informed consent. As all participants were minors at the time of the study, school district approval, as well as parental consent, was also obtained. All identities were protected to the greatest extent possible. Because participation in the project was required as a part of the course grade, only data from consented students were utilized for this study; group work from class members who were not consented was discarded, even with consented members functioning within the group.

As with any research, there are limitations to this study. The population of 34 high school chemistry students at a low-income, rural high school is not representative of all science learners. In addition, the adoption of a one-to-one laptop initiative within the school district affords students access to technology in ways that many districts and students do not have available, again limiting the population of learners with access to the technology, support available, and training. The study was limited in time because of the ending of the school year and other curricular constraints. The teacher as researcher also adds to the limitations.

The students in the participating classes were all members of the college preparatory curriculum within this district. As members of this group, student achievement was often focused on performing well and attaining good grades. These students saw science as a part of their future, at least for several college classes, and many were intending to major in
science or medical fields. Their interest in science could have engaged them at a higher rate than other groups. In addition, they were not given a pre-test on alternative energy, so it is unknown what levels of knowledge or interest were expressed prior to the project. The groups within the classes were self selected by the students as lab groups prior to the project. Although there are benefits of students working within self-selected groups, the possibility exists that students would have been more likely to edit and modify the work of students that they did not know. In addition, the dynamics within these groups could have affected the students’ work habits and willingness to participate. Although all students were provided training with the technology, and students take the laptops with them throughout the school day and year, some students may not have been as facile with the technologies used. This inequity in ability was not addressed except by demonstration of the use by the school’s technology coach prior to the implementation.

The short time frame of the study did not give the students time to experiment with different methods of constructing their arguments or to revise their work. In addition, the interviews were limited to students with a free period in their schedule who were willing to participate in the interview. Others who expressed interest in being interviewed were not able to find time in their day to participate. Interviewing students as a follow-up activity was also not possible because of the end of the school year. More participation in the interviews could have greatly affected the insight into student use of each tool and their understandings of argumentation.

Finally, although the teacher as researcher has been studied (Jacobs, 2004) within the classroom, studying another classroom could have provided greater insight into the
interactions between students. By having another researcher to capture data, a wider focus on the groups could also have been implemented.

**Chapters 4, 5, and 6: Data and Findings**

The next section of my dissertation presents data, analysis and interpretation on how students used Web 2.0 technologies over the course of the alternative energies unit in a variety of ways both intended by the instructor as well as self-determined by the students. I focus specifically on how Web 2.0 technologies were utilized by the students to support three sub-practices of argumentation (e.g., sense-making, articulation, and persuasion) within the alternative energies unit.

This analysis is divided into three chapters, each answering one research question as shown in Figure 3-7:

Chapter 4: How do students use the social bookmarking tool?

  a. How do they use it to support (or not support) argumentation?
  b. Specifically, how do students use the social bookmarking tool and tagging to support their individual sense-making (a sub-practice of argumentation) about alternative energy resources?

Chapter 5: How did the students use the wiki in the completion of a group project?

  a. How do they use the wiki as support for jointly co-authoring shared publications about alternative energy asynchronously?
  b. In particular, how do students use the process of co-authoring in a collaborative online environment such as a wiki to support articulating and communicating their understandings?
Chapter 6: How do students use multimedia technologies to persuade others (a sub-practice of argumentation) towards their viewpoint about alternative energy resources?

a. How does student participation in the multimedia artifact design process support (or not support) the practices of scientific argumentation?

The structure of Chapters 4-6 is the same. First, I answer each research question across all consented students. Second, I developed case studies of small groups’ interaction to highlight a theoretically important aspect of the large group findings. To enhance the trustworthiness of my interpretation, I triangulated the interpretation across multiple data sources, which are included within the case studies. Figure 3-5 illustrates the structure of this section of my dissertation. In the next chapter, I focus on social bookmarking.

Figure 3-7. Diagram of the structure of the dissertation analysis.
Chapter 4

Social Tagging in Support of Sensemaking

Chapter 4 addresses how students used the social bookmarking tool in the alternative energy unit. I examine how social bookmarking supported (or did not support) argumentation, and how students used social tagging to support their individual sensemaking.

Four data sources were used in the analyses in this section:

(e) video recordings of students conducting online research during their in-class time using the social bookmarking tool delicious.com,
(f) video recordings of the students’ focus group interviews at the end of the unit,
(g) digital artifacts from the learners’ social bookmarking accounts including students’ networks, links, and tags, and
(h) students’ individual reflections about their learning process written at the end of the unit.

These data sources were analyzed to examine how the students utilized the social bookmarking and social tagging across all classes. Secondly, I present a case study that analyzes the work of one group of students who researched and created the hydroelectric wiki. This case study was chosen to illustrate how one asynchronous group of students made sense of information about hydroelectric energy as they used the social bookmarking tool.

Social Tagging Findings

From the initial analysis, the following five themes emerged and are discussed in the remainder of this chapter. The students used social bookmarking as

(a) a sensemaking tool,
(b) a communication tool.
(c) a time-saving tool, and
(d) a project management tool.

In addition to the four themes related to the use of social tagging as a tool, an additional theme related to social tagging was highlighted by the analysis:

(e) social tagging as a support for collaborative sensemaking.

**Social Tagging as a Tool for Sensemaking**

The first analysis that focused on social tagging found students using social bookmarking as a way to make sense of the information found about alternative energy. The coded tags were analyzed for the students’ inferred tagging strategy and for included tag content. The codes applied, an explanation of each, the number of tags coded within each category, and percentage of codes are summarized in Table 4-1.

Table 4-1. Codes Relating to Tagging Strategy, Code Definition, and Results of Tag Analysis.

<table>
<thead>
<tr>
<th>Categories of tags</th>
<th>Definition of each category</th>
<th>Total of students’ tags</th>
<th>Percent of students’ tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tagging strategy (coded separately)</td>
<td>(based on Kuhn, Cahill, Quintana, &amp; Schmoll, 2011)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Support</strong></td>
<td>Student created a tag using the exact words found in the title of the webpage saved in delicious.com.</td>
<td>350</td>
<td>53%</td>
</tr>
<tr>
<td><strong>Annotation</strong></td>
<td>Student summarized the content found within the saved webpage. The tags were created by students’ reflection on the content.</td>
<td>305</td>
<td>47%</td>
</tr>
<tr>
<td><strong>Content and usage analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Student tagged web resources based on the teacher’s categories for organization and development of the wiki on alternative energy: Advantages/disadvantages, safety, health, geographical location, jobs, costs, facts or definition, and other similar topics.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Student identified the alternative energy resource as relevant to nuclear, wind, solar, geothermal, biomass, or hydroelectric.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>155</td>
</tr>
<tr>
<td>Communication</td>
<td>Student created a tag intended to communicate information to another team member either by sending the website address or providing information in the tag.</td>
</tr>
<tr>
<td>Quality</td>
<td>Student wrote an assessment of the quality of the website as a tag.</td>
</tr>
</tbody>
</table>

**Emerging codes (included in content and usage analysis)**

| General | Student created a tag indicating general information such as broadly focused research or statistics – not specific topical information. | 63 | 9.6% |
| Picture | Student indicated that the website contained a photograph, graphic, chart or other media selected for inclusion on the wiki. | 7 | 1.1% |
| Position | Student indicated that the website’s information was biased towards one viewpoint. | 1 | .2% |

**Social tagging to organize and annotate.** According to research from Weick, Sutcliffe, and Obstfeld (2005) and Bell (1997), sensemaking serves an educational purpose for groups when it allows students to make thinking visible. I build from and add to this perspective on sensemaking through examination of the way in which students made their understandings concrete by applying social tags to their bookmarked links.
The students chose their social tags in two ways: selecting *keywords* from the titles of the websites and *summarizing* the content of the websites. The students used the keywords by applying tags to the links as a way of making sense of the information through organization and summarization as they researched their assigned alternative energy (see Figure 4-1). I found that students applied more tags (54%) from words copied from the titles of the websites (coded as support) instead of summarizing (coded as annotating) the website or using key terms found within the website text (46%). Building on findings from research on the annotation process with children in middle school by Kuhn, Cahill, Quintana, and Schmoll (2011), I found that the high school chemistry students used reflection and synthesis to organize new information through self-created social tags, as well as choosing words within the title to use as a social tag. Although the slight majority of all the tags applied were words found in the website titles, 27 out of the 33 students who researched during the project created at least one social tag that summarized the information on their website. This summarization process while creating tags has been linked to improved construction of knowledge (Levin & Wadmany, 2006; Or-Bach, 2005). I posit that students in this study were using the annotations both to help with the construction of knowledge and to support their memory of the content on each website.

The students also made sense of the alternative energy information online by organizing the websites they found through applying words based on categories used to organize the wiki to the links in delicious.com. Building on the work of Heer and Agrawala (2008) which found that visualization software users made sense of information using organizational strategies, when I analyzed the students’ social tags for content, the students primarily made sense of the information by labeling links with the categories from the wiki
as an organizational strategy as well. Students used the topics chosen for the wiki as the categorization keywords for social tags applied to their bookmarks about 64% of the time (see Figure 4-1). The type of alternative energy was the second most common categorization tag applied by students. Students infrequently applied social tags that did not directly reference energy or topics; these tags were coded general: statistics, definition, and information.

Figure 4-1. Sense-making purposes of social tags.
Categories of the social tags applied by students in delicious.com to bookmarked links about alternative energy.

The categorization to organize their websites (by type of energy, topics within the website, key information about the energy)—taken with their summarization work—allowed the student to make sense of the information about alternative energy resources.
They made sense of found online resources by applying words from the website title as tags as well as creating their own terms by summarizing website content. Students applied tags to the websites in a purposeful way using terms that corresponded to sections on the wiki to organize their found resources and facilitate their work.

**Social Tagging as a Tool for Communication**

Research by Rose and Barton (2012) and Warren, Ballenger, Ogonowski, Rosebery, and Hudicourt-Barnes (2001) found that students made sense of science content with a multitude of tools and various communication methods within the classroom. I added to this perspective by examining how students utilized the social bookmarking website, delicious.com, as a tool to communicate and share resources with the classmates, group members, and the general public. Students communicated via the social bookmarking website nine times with other students, group members, or the general public in three different ways: by

(a) targeting websites for their group members,
(b) identifying websites that provided “good” information, and
(c) evaluation of websites’ positionality or bias.

Bruckman (2006) advocated that online researchers pay attention to actions by participants that fall outside the majority; even single instances can provide meaningful insights. Likewise, while I focus on actions that are not common across the dataset, these are important ways of participating for these students and groups. In this instance, the actions of the few highlight the potential affordances of social tagging as a communication tool.

**Communication by targeting resources for group members.** The students used the social bookmarking website to communicate and share resources directly with group
mates within the alternative energy unit. One student, Craig, used the “Send” feature in the social bookmarking website to deliberately share an online resource with his group mate, Anna. Craig found a website containing information about biomass advantages and disadvantages that he felt would help Anna with the segment of the wiki that she was working on. He intentionally shared the resource with her via the social bookmarking website (see Figure 4-2) stating:

“I had seen what it [the share button] was supposed to do. When I found a link I knew that Anna could [use], I sent it to her instead of writing it down.”

Craig used the social bookmarking website as a communication tool to share materials with his group mate virtually instead of writing down the information, copying the link, or sending it to her in an email outside of school. Craig determined through experimentation (“had seen what it was supposed to do”) how the share button worked and then used it to send the website link within the application to Anna, instead of communicating it through other means that were easily available. Although the ability to send links to another member is present on the website, this process was not demonstrated to the students. In addition to Craig, two other students utilized the send feature within delicious.com. Marcella and Carol were part of the same wiki group, but in the morning class; they used the “share” feature within the social bookmarking website to send links to their own delicious.com accounts. Discussing this action after the conclusion of the project, Carol and Marcella thought they were bookmarking links within their social bookmarking accounts as directed by the teacher at the start of the unit. Their behavior, however, differed from that of Craig; these students unintentionally sent links to their personal accounts instead of saving the website addressed into their delicious.com accounts. This was tracked through the website, which generated a
tag for this action. Although Marcella and Carol were not intentionally trying to communicate with others within the delicious.com platform, this communication process still occurred. These actions highlight the different ways in which students can attempt to make sense and communicate using technology. Often students are not given time to experiment with technology within the classroom. It is through examining unplanned and undirected student use of the tools that the affordances can truly be determined.

![Figure 4-2. Delicious.com account illustrating targeted communication.](image)

Craig utilizes self-initiated sharing of resources with a networked group member in another classroom.

**Communication through identification of information.** Another way in which students used social tagging as communication was through identification of pertinent information to, not only their classmates, but to all potential users of delicious.com. Tanner
used his social tags to communicate with his group members, classmates, and the general public while researching about wind energy. Tanner found a website on hydroelectric energy that he felt contained good information about turbines used for that type of energy. He bookmarked the website, applied the tag “turbine”, and commented on it. Tanner posted this note to the link (via comments and not applied as a social tag on delicious.com):

“If anybody may need turbine info this has some”.

Tanner’s social tag applied to the bookmarked hydroelectric energy webpage allowed him to share the resource openly with any students in his class who were looking through his saved links, as well as anyone publically searching for turbines (the social tag he applied) on delicious.com. His additional comment addressed the content of the website not available from the title alone, specifying the information he found on water turbines was there.

Tanner’s comment was the only annotation of this type on delicious.com from the students. This is similar to a finding from Ames and Naaman (2007) that found that users of another type of social tagging site, Flickr.com (a photo storing and sharing website), most often annotated photographs to facilitate searching and understanding context for other users, not themselves. From the perspective of supporting student learning, this social sharing can also be seen as evidence of learning. For example, Farwell and Waters (2010) found that sharing bookmarks promoted the development of a complete understanding of content. This study shows how students similar to Tanner can both enhance others’ experience while showing evidence of learning. This finding has important implications then for educators, because choosing a technology with social tagging capability where learners can share materials with others could influence the learning experiences of students.
Communication through evaluation. A third finding related to the students’ use of social tagging as a method of communication was the evaluation of online websites. Farwell and Waters (2010) found that students felt that websites and online materials were validated through the use of social bookmarking when more people chose to bookmark the link. In a similar vein, it was expected that students would use social tags to identify the positionality and quality of the website; however, the majority did not assess the utility of the online resources that they found. The instructions given to the students for the alternative energy unit asked them to create a neutral wiki page (not deliberately slanted either for or against) to illustrate both the positive and negative features of the energy resource. From the teacher given instructions on the wiki home page:

“In order to form a non-biased view, you should incorporate both perspectives, pro-energy and anti-energy, into your work [on the wiki page].”

The teacher also stated to small groups of students several times, “Make sure you show both sides of the energy in the wiki.” With these specific directions indicating that the wiki pages should not be deliberately slanted for or against the alternative energy being given to the students, during analysis two a priori codes were created, position (a social tag indicating bias) and quality (a social tag indicating information valuable to the project). During analysis only one tag was coded “position”, and four tags were coded “quality”. Examples of position and quality excerpts from the students’ work are given below:

**Position:** Ellen indicated that a website on the benefits of utilizing biomass as an energy resource was written from a position favorable towards biomass energy with the word “backs-it”.
Quality: Tanner used the word “goodsite” to apply to four website links on hydroelectric energy indicating that he felt that the website contained valuable information for his group’s wiki page. Although several students’ tags communicated the position or quality of the website, most students did not utilize the social tags as a method of indicating the bias of the webpage or their interpretation of value of the information found on the webpage. Instead, an analysis of the data showed that most students chose not to bookmark or identify websites of poor quality. They also did not use labels to identify whether the sites were biased or not when bookmarking information about alternative energy topics. However, students did discuss the quality or bias of websites face-to-face during class time.

Gary: [looking at a webpage on his computer] Oh wait, we can use this! [Ben and Tommy both lean in to look at Gary’s computer screen.] Oh ... never mind.

Ben: Huh?

Tommy: It’s [the webpage] slanted.

This group of students worked together as they added information to their wiki page, discussing the information that they found and vetting the websites collaboratively as they researched and created their wiki page. Although the students talked about the need to use bookmarking websites, apply social tags, and use delicious.com during this time, they did not specifically state that they were bookmarking the page or applying tags, even as the video showed them saving links. Adding to research (Weick, Sutcliffe, & Obstfeld, 2005; Heer & Agrawala, 2008) on sensemaking in groups, these youth made sense of the information on the websites through face-to-face discourse as they made decisions on the quality and utility
of the website and discussed the merits of including the information in their project. Even though each student was required to bookmark 10 websites per classroom requirements, Gary, Ben, and Tommy rejected websites that did not meet their criteria for quality; only after they vetted the questionable websites together, did they bookmark the sites on delicious.com and apply social tags. This collaborative discussion allowed the students to make sense of the information by reflecting on how the information aligned with their understandings about alternative energy as well as how it would fit into the design of their wiki page (Kuhn, Cahill, Quintana, & Schmoll, 2011).

**Social Tagging Served as a Timesaving Tool**

Research (Lonn & Teasley, 2009) indicates that students consider efficiency as a valuable affordance of technology in the classroom. Analysis of the interviews and reflections in my study indicated that students utilized the efficiency of social tagging to find targeted topic specific information quickly in two ways:

(a) student-created networks and

(b) the social tags applied by students over the course of the project.

These two time saving affordances of social tagging helped students meet deadlines and select science-related resources that targeted information about specific alternative energies in an efficient manner.

**Student-created networks.** The networking feature on delicious.com provided a way for students to form groups in which the members could easily view each other’s links and applied tags; students used the other network members’ links and tags to help find subject specific webpages efficiently. When researching for information to complete the second
phase of the project, students formed connections with non-group classmates, which created
networks. By creating networks, students could access the other students’ previously
completed research. The students used their classmate’s tags to sift through bookmarked
links to select evidence to use in their video. In the reflections, several students commented
on the value of networks or other students’ social tags when constructing the wiki page and
video.

**Tara:** For the video, I looked at Shawn’s [tags]. Just to see what he had for
stuff.

**Jason:** Yeah, I used their tags for the video, then. One or two things. I linked
to the people in the solar group, and looked through their tags when we
were writing the script.

**Susie:** I liked the tags for the video, so you didn’t have to go the whole way
through the website to see what was on it. You could look at those
[tags] and say, “Ok, I need costs or whatever” and save time by
skipping what wasn’t important.

Using their classmates’ saved bookmarks and tags allowed students to target their internet
researching and find specific pieces of information that they felt would be valuable in an
efficient manner, saving them time and energy. Adding to research (Lonn & Teaseley, 2009)
on the students’ perceived affordances of efficiency of technology in the form of Learning
Management Systems, the high school students in my study also found great value in the use
of the social bookmarking to efficiently find targeted information to support their arguments.
In addition, the interaction between networked students (Farwell & Waters, 2010), as well as
with the information being shared, facilitated construction of knowledge (Hsu, Ching, & Grabowski, 2008).

Social Tags as a Way to Efficiently Retrieve Information

Social bookmarking websites are intended to provide support and organization for users (Golder & Huberman, 2005; Hsu, Ching, & Grabowski, 2008). During the alternative energies unit, the students in my study felt that the tags helped them organize their materials and allowed them to find information quickly that was previously bookmarked to complete their section of the project. Students were also able to use other group members’ tags to search for helpful links containing information about alternative energies without having to examine multiple websites. Adding to the research, in interviews and reflections the students stated that social bookmarking and tagging, although adding a step in the research process, also functioned as a timesaving tool. In addition, students in this study used the tags to target their searches, quickly finding specific information within websites.

Andrea: “[Tags] were helpful because there were links to different information that helped make it faster to find the information I needed.”

Tammy: “My researching bookmarks were very helpful and resourceful. I used them to keep things organized for my video and wiki.”

Although this organizational benefit of using the social tags was implied by the technology itself, student use of delicious.com adds to the research about social bookmarking by identifying affordances perceived by students.
Even the students who did not tags their own links found links applied by others beneficial when they searching for information. Cameron, for example, did not bookmark or apply social tags to any websites; however, when he conducted online research in order to build his group’s video, Cameron used the social tags applied by other classmates. He noted that by using others’ tags and saved links, he could find information efficiently.

Cameron: “When making the wiki, the tags were helpful. They helped organize the project because the labels let me see what each page was.”

Cameron felt that the use of other students’ social tags helped him find organized information to use in the wiki project.

Students also found the social tags and tagging process difficult to use and understand. Eight additional students found the tags beneficial, but were not certain how to apply them to websites or how to use them to support their learning. During the students’ interviews and reflections, the students indicated that more practice or familiarity with the social tagging process might help them more fully utilize the technology while researching.

Mary: “The tags were useful. I wasn’t used to them though.”

Craig: “They helped find the stuff for it [the wiki], but I still don’t know really how to use them.”

Tammy: “Although the tags were very helpful, unfortunately, for the video I didn’t use them.”

Tammy’s use of the word “unfortunately” indicates that she can now see a benefit to the use of social tagging, although she says she did not use tags for the video project. Six students indicated in their reflection or the interview that they felt they did not use the tags for the project; others did not mention how they used the tags after applying them. These students
felt that the tags and tagging process either did not help with the project or made it more difficult.

   Craig: “The tags weren’t very helpful.”
   Tanner: “I did not use the tags.’
   Eric: “They [tags] were hard…another step you had to do.”
   Erika: “I didn’t even look at them when I was working on it [the video project].”

These findings align with research (Kuhn, Cahill, Quintana, & Soloway, 2010) on social bookmarking indicating student confusion about and difficulty with the tagging process and extend this perspective to high school students. Cameron did not tag any links, but found the use of others’ tags beneficial. Tammy also saw the benefit of utilizing the tags in hindsight. Only three students did not apply any tags to their links saved in delicious.com. There were no appreciable differences in the quality of the video produced for the groups in which these students participated.

**Social Bookmarking as a Project Management Tool**

In addition, the students used the affordances of the social bookmarking website as a project management tool to keep track of the project and the work of their classmates. The student interviews and reflections indicated that students found the tagging process helpful to their initial research project as a way of keeping track of found materials and requirements as well as the progress of the group.

**Researcher:** Did you find using social bookmarking, delicious[.com], helpful?

**Group:** (as a whole) yeah…
Jason: You could go on and look to see what other people in your group had found and base what you were looking for on them.

Susie: Each day you could just go in and see what the other group did during their class, and you could keep going on the research then.

Elle: And you could look back through their links and see where they got their information from…which was good.

Jason: I went through to see if everyone had their ten [required links], and I’d tell them, “Hey, you don’t have enough!”, and then [looked] to see what I had to get yet.

The students used the applied tags and bookmarked links within this shared space to keep track of the group’s progress on the project. For example, Jason used the social bookmarking website to monitor members’ work; he kept track of how many links each had bookmarked and prompted the other group members to complete their work. Elle also vetted the other students’ research by tracing the work back through the links to see the source.

In addition, Jason and Susie based their work patterns on the social tags of their group members. By examining the applied tags, Jason and Susie were able to target their efforts towards topics that had not yet been investigated and manage the research on the project across asynchronous classrooms. When students were working online with new technology or media, research (Stahl, 2007) has found that they often invented creative practices and methods of making meaning utilizing the new technologies. In a similar manner, when confronted with a new technology (delicious.com) and new conditions (a project spanning two asynchronous classrooms), these students found inventive ways of monitoring group progress towards a collaborative goal.
Case Study Analysis: Social Tagging to Support Science Discourse

In order to examine how the students used the social tagging as a learning tool to make sense of the information found on the Internet, I created a case study. Students in the hydropower energy group were selected for two reasons. First, the hydropower group was selected because of the high number of tags that were applied to the group members’ links on the social bookmarking site, as well as the high ratio of tags coded as annotation versus support in comparison with other groups (see Table 4-2). Second, the students in both the morning and afternoon section of the hydropower group exhibited a unique method of researching and making sense of the material through discourse, making this group worthy of further analytical attention.

The hydropower group consisted of two sets of students working together as an asynchronous group of five students: two morning students and three afternoon students. Mandy and Susie were two female youth aged 16 and 15 in the morning chemistry class. Ben, Tommy, and Gary were male youth aged 16 in the hydropower group in the afternoon chemistry class. The students were selected by the teacher to form an asynchronous group to research hydropower energy and create a wiki that could be used as a classroom resource for this energy source. Mandy and Susie and Gary, Ben, and Tommy collaborated on research across both groups asynchronously while using web 2.0 tools. Both groups, in separate classes, chose to sit around one-half of a lab table when beginning research on hydropower. As they worked, both the morning and afternoon groups shared ideas about websites with the other students within the classroom, noting which sites might be valuable, as well as criteria that were required for their research section and to complete their wiki page.
Overview of the Hydropower Group’s Social Tagging Process

Table 4-4 summarizes the social tagging process for the hydropower group. Mandy selected 10 websites while researching hydroelectric power for the project. She used 23 different terms to apply 38 times as keywords to her 10 selected links; the majority of her terms chosen (28 annotated versus 10 support) were not found in the title. Mandy’s development of new words used as social tags was coded as her intention to summarize content from the websites, indicating an attempt at making sense of the information. Many of her annotated terms indicated specific information found within the website, not simply organizational terms or topics selected for use within the wiki page. In addition, one site selected by Mandy was tagged “picture”; an image from the webpage tagged with “picture” was later used on her group’s wiki page. Mandy used the tags to indicate specific information that she felt could be applied to sections or segments of the wiki page.

Table 4-2. Delicious.com Data from the Hydropower Group.

<table>
<thead>
<tr>
<th>Student</th>
<th>Links</th>
<th>Tags</th>
<th>Different words used</th>
<th>Network connections</th>
<th>Tags coded Support</th>
<th>Tags coded Annotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben</td>
<td>10</td>
<td>68</td>
<td>34</td>
<td>4</td>
<td>29</td>
<td>39</td>
</tr>
<tr>
<td>Tommy</td>
<td>10</td>
<td>20</td>
<td>15</td>
<td>4</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Gary</td>
<td>10</td>
<td>35</td>
<td>20</td>
<td>4</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td>Mandy</td>
<td>10</td>
<td>38</td>
<td>23</td>
<td>3</td>
<td>10</td>
<td>28</td>
</tr>
<tr>
<td>Susie</td>
<td>10</td>
<td>26</td>
<td>23</td>
<td>3</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>187</td>
<td>115</td>
<td>18</td>
<td>83</td>
<td>104</td>
</tr>
<tr>
<td>Average</td>
<td>10</td>
<td>37.4</td>
<td>23</td>
<td>3.6</td>
<td>16.6</td>
<td>20.8</td>
</tr>
</tbody>
</table>
At the end of the unit, Mandy felt that although the “tags were useful, [She] wasn’t used to them” and she “could use this on many projects in the future”. She wrote that the tags were beneficial during the construction of the project artifacts and arguments: “The tags were there to back our arguments up”.

Mandy’s group member, Susie, also saved 10 links on delicious.com. Susie applied 26 tags using 23 different terms with 10 copied from the title of the webpage, and 16 tags that summarized information found on the 10 websites. Primarily, Susie’s tags indicated topics found within the websites that could be used to complete the wiki page. For example “cost”, “price”, “expensive” were tags applied to a website that Susie later used as a source of information for the section of the wiki on cost to build the plant, as well as cost of the energy produced. In this manner, 25 of her tags were coded as topic, with one indicating the type of energy, hydroelectric.

In her end-of-unit reflection, Susie stated that she considers social bookmarking to be a potential resource for “working on group projects”. She used the tags for this project to “help me and my info I found” as well as to target content for specific topics on the wiki pages. She stated that the tags “helped me find my stuff easier, and I didn’t have to go through all my bookmarks.” Susie felt that after the project she would definitely use delicious.com again when she had to do a research project.

Gary utilized 20 different keywords to annotate 10 websites with 35 tags total. Gary’s social tags were primarily coded as support -- meaning the words were the same or very similar to those in the website titles. Eight of the words, however, were not found within the title, indicating that he had read the material and summarized it (annotation). Overall, Gary’s keywords were coded as 33 topic, 1 type, and 1 general. In his reflection,
Gary stated, “I don’t like bookmarking sites. However it did help out with keeping track of things.” Even not liking the site, he felt that using this tool allowed him to “narrow(ed) our searching time down and had useful information” that allowed them to complete the project in a timely manner.

Gary used the social bookmarking website as a way to capitalize on the work from other groups. When researching the final portion of the project (the student-created video), students were prompted to use the wiki pages created by classmates as a knowledge resource for their information. In addition to the wiki pages, Gary also utilized the previously applied tags and links from another class member’s social bookmarking account to find additional information. Finally, when constructing the video as the final portion of the project, Gary used the tags and sorting features in the (other classmate’s) delicious.com account to structure his argument so that “it followed a neat and constricted path. We put our most important thing at the end.”

Tommy saved 10 websites and used 15 keywords to apply 20 tags: 13 tags were summarized and 7 copied from within the titles. Several of his links had social tags applied that highlighted specific details within the website. The tags applied were coded as 12 topic words, 3 type, and 2 general, with 3 not coded. In his reflection, Tommy stated briefly that he found social bookmarking made it “easier to keep track of work”. In addition, he used the social tags when constructing the wiki page and video and found them “helpful”. Finally, Tommy felt that the social bookmarking and tagging process helped target their project more specifically, “We were able to focus on our argument more efficiently” by using tags or sorting words in delicious.com.
Like the other group members, Ben selected 10 web links to save via the social bookmarking website. He used 34 different keywords to apply 68 tags – 39 coded as annotation and 29 as support. Because of the number of keywords chosen and frequently applied, they are at times repetitive, but are specific to the information found in each of the websites. For example “EIA Energy Kids – Hydropower” is tagged with “power”, “statistics”, “highest producers”, “Washington”, “New York”, “California”, “Oregon”, “Alabama”. By summarizing the information within the site, he facilitated the wiki organization as well as summarized the information available. In addition, Ben’s tags were coded with 45 tags as topic words, indicating that they could be used to organize the wiki by content section, 20 type (hydro, hydropower, or hydroelectric for example), and 1 general “facts”. Ben declined to write a reflection statement or participate in the focus group interview.

Social Tagging as a Support for Collaborative Sensemaking

The hydropower group was unique in that it was the only group in my data set in which students within both asynchronous sections utilized the same process while researching. The students in the both morning and afternoon groups verbally discussed the websites that were selected for bookmarking in delicious.com, as well as the tags that they applied while researching. The other groups primarily worked in silence or had off topic discussions while researching. Susie and Mandy discussed the selection of material for use on the project.

Susie: Well, what do you think about this one? [gestures to her screen]
Mandy: [looks at Susie’s screen] I think that that is a good one…it has about the costs…[points] a good picture.

Susie and Mandy made decisions about the merits of a website, including the quality of content and how well the website met their needs, before bookmarking the site in class. This discussion face-to-face vetted the website before posting, allowing Susie to only post quality materials that they believed would help them complete the project. This process was shown again within the afternoon group during a discussion about the inclusion of coastal tides within Gary’s bookmarks for hydroelectric energy.

Gary: Do you think tidal power is like hydro? Its using coastal tides…

Tommy: I would think so.

Ben: Why not?

Gary: Ok, so I’ll get that too.

Gary’s delicious.com account showed a bookmarked website on tidal power (titled “Tidal power”), where he selected “generation” and “dynamic” as tags, demonstrating an understanding of the content material on the site by summarizing to create the tags in place of using words found in the title. Gary and Tommy also discussed the costs of hydroelectric power found in a website that Tommy was researching. The classroom video showed the two students looking at Tommy’s laptop while Tommy gestured at the screen; they discussed the content before the website was bookmarked.

Tommy: Well, what…on here, the cost is pretty high, but then …. 

Gary: I thought it was pretty cheap …

Tommy: yeah… its .6 cents per kilowatt hour after…

Gary: Ok, well mark that.
During this discussion, Tommy bookmarked a website link titled “renewable energy, hydroelectric” and tagged the site with the words “cost, per kilowatts”. Tommy and Gary used the social bookmarking process to collaboratively make sense of the costs of the power before bookmarking the website and applying the social tags to the link.

**Discussion of the Case Study**

Through this case study analysis of the hydropower group above, three findings related to the role of social tagging to support learning emerged. The hydropower group of students used social bookmarking process much as the majority of students to make sense of information by

(a) organizing information to later retrieve it efficiently and

(b) summarizing the information.

However, the students in the hydropower group also used the social tagging process uniquely to

(c) support collaborative discourse within the classroom.

**Organizing to make sense of information.** Much like the majority of the students within the class, the hydropower group members used social tags as a way to organize their research for the project. The students applied social tags to websites that highlighted key components within the website and targeted this information’s placement in the wiki. These students found that, even if they did not enjoy using it, the social bookmarking website had definite benefits when sorting materials and organizing the information. In addition, to using the tags to organize their information in anticipation of building their portions of the wiki, Gary, Ben, and Tommy went beyond their own work, however, and utilized social tags from
students in their group, as well as those in other groups to find information, sort it, and use the sorted results to structure the content on the wiki and arguments presented in their video. Given that studies on sensemaking (Heer & Agrawala, 2008; Weick, Sutcliffe, & Obstfeld, 2005) often focus on organizational aspects such as labeling as well as of communication of understandings, my study adds new empirical support for the use of social tagging sites to support sensemaking in science learning situations. As students in my study stretched beyond their physical and assigned online group members’ understandings of hydropower that were evidenced in their social tags to the social tags of other groups, the students were able to extend and enrich their learning (Linn, 2006) by interacting with the tags applied by the other groups. Fisher, Counts, and Kittur (2012) examined distributed sensemaking in which users leveraged annotations of unknown users to help make sense of new information. The empirical account presented here of the collective visible thinking of multiple students in the hydropower group demonstrated how high school students can leverage the social tags of other groups as a support for sensemaking.

**Summarizing to make sense of content.** Research by Kuhn, Cahill, Quintana, and Schmoll (2011) indicated that social tagging supports synthesis of content, leading to a deeper understanding of the material through this annotation process. The hydropower group primarily applied social tags that summarized the website content; within this group only Gary had more tags chosen from the titles than created by summarization. The hydropower students were more deeply engaged with the content in order to create the summarized tags than the majority of the other students. Through this annotation process, students sifted through the content to find information that fit the structure of their wiki page before summarizing the content to create social tags. In this way, my study demonstrates that
summarizing during the process of social tagging can support students in making sense of the content

**Social tagging to support collaborative discussion.** Both the morning and afternoon students in the hydropower group used the social tagging process as a support for in-class, collaborative discourse. As the students researched individually in class, they shared their results with other in-class group members, and discussed the website content and how it could be used to complete the project. The sites were bookmarked and social tags applied following this in-class discussion. Primarily this group’s tags were created by summarizing the webpage information instead of labeling with words selected from the title. Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) found that a small group of middle school students in a museum made sense collaboratively through face-to-face discussions when annotating data. My findings indicated that high school chemistry students who engaged in this collaborative sensemaking discourse asynchronously and face-to-face also created tags that indicated much deeper understandings of the content.

**Summary of Social Tagging in Support of Sensemaking**

Research on sensemaking has spanned medicine, computer science, and education. Often the focus within these studies is on the organizational strategies that participants adopt when making sense of information: labeling, categorizing, and classification of information (Golder & Huberman, 2007; Heer & Agrawala, 2008; Weick, Sutcliffe, & Obstfeld, 2005). My study’s findings supported the use of social bookmarking as a sensemaking tool in this sense; the alternative energy students utilized delicious.com as a support to collect, organize, and annotate online resources. In science fields, selecting evidence (Eberbach & Crowley,
practices that are important focuses (NRC, 2012). Sensemaking in science focuses on aligning discipline specific evidence and claims (Berland & Reiser, 2009; Duschl, 2000). As the students chose websites to bookmark, they selected evidence about alternative energy to use in the construction of their wiki page. In addition, the process of summarizing websites and selecting key words to use as social tags aligns with those of creating inscriptions.

Stahl (2007) examined students’ online communications when co-constructing knowledge artifacts; students used the provided tools in creative ways to make meaning of the content. Likewise, Rose and Barton (2012) found students used both everyday strategies and disciplinary lenses to make sense of science content. In a similar fashion, students used the affordances of the social bookmarking website in unexpected ways to complete classroom projects by using it as a timesaving tool, a communications tool, and a project management tool. By working efficiently by using tags and creating networks to sort the information previously gathered and indexed by others, students leveraged the affordances of the social bookmarking website to make sense collaboratively (Cahill, Kuhn, Schmoll, Lo, McNally, & Quintana, 2011; Fisher, Counts, & Kittur, 2012), as well as complete the project requirements. In addition, students created unique ways to monitor progress and support each student’s work on the project by tracking progress of the asynchronous group through shared research space. Adding to the work of Rose and Barton (2012), this bridging of students’ scientific and everyday sensemaking can help develop the students’ understanding of the science content leading to deeper understandings (Berland & Reiser, 2009), as well as enable them to work more efficiently.
A small group of students engaged in collaborative sensemaking discourse within the classroom while selecting websites and creating social tags. Through participation in this process, students engaged more deeply with the content, which was evidenced in the creation of a greater number of summarized social tags. Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) found collaborative sensemaking discourse occurred in middle school students in museums when using the Zydeco program to annotate photographs; my findings extend the parameters of the research to high school students utilizing a social bookmarking website to select content and annotate through the use of social tags.

Although most students utilized the social bookmarking website to save bookmarks and tag online information about alternative energy, several students struggled when selecting or creating tags to organize and summarize the information that was found. Research shows that often students found it difficult to select (Eberbach & Crowley, 2009) and annotate evidence, which required reflection on the purpose that the information could serve in their inquiry (Kuhn, Cahill, Quintana, & Schmoll, 2011). One possible reason for this difficulty is the students’ lack of understanding of the underlying discipline specific terminology, concepts, and practices that are necessary to make sense of the information. Utilizing the everyday strategies and tools that students possess to make sense of science content (Rose & Barton, 2012) could help support students as they engage in sensemaking and argumentation; consequently, my study suggests that social tagging serves the role of helping students make sense of science content and engage in argumentation.
Chapter 5

Wiki in Support of Articulating Understanding

Chapter 5 addresses how students used the wiki in the alternative energy unit. I examine how the wiki supported (or did not support) argumentation and how the students used the wiki to support their articulation of understandings about alternative energy. Four data sources were used in the analysis for this section:

(a) video recordings of students’ working in class while they were constructing their wiki page on wikispaces.com,
(b) video recordings of the student focus group interviews at the end of the unit,
(c) digital artifacts from the learners’ wiki group page including the wiki history and discussion boards, and
(d) students’ individual reflections about their learning process written at the end of the unit.

These data sources were analyzed to examine how the students used the wiki as a tool across all classes, as well as the challenges that they had. Second, I present two case studies that analyze the work of two groups of students who researched and created the solar and nuclear wikis.

Wiki Findings

The following findings are discussed in the remainder of this chapter. The analysis showed that the students used the wiki as:

(a) a tool to support for articulating understandings,
(b) a tool to support communication, and
(c) a tool to facilitate project management.

However, several challenges to wiki use also were made evident through the analysis:

(a) attribution of work is difficult,

(b) communication is a challenge, and

(c) technological issues with wiki design limit co-authoring.

In addition, the case studies illustrate how two similar groups of students used very different authoring strategies to construct their wikis based on the students’ perceived affordances of the technology and assumed ownership of the wiki page.

**Wiki as a Tool for Articulating Understandings**

To better understand the student use of the wiki, I used the four dimensions of argumentative knowledge construction from Weinberger and Fischer, (2006) as an analytical framework to examine the wiki transaction history, discussion boards, and student reflections:

a) participation,

b) epistemic, and

c) social mode of co-construction

d) argumentation.

In Table 5-1, I defined terms and provided examples from my study for participation, epistemic, and social knowledge construction. The fourth dimension, argumentation, was not evident in the text of the wiki. As students were given instructions to create a knowledge artifact that discussed all sides of the issue, I posit that students did not create claims or justifications within the wiki structure. To understand how learners used the wiki,
particularly as a support for articulating student understandings, four additional emergent codes were added (bottom of Table 5-1).

Table 5-1. Wiki Analysis: Summary of Codes, Definition, and Examples (based on Weinberger & Fischer, 2006, with four new emergent codes).

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Example from the dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Epistemic dimension</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Problem</strong></td>
<td>Problem space: Select, evaluate, or relate components of the problem of constructing the alternative energy wiki page to show all aspects of the energy. Does not involve the content.</td>
<td>On the wiki page: “We need captions under the pictures to explain them.”</td>
</tr>
<tr>
<td><strong>Concept</strong></td>
<td>Concept space: Summarizing, rephrasing, discussing theoretical concepts, content material</td>
<td>In the wiki: Initial: “animals because the turbines are noise outside of the water...” Final: “I think it needs to be more like this. ‘animals due to the noise created by the turbines which is amplified by the water...’”</td>
</tr>
<tr>
<td><strong>Relationship</strong></td>
<td>Relationship between ideas about how to construct the wiki page and present both sides of the alternative energy and concepts. How the knowledge about alternative energy can be used to fulfill all requirements and construct the wiki page.</td>
<td>From classroom discussion: Ethan: “I think that that [paragraph] should be under advantages not science.” Molly: “But its how it works.” Ethan: “But we need more advantages, and it fits too.”</td>
</tr>
<tr>
<td><strong>Off-task</strong></td>
<td>Not related directly to the task of creating the wiki page content, i.e. formatting, colors, discussion of personal issues or information</td>
<td>Removing Tanner’s name from the wiki page. Changing colors back and forth.</td>
</tr>
<tr>
<td><strong>On-task</strong></td>
<td>Related to the problem, the concepts, completion of the task</td>
<td>Adding information to a section on the wiki page.</td>
</tr>
</tbody>
</table>
### Social mode of co-construction (Initial code)

<table>
<thead>
<tr>
<th><strong>Elicitation</strong></th>
<th><strong>Definition</strong></th>
<th><strong>Example from the dataset</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Using learning partners or their created materials as resources</td>
<td>From classroom discourse: Tammy: “What’s the word for that?” Shawn: “I don’t know.” Lisa: “Turbine.”</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Code</strong></th>
<th><strong>Definition</strong></th>
<th><strong>Example from the dataset</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Externalize</strong></td>
<td>Contribute information or explicate understanding without referencing other contributions</td>
<td>Adding a paragraph of information to a section that does not bridge, build upon, or connect to material before or after the segment.</td>
</tr>
<tr>
<td><strong>Quick</strong></td>
<td>Quick consensus building: accepting quickly to continue. Coordinating discourse move.</td>
<td>In the discussion boards: James: “We need more advantages.” Tamera: “Ok.”</td>
</tr>
<tr>
<td><strong>Integrate</strong></td>
<td>Integration-oriented consensus: changing views through persuasion of partners, synthesizing information</td>
<td>Erika: “Under cost, you need more information…” Susie: “It’s lacking.” James: “Have some but will try to find more things.”</td>
</tr>
<tr>
<td><strong>Conflict</strong></td>
<td>Conflict-oriented consensus: critique, multiple perspectives, and point out aspects of peer’s contributions in order to modify them or present alternatives.</td>
<td>Sara changes Evan’s information in the wiki by modifying his statement. “Wind turbines have had minimal health problems over the years, but even newer ones still have complaints of dizziness, vertigo, nausea, anxiety, and sleep loss.”</td>
</tr>
</tbody>
</table>

### Additional codes used in wiki analysis that emerged from the data

<table>
<thead>
<tr>
<th><strong>Communication</strong></th>
<th><strong>Discussion between students</strong></th>
<th><strong>In the wiki: “I’m working on paraphrasing the information on our wiki page. don’t be afraid to help me :)”</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delete</strong></td>
<td>Delete section or segment, not just revise or rearrange</td>
<td>Remove segment of text, picture, comments, communication, or other information without replacing.</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>Monitoring progress, assigning tasks, directing arrangement, “boss”</td>
<td>Written on the wiki page: “DO NOT DELETE THIS!”</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>Rearranging, formatting, moving sections on the wiki, discussion about how to arrange.</td>
<td>On the wiki page: “I’m making a table of contents” and then creating the table of contents, moving segments to make the page flow.</td>
</tr>
</tbody>
</table>
**Variances in Student Participation**

Active participation in online communities has been linked to knowledge construction; consequently, in a CSCL environment, logging in to the online system as well as contributing to the wiki indicated that the student was in a position to learn (Weinberger & Fischer, 2006). Because all students were working online and were able to contribute to the wiki, a greater homogeneity or evenness in participation could be expected (Weinberger & Fischer); however, homogeneity in participation was not observed for these students. Of the consented students, 33 (out of 35) participated in the wiki portion of the project in some way (see Table 5-2). [Two consented students had extended absences during this time and utilized the wiki as a knowledge artifact for later work, but did not participate in building it during this segment of the project.] The 33 participating students added the content to the wiki and edited the format; these online interactions are called wiki entries. In my study, there were a total of 257 wiki entries. The individual participation was very heterogeneous; the number of entries for each student varied from 1 entry on the wiki to a high of 36. Within these wiki entries, often students completed multiple transactions (i.e., several edits or formats occurred within one wiki entry, one time-stamped by wikispaces).

Six students logged only one or two transactions over the course of the project. Cameron was present and in class for the entire project, but did not have any wiki entries attributed to his name (i.e., no contributions to the page design or content). On the classroom video, however, he was observed viewing the wiki page for his group. The only online evidence of his contribution to the wiki project was the posting one critique to the discussion boards.
Within each large group, I found that there were one or two students who made the majority of the entries – close to double the average. In two groups, these students were found in both the morning and afternoon classes (see Table 5-2), with one in the morning and one in the afternoon class. However, two groups had different patterns. In one group (the solar group), two students made most of the contributions and a third student also participated heavily; again, one student in the morning and the afternoon recorded the highest number of entries and the third student (in the morning class) also contributed at a much higher level than those students in other groups. In the nuclear group, only one student participated at a much higher level than the other students in her group; she was in the afternoon class. From the perspective of student learning, this inequity in participation indicated a lack of collaboration between all students on the creation of the knowledge artifact, which could lead to lower test scores for the less engaged (Fong & Wang, 2007; Peters & Slotta, 2010). In addition, having one student in each face-to-face class who participated at this high level within almost every group raises questions about how and why students take on the responsibility of the construction of the wiki page, as well as reasons for students’ lower levels of participation.

Table 5-2. Student Participation in the Wiki across All Groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number entries per student member</th>
<th>Total</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Wind</td>
<td>2</td>
<td>23 AM</td>
<td>23 PM</td>
</tr>
<tr>
<td>Solar</td>
<td>32 AM</td>
<td>9</td>
<td>20 AM</td>
</tr>
<tr>
<td>Nuclear</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>6</td>
<td>9</td>
<td>13 PM</td>
</tr>
</tbody>
</table>
Key
--- Indicates no student member.
Highlighted entries indicate the greatest number of wiki entries for morning or afternoon classes.

Student Engagement with the Content Varied

The students not only participated unevenly in construction of the wiki based on their number of entries, but also they demonstrated differences in the level of engagement within the construction of the wiki and the content when they did choose to participate as measured by the number and pattern of editing. The groups varied in the percentage of time on-task while working on the wiki. The solar group of six students had the highest number of entries (103) and relatedly, they had the lowest number of transactions found to be off-task behavior, approximately 7% (see Table 5-3). The nuclear group had the lowest number of entries and the most off-task behavior on the wiki; the nuclear group had 24 entries total, and relatedly, they had 23.6% of transactions coded as off-task behavior. The wind and hydroelectric group totals were between those of the solar and nuclear groups totals. The wind group had 77 entries with 17.5% off-task behaviors; hydroelectric had 53 total entries with 14.8% off-task behaviors. The individual students in the solar group not only contributed more to the wiki, but also contributed more to construction of content on the wiki than the other groups as shown by the number of off-task transactions. In the nuclear group, students only had 24 entries total. In addition, when the nuclear group members did add to the wiki, often it was not constructive (for example, changing colors of the font and not adding or editing content).

Table 5-3. Summary of Wiki Analysis Coded with Categories Based on the Four Dimensions (Weinberger & Fischer, 2006).

<table>
<thead>
<tr>
<th>Category</th>
<th>Solar</th>
<th>Wind</th>
<th>Nuclear</th>
<th>Hydroelectric</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of group members</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>
Examination of the classroom video showed that in the nuclear, hydroelectric, and biomass groups, when the students were off task, they were playing online games or chatting with classmates face-to-face, under the guise of working on the wiki. When the teacher moved into the vicinity of Merle, Matt, and Andy, they switched screens to appear to be working on their wiki. I posit that these students who completed very few wiki entries and or who had many transactions coded as off-task possessed a “gaming mindset” towards the computer activities (Baker, Corbett, & Koedinger, 2004), where the students perceived the primary affordance of the computer to be entertainment (Kay, Meyer, Wagoner, and Ferguson, 2006) leading to fewer wiki entries and less engagement with the content.
Students Articulated Understandings About the Project and Process

When students demonstrated on-task behaviors, the way that they articulated their understandings of the problem, content, and relationship between them also varied across the groups. Weinberger and Fischer (2006) used the epistemic dimension found in Table 5-1 to describe how students articulated their strategies when constructing knowledge to solve a problem. I use this framework to unpack how the groups of students used the wiki as a tool to articulate their understandings about construction of the wiki, the content that was being added to the page, and how to apply the content to complete the task.

Evidence of the students’ written discourse about managing the content and the completing the criteria for the project was rare; only 28 transactions were considered to be epistemic activities that described how the students solved the task of constructing the group wiki page (see Table 5-3). The solar and nuclear group both had 9 transactions. The hydroelectric group had 8, with the wind only having 2 transactions. The solar and wiki groups primarily discussed components of the problem – actual pieces of the task that were required such as the number of pictures that were still required. The concept components were only present in the solar and hydroelectric groups. This discourse consisted of deliberately addressing actions of summarizing or rephrasing content. Actions connecting problem and concept were found only in the nuclear and hydroelectric wiki pages. Each of these transactions reflected student attempts to articulate their understandings about not just the alternative energy content, but the project requirements and the connection between the two. Extending from the research on high school math students’ use of a wiki as a space to connect knowledge and practice (Fong and Wang, 2007), I posit that these highlighted transactions made visible the process by which high school chemistry students connected
their understandings of the content and the requirements for construction of the knowledge artifact.

**Students Rarely Articulated Collaborative Understandings**

Research (Cress & Kimmerle, 2008; Fong & Wang, 2007; Larusson & Alterman, 2009) has found that wikis support the collaborative construction of group artifacts; however, my study indicates that although students co-constructed their wiki page, they did not often collaborate when articulating their understanding of content. I examined the number of elicited and externalized transactions (see Table 5-3) to understand how students collaborated when constructing the wiki page. I considered elicited transactions to be moves or edits of other students’ work and take these transactions as evidence of online collaboration. An externalized transaction was considered a transaction where students added or edited the wiki without editing or elaborating directly other students’ work. Within the wiki pages, the solar group had the most externalized transactions (91) by more than twice those of the next highest, the hydroelectric group; however, they only had 14 elicited transactions. The hydroelectric group had the highest number of elicited contributions. Nuclear had the lowest number of both types of transactions with only 18 total. The number of contributions made to each wiki page indicates that students added text or edited the wiki, many multiple times, but did not often edit work of their peers, even with encouragement from the teacher to do so when needed. The wiki pages for the hydroelectric, wind, and nuclear groups were primarily composed of text written by multiple members in stand-alone sections. Often students added information by elaborating on already-written sentences on the wiki by sandwiching them with additional complete sentences of text. Larusson and Alterman (2009) found that wikis
supported collaboration and co-construction of knowledge artifacts. The students in my study utilized the wiki as a support for their co-construction of the wiki and articulation of each student’s individual understandings. However, I found that most students did not use the wiki as a support to collaboratively articulate their group understandings of alternative energy.

**Student Strategies for Negotiation of Consensus Varied Greatly**

Weinberger and Fischer (2006) stated that when collaborating, learners negotiate and come to consensus about tasks and content; this process of negotiation has been linked to construction of knowledge. Negotiations occur in three ways: *quickly* -- simple acceptance of the others’ contribution in order to move on, *integration-oriented* -- one learner’s views are revised to align with their partners’, and *conflict-oriented* -- changes are made in response to critiques either by strengthening their own position or through modifying by presenting alternatives (see Table 5-1). The students in all groups used these strategies in both the discussion forum comments and responses as well as on the actual wiki page by replying or changing the content. In my study, students in the nuclear, solar, and wind groups utilized all three strategies for coming to consensus, while the other, the hydroelectric group, did not demonstrate consensus-building strategies (see Table 5-3). This group (the hydroelectric group) only engaged in strategies that allowed them to answer quickly with little or no additional work on the wiki. The solar group utilized all three strategies at least one time with nine conflict-oriented discussions; examining the wiki history showed that students within the solar group provided additional information in their forum responses or by modifying the content or formatting on the wiki. Although Weinberger and Fischer (2006)
found stated that integration-oriented consensus rarely occurred, the wind group used this strategy four times. As critiques were posted that targeted deficiencies in their wiki, James and his wind group members acquiesced the point and added or changed materials to align with the one who had commented. These wind students did not discuss their viewpoint or provide information to strengthen their already posted work on the wiki. James was a primary contributor for the wind group before any comments were posted; after receiving critiques, James again was the primary contributor when adding information to the wiki in response. As articulation of understandings requires group members to make their thinking visible (Bell, 1997), the group’s chosen process of negotiation within the wiki had an effect on the articulation of a group understanding about alternative energy. The solar, wind, and nuclear groups used integration and conflict-oriented strategies to modify their wiki in response to student critiques, while the hydropower group chose to not respond or modify their wiki at all. In my study, the strategy that high school students chose when responding to critique within the wiki discussion board had an impact on how each group implemented subsequent changes on the wiki. Weinberger and Fischer (2006) stated that engaging in conflict-oriented consensus building was important for collaborative learning. As such, I posit that student critique and responses within the wiki discussion boards had the potential to support students in more clearly articulating their understandings, thus making their thinking visible (Bell, 1997) on the wiki, as well as supporting student collaboration.

**Students Used the Wiki to Communicate in Unexpected Ways**

Communication is an important aspect of collaboration. Although wikis have been shown to support collaboration (Fong & Wang, 2007; Larusson & Alterman, 2009), research
(Cress & Kimmerle, 2008; Liccardi, Davis, & White, 2007) indicates that communication within a wiki can be difficult even with discussion boards provided for this purpose. The students in my study communicated in the wiki by utilizing the discussion boards to provide critiques and responses; the students also used the wiki page itself as a way to communicate with not only their group members, but also with classmates in other groups. Students in several groups chose to communicate on the wiki by posting statements at the top of the wiki page to provide directions and guidance. In addition, almost all students listed their name, delicious.com user name, and topic that they chose to research at the top of the wiki page. This communication through posting on the wiki page provided a way for students to disseminate information to others about their work. Given that Stahl (2007) found that students used inventive ways of making meaning in online environments, my study adds to this perspective by recognizing how students creatively utilized the affordances of the wiki environment to communicate content as well as procedural information, organizational strategies, and management of tasks with their peers.

**Challenges in Attribution of Student Work**

Trentin (2009) found difficulties in assessing individual students’ learning as a result of group work on the wiki, even though individual contributions could be determined by tracing the wiki history. My study highlights a new difficulty with present assessment methods for educational researchers: measuring individual student contributions to a jointly constructed wiki. During the alternative energy project, students were each required to post five contributions to the wiki page as a part of their grade on the class project. The technology coach for the district demonstrated logging in and posting to the wiki, as well as
showing how the contribution appeared in the wiki history. When analyzing the wiki, I found a discussion board post illustrating how assigning contributions to a single student based on their entries in the wiki history could wrongly attribute work to an individual student, when in actuality, a group worked on the entry. Interactions of Brandi and Emma, a pair of female students from the wind group, illustrated this. Brandi and Emma posted about their contributions to the wiki in the discussion board writing,

“We worked together on this, but only used Brandi’s computer to post to the wiki. We used Emma’s computer for research, and then decided what would be posted.”

This collaborative process of working on the wiki was verified through alignment of the video recording of Emma and Brandi working in class and the time stamped entries on the wiki. As stated in their post, Emma and Brandi sat closely at a desk with both laptops open in front of them and searched for material on one laptop and added content to the wiki on the other. Emma and Brandi were not the only group to work this way. Through a video analysis, Fredrick was observed entering content on the group wiki page using Jarrod’s computer; after checking the wiki history for entries, Fredrick had no entries on that day. In both cases, this physical collaboration within the face-to-face environment and use of another student’s laptop occurred in spite of the students’ understanding that wiki entries would be used to determine a portion of their class grade. Without the students’ discussion of their contributions on the wiki page (and subsequent examination of the classroom video), Frederick’s and Emma contributions to the wiki would not have been identified. This finding illustrates how relying solely on online records can over- or under-attribute actual work. Given that research (Peters & Slotta, 2010) on analyzing student contributions to a wiki has often focused on counting student transactions within the wiki history, these findings
highlight potential methodological issues with current trends in wiki analysis. It is not enough to count student transactions within the wiki history as the only method of analysis; other methods of attribution and verification of student work are needed to accurately describe and examine how students utilize the wiki for collaborative work.

**Case Study Analysis: Individual Articulation versus Collaborative Co-construction**

To examine how the students used the wiki as a learning tool to articulate their understandings of alternative energy and support co-construction of a group artifact, I created a comparative case study. Students in the nuclear and solar groups were chosen as case studies for several reasons:

1. Both wikis were scored at a proficient level for teacher requirements of the science content (both factually correct and breadth of information), organization and formatting (including grammar), and descriptive elements (i.e., number of pictures or graphics with captions).
2. The groups had large differences in the student participation, measured through:
   a. number of student entries: the solar wiki had the highest number of student entries on the wiki with 106 total, and the nuclear wiki had the lowest with 24 total, and
   b. homogeneity of participation within each group: at least one student in each group had a significantly greater number of entries than others.
3. A number of epistemic differences (as defined by Weinberger & Fischer, 2006) were noted between the groups: the nuclear group was significantly higher in both off task
wiki behaviors as well as having entries coded as problem space, concept space, or relationship between them.

Within each class, the student groups consisted of self-selected “lab partners” during the last nine weeks and were used to working together on projects, homework, and lab activities. The type of alternative energy assigned to each group was randomly selected. The instructor randomly paired the groups across the two classes to form the asynchronous wiki groups for each topic.

**The Nuclear Group: Individual Contributions to Construct a Group Wiki Page**

The nuclear wiki group consisted of seven members split between the two classes with Andy, Matt, and Merle in the morning and Luke, Molly, Shelly, and Ethan in the afternoon. Through this case study, I examine how the nuclear group co-constructed their wiki through student’s individual contributions of text and pictures. The nuclear group members:

(a) utilized the wiki’s affordances of efficiency and entertainment,

(b) did not collaborate through editing or discussion, and

(c) allowed Molly to assume ownership of the wiki page.

In addition, students found the wiki challenging to use because of

(a) communication with other members

(b) and limitations to the technology.

**Overview of the wiki construction process.** Overall, the nuclear wiki group contributed the least number of entries during construction on the wiki, with a total of 24 time-stamped entries. Although each entry *could* have been comprised of multiple transactions (addition, edit, delete, and format changes), the majority of entries were not,
based on the track changes within wiki history. The distribution and type of student entries for the nuclear group is shown in Figure 5-4 below.

![Student Contributions to Nuclear Wiki](image)

**Figure 5-1.** Student contributions to the nuclear wiki.

When working, nuclear group members did not collaborate on the content, and students added information to chosen topics in small blocks of text. Molly primarily edited the aesthetics of the entire page into a cohesively appearing whole. Over the course of the project, Matt, Merle, and Andy only posted a total of five times on the wiki page; likewise, Shelly, Ethan, and Luke had an additional five entries total. They worked quickly – all posts other than Molly’s were made within the first two days of wiki work with no evidence that these students returned to the wiki content page, although they did respond to comments in the discussion forum. Other than Molly’s work, all work added by the group members was a self-contained text segment or picture; students did not add material or form connections between other sections of the wiki. In the afternoon class, a few face-to-face conversations
were centered on the project. Molly and Ethan discussed where a section of information would be best placed. Although they did not debate the validity of the information being added or whether it should be included, they discussed how to organize it, as well as took into account the requirements of the project.

Ethan: “I think that that [paragraph] should be under advantages not science.”

Molly: “But its how it works.”

Ethan: “But we need more advantages, and it fits too.”

Other conversations focused on the requirements of the wiki page construction and not on the actual content.

Molly: “How many pictures did we need?”

Shelly: “Five.”

Molly: “Is there anything special that they have to be of?”

Shelly: “No, I don’t think. Just five.”

Molly: “K.”

Again, the students were focused on the requirements of the project or where content needed to be placed on the wiki and not their understandings of the content.

The wiki logs and classroom video indicate that there was very little on-task interaction between the students face-to-face or on the wiki page during the class time. For the nuclear group, 23.6% of their wiki contributions were considered off-task. The students’ contributions primarily focused on non-essential formatting changes: colors, alignment of photos and headings, and fonts. Even though all students within the nuclear group appeared to be engaged on the wiki project during class, only Molly actually logged multiple contributions during most class periods. During construction of the wiki, the students in both
classes sat in close proximity to the others in class and appeared to be diligently working: quietly sitting at their computers, concentrating on the screen, and occasionally leaning over to look at each other’s screens and whispering. However, when the laptop screens were viewed on video from behind the students, the majority of the students had two windows open: one with online math and logic games and a second containing research about nuclear energy. When the instructor walked towards the table, the students switched screens with a keystroke from the game to their research or the nuclear wiki page.

Students utilized the affordances of efficiency and entertainment. The majority of the students in the nuclear group efficiently attended to the basic requirements for the wiki page in order to utilize the entertainment options available on the laptop. The group members quickly entered “their” information into the wiki, utilizing the efficiency of online research and the wiki platform, and then turned to their primary perceived affordance of the technology, entertainment.

The nuclear group did not utilize critiques as a means of deepening their understanding of alternative energy. To Luke, commenting was a duty; he said, “I did it real fast to get it over with.” The critique of other wikis did “help us know what we were missing” [Molly], although several didn’t enjoy this section or work hard at it. Within the discussion forum, students in the nuclear wiki group responded to some critiques on their own wiki page over a week after the wiki page work was completed; Merle stated, “Ok. Check it out now.” as a response to two critiques. Mandy (from the hydroelectric group) posted to the nuclear discussion board to share her group’s idea of adding the delicious.com information for each group member to the wiki page.
Mandy: This is good, but look at our page or Emma’s group's page and see how we have our delicious accounts linked beside our names. It helps find for research from our cites [websites] that we tagged.

Matt: Oh okay come over here and show me how to do that.

On the video, Mandy was observed moving to Matt’s table and helping him incorporate this change on the nuclear wiki page; this critique posted within discussion boards prompted immediate in class changes. Matt stated that he was willing to use the critiquing process to help improve the other group’s wiki pages, “[I] knew we were using another one [wiki] later, so I wanted them good”, but he did not make any attempt to make changes or to apply the critiques to his own wiki page. The delicious.com information included on the nuclear wiki page as a result of a discussion post was also referenced in another critique response. Juli posted a critique stating that the nuclear wiki needed more information on the science behind the nuclear energy. Shelly responded to the critique by referring Juli to their delicious.com accounts instead of elaborating on the information on the wiki page.

Juli: I like your pictures and it explains it well but I feel confused by the science behind it. Maybe you can explain it a little more.

Shelly: If you go to my delicious account it may help you understand a little more.

The nuclear group members, other than Molly, did not return to their wiki page to edit or elaborate after posting their initial segment of text. The students in the nuclear wiki group worked together to construct a wiki page that met the course requirements and required minimal effort and interaction.
**Students did not peer-edit, even with prompting.** In the nuclear group, only two students edited other student work: Andy and Molly. Andy fixed one spelling error; Molly manipulated the formatting several times, changed font size and color, aligned segments, and centered pictures. She also added and fixed punctuation in her own and within the other students’ work. However, Molly only edited other students’ work two times, once to change a picture caption and the second to elaborate on a sentence written by Ethan. In editing, Molly elaborated on Ethan’s sentence, but also changed the intention of his statement about the costs of nuclear energy to align with her understanding of alternative energy. No discourse was found in the discussion boards or on video discussing these changes.

The students expressed tension that they felt when editing other student’s work. Merle feared that he would “delete something important”. Even Molly, who did the majority of the work and editing on the nuclear wiki, did not often edit someone else’s content. Molly didn’t like “editing. I don’t like it when someone does that to mine.” During the focus group interviews, several group members discussed their aversion to editing.

Andy: *I did* it [edited other’s work].

Elle: I felt bad. I don’t know what the other class was doing. They put bullets. I made them into sentences…and they would go in and make more bullets.

[laughs]

Andy: And it depends…on if it sounds better.

Matt: And depends on who it was too…if they [the other person] would be ok with it.

Susie: And not knowing if you were right [laughs] if you changed some of their …

Its easier to add stuff to it … than to change their work.
Andy: Working with people you are comfortable with – or complete strangers.

Researcher: So if we went with another school?

Elle: I’d still be scared.

Matt: I wouldn’t care then.

Andy: [Shakes head in agreement] Yeah. It’s easier with people you are familiar with, but it doesn’t bother me.

The students agreed that editing work of close friends, as well as that of strangers, would be the easiest, but still would cause them anxiety for two reasons, (a) the possibility of hurting someone’s feelings and (b) the fear of themselves being incorrect. In spite of her expressed distaste for editing, Molly did make changes to many sections of the wiki, including rewriting Ethan’s work. Other than Molly and Andy, who changed the spelling on one word, the students in the nuclear group did not edit the wiki page.

**Molly assumed the role of project manager.** All group members contributed to the wiki, however Molly was by far the most prolific member of the group (both morning and afternoon members). She made 14 of the 24 entries on the wiki, and many of her entries were composed of multiple transactions (add, edit, format, or delete); her changes were implemented across the entire length of the project and not concentrated within the first few days allotted for work. When contributing to the wiki, Molly added explanatory segments to sections of the wiki posted by other group members, as well as editing both her own posted work and several posts of the other group members. Near the end of the project, Molly added two large additional sections to the wiki to finish topics that were not completed by the other members. One of the segments added was about the science of nuclear energy; based on time
stamps, this addition to the wiki was posted in response to the questions and critique of the other classmates.

**Challenges with communication and technology.** The nuclear group students felt that better communication tools and improved wiki technology could have created a better learning environment for this project. Specifically, Matt and Susie felt that decisions were made more difficult because of the limitations of communication on the wiki, which created a problem for when constructing the wiki.

Susie: It was hard with the wiki across the two classes. We ended up having to write a little note at the top and then highlighting it so that they would see what we were talking about.

Matt: Having a “conference call” kind of thing even once maybe would have helped with some of the things. Talk to them while we are doing it so we have some ...there was some overlap where Andy did some work on a couple topics but didn’t paste it up fast enough, and then John did it and put it in, so he [Andy] had to redo topics.

Although discussion forums are present on the wiki page, students did not utilize them often for communication *within* the group.

Elle: You had to remember that they [discussion page/posts] were there.

Andy: It was easy though.

Elle: Well, yeah, if you knew.

Matt: Well having a better wiki [would help] that was more efficient with saving and things…or more advanced. More like a word document
that you could do more things with like with your text. More like google docs or something. That would … on the formatting.

Andy and Susie: [shaking heads] yeah

Susie: We ended up looking up stuff on Mandy’s computer and then typing it into the wiki on mine, so we didn’t worry about erasing….

Elle: Yeah, we did the same thing…

The issues with communication and technology use led students to forming their own “work-around” to accomplish their desired tasks. The students utilized the wiki editing capabilities to leave messages and used organizational strategies such as listing accounts and topics “taken” at the top of the wiki page as methods of communication. Technology issues such as the wiki erasing work when more than one person was editing led to several solutions:

(a) students shared computers to enter information and

(b) typed their information on a word document to quickly copy and paste the work into the wiki.

In addition, students changed topics and retyped work to compensate for technological problems. The students used creative techniques to solve communication and technological issues within the wiki in order to accomplish their task of constructing a wiki page on nuclear energy.

The Solar Group: Wiki as a Support for Co-articulation of Group Understandings

Members of the solar wiki group were divided between the two classes with Tammy, Lori, and Shawn in the morning class and Dane, Tim, and John in the afternoon. Through
this case study, I examine how the solar group co-constructed their wiki through the students’ collaborative contributions of text and pictures. The nuclear group members:

(a) utilized the wiki as a tool for co-construction of knowledge,

(b) edited the work of their peers,

(c) used the wiki as a tool for communication, and

(d) took co-ownership of the wiki page.

In addition, students used challenges with technology as an opportunity to share expertise.

**Overview of the wiki construction process.** Tammy and Lori were 15 year-old females, and Shawn a 16 year-old male. The afternoon class consisted of Dane, John, and Tim, all 15 year old males at the time of the study. The group members logged a total of 103 distinct entries on the wiki, with the majority of these consisting of multiple transactions (several additions, formats, or deletions during one time stamped entry). Morning members of this group, Shawn, Tammy, and Lori, typically sat at the lab table with their laptops plugged into the tables and appear to be engaged with the project and working the majority of the time even with occasional side conversations that centered on personal matters. The afternoon members, Dane, John, and Tim, also sat on one side of a lab table with their laptops close together. They worked silently most days during class time, with only quiet asides while gesturing to their screens. However, Dane and Tim are observed several times over the course of the project moving about the table and conversing with other groups’ members about off-task topics.

**The wiki as a tool for co-construction of knowledge.** The solar group students used the wiki as a support to articulate their understandings about each topic and elaborate on other students work as they constructed their knowledge artifact on solar energy. Although
students in this group did not all participate homogeneously, the majority demonstrated on-task behavior most of the time. When constructing the wiki, only 7.5% of the group’s transactions were coded as being off-task. Although the solar group had a large number of externalized transactions, they also had 14 elicited transactions, illustrating student collaboration and co-construction of knowledge (Peters & Slotta, 2010; Weinberger & Fischer, 2006). In addition, this group’s nine conflict-oriented transactions occurred in the discussion forum where students were negotiating consensus about edits and critiques. Although the group members often agreed with the suggestions made by the other classmates to resolve them, they also advocated for their own choices on the wiki, particularly emphasizing the content over aesthetics of the page.

**Students co-constructed knowledge face-to-face and online.** Most of the class periods the morning group worked quietly at the table, with the conversation occasionally steering to personal matters, but returning quickly to the project at hand. Their conversation in class involved discussion about the wiki page, often asking each other for validation of content or specific word choices that were then applied to the wiki (verified via time stamp). The segment of wiki shown below (Figure 5-2) highlights two students’ work, Tammy and Lori, as they add, edit, and rewrite each other’s work on the wiki. The initial text was constructed by Lori; it is shown as black. The red segments are text deleted by Tammy, and the green segments are text added by Tammy. In addition, I include a segment of classroom discourse occurring at the same time.
Advantages:

- Using solar panels do not pollute the air.
- Using solar panels do not release carbon dioxide, nitrogen oxide, sulphur dioxide, or mercury into the atmosphere, as many traditional forms of electrical generation do.
- The solar panels operate silently, have no moving parts, and don’t release offensive smells. Doesn’t smell, making this energy source suitable for society.
- This energy source will not contribute to acid rain, global warming, or smog. No pollution. There’s no pollution from this source.
- Inexhaustible fuel source. Provides energy source.
- Solar power energy is a supplement to other renewable sources: Versatile, can sources, such as wind power or hydroelectric power sources.
- Solar powered energy is very versatile. It is known to power cars and satellites.
- Solar power reaches where wires can’t reach, such as deep woods, vacant lots, areas, and outer space.
- Farming and agriculture and agricultural suppliers rely on solar energy by building barns accessible to sunlight lighting during the day, saving them money on electricity bills.
- Sunlight is free. Can of cool.
- Solar panels are dependable; they can sit upon roofs and can be avoided from damage of ground materials, materials, such animals and cars.

Figure 5-2. Screenshot of wiki history page.

History of solar energy page showing original text, peer edits, and additions.


Shawn: “I don't know.” [Tammy types, and Shawn watches.]

Tammy: “What kind of power?” [Shawn gestures with hands and shrugs]

[Tammy asks Lori] “What is the name of wind power? wind?”

[Lori shrugs]

Tammy: [asks loudly to the room] “Who has the water source? What’s it called?”

Unseen student: “Hydroelectric”

The students within the solar group discuss the additional sources of power in class before incorporating information in the wiki; this face-to-face discussion goes beyond the structure of the online co-construction facilitated by the wiki. During analysis, I aligned the student conversation and the wiki work using time stamps on the wiki and video to determine how the student was working on the wiki at her desk. This pattern within the morning group
surfaces several times. Again, while working on construction of the wiki, the students discuss grammatical structures face-to-face as they work on the wiki.

Lori: (Looks up from laptop, stops typing. Directs statement to Tammy and Shawn) If I'm saying that a person is affected, is it affected or effected?

Shawn: (Looking up from watching Tammy’s screen) What? What?

Tammy: Affected.

Lori: (types “affected” on the wiki page).

These examples, as well as the pattern of editing shown on the wiki page, illustrate the students’ collaborative process as they articulated their group understanding of alternative energy on the solar wiki page.

**Multiple students edited the work of their peers.** The main contributors to the solar wiki page, Tammy, Sally, and John, all edited other student’s work by correcting grammar, reformatting, and elaborating on sections of text by adding more information to the wiki. However, they stated that they did not enjoy this process.

Lori: I did…and didn’t feel comfortable editing other’s work. I felt bad knowing they probably put a lot of work into it, and I changed it.

John: I don’t mind people fixing my work as long as I understand what I did wrong and how it is being fixed.

Tammy: I didn’t want my stuff edited [laughs].

Tim: I was fine editing and being edited (however he did not edit anyone’s work on the wiki, even his own, other than one format change).

Even though they were not comfortable with editing, the solar group members made more than superficial edits to the wiki page as they were co-constructing the wiki. Shawn added a
total of 136 words to the wiki in 10 transactions, the largest a section of 45 words. He also added two pictures and edited the wiki seven times with a total of 36 changes. During these edits, Shawn primarily edited his own work, but added grammatical corrections to other group members’ work three times. Tammy and Lori were very active members of the wiki, adding 480 words and 697 words respectively. Tammy edited 16 areas of the wiki and elaborated 12 times on both her work (10) and other members’ work (2), as well as deleting 81 words. She added three pictures and removed two from the wiki. Lori edited 152 words on the wiki, with five editing transactions within another group member’s work. She deleted 23 words and added two pictures to the wiki. In the afternoon class, Tim and Dane each had three transactions on the wiki. Tim added one section of text containing 345 words and two photos, then changed the heading on his section to match the formatting on the rest of the wiki. Dane added content to the wiki two times for a total of 162 words and elaborated on a section that he had posted by adding 17 additional words and two pictures. They did not edit or format other group members’ work. John contributed significantly to the wiki by adding 606 words and six pictures, deleting nine words, and making 145 format changes. John chose to add the text in two different ways: he entered the content into his self-assigned section several times over the duration of the project and added text as stand-alone sentences to elaborate on other student’s work. He also added captions to pictures that he and others placed on the wiki.
Multiple students assumed ownership of the wiki page. Within the solar group, multiple students took on responsibility for the wiki project. In the solar group, Tammy, Lori, and John were primary contributors of the wiki page with the majority of the entries (32, 20, and 36 each respectively). Shawn added nine entries, and Tim and Dane each had three entries. Tammy, Lori, John, and Shawn contributed through text additions, deletions, formatting changes, and photo insertions or deletions; Tim and Dane posted sections of text to the wiki. Tim also had two formatting changes to his own work. To organize the group work, Shawn initially added delicious.com account names for the morning group to the wiki heading. Tammy posted one discussion comment about the division of work with a list of topics and group members, also assigning topics to the students in the morning class. John then posted all group member names, the delicious.com account information that he had access to, and the project assignment details provided by the teacher onto the wiki. These
organizational actions by Shawn, Tammy, and John helped direct the group’s research and construction of the wiki. John, Tammy, and Lori edited the wiki as a whole entity, not just their own sections. With these actions, multiple members of this group exhibited concern and ownership of the wiki page, going beyond simply meeting the class project requirements.

The wiki as a tool for communication. The solar wiki group used the wiki as a communication tool in several ways. The group used the discussion forum to communicate with each other as well as with students in the other groups. They also utilized the wiki page as a method of communication through assigning topics. By posting links to their delicious.com accounts, the solar wiki group communicated with their classmates about their research and the content that they created.

Communication through the discussion forum. In the discussion section of the solar wiki, 14 comments were posted by other members of the class; there were 46 total responses to these posts. Within the group, Tammy responded to 3 comments, one in which she emphasized that their wiki was focused on content over style.

Craig: “Your page has a lot of information ill give you that but, it really doesn’t keep my attention through out the whole page. your information needs to be mor interesting”

Tammy: “We want our wiki to be more informative rather than attractive. Keeping it organized and getting the point across is our main priority.”

Lori responded to four comments; one comment suggested adding more information about disadvantages and solar furnaces, another about costs for panels. The time stamps indicate that for both comments, she responded in the discussion forum, and then added additional information to the wiki page to address the critiques. In the forum she responded:
Merle: This page is very good but you talked about how you could put the panels on the ground but it would cost more, how much more would it be to do this?

Lori: Thanks for the input Merle. I tried to fix that as much as i could, but it's hard to estimate how much more it would be exactly. The total cost depends on the persons individual needs; how much power they need, how much space they have, etc.

Within the wiki, Lori added additional information to make the segment about solar panels more clear (See Figure 5-4). The red highlight shows deleted text; green highlight indicates added text.

![Solar Panels on Ground](image)

**Space Required:**

Usually the panels are three-by-five foot cells but they can also be found in the form of roof tiles or be blended with the usual building supplies such as windows or siding. In good sunlight, one square foot of a solar panel will put out 10 watts of power, although the size of the system mainly depends on the needs of a person's individual home and the amount of energy used there. If putting the system on the roof, the roof space needed will depend on which module is used. Typically, each kilowatt will take around 85 square feet of roof space. While the most common place to mount the systems is on the roof of the home, they can also be mounted on the ground although this method costs more, more because the systems are bigger. The total cost, however, depends on how much power is needed. The more power, the bigger the system, the higher the cost.

Figure 5-4. Screenshot of solar wiki page with elaboration by Lori.

Tim responded to a critiquing comment, posted additional information, and made formatting changes to match the suggestion made. Dane responded to a critique by asking the commenter for clarification, “Could you give me an example?”, which went unanswered.
John responded to two comments. The first comment, also answered by Tim, dealt with formatting. John responded to the second comment by stating, “Dane has the information in a word document and is waiting to paste it up.”

**Communication using the wiki page.** Shawn communicated with the group indirectly by using the solar wiki page. He provided information about the project by posting his name and delicious.com account information; this communication with the other members allowed them a way to follow his research compiled on the social bookmarking site. John also added to the delicious.com information that was posted on the wiki. During the following class period, Shawn assigned himself a topic by posting his name after the bulleted point, “cost to build/install”. Lori assigned herself a topic, as well as adding Tammy’s name to “Advantages and disadvantages”. This group also utilized the discussion board as a means of communication with the afternoon group members by posting their names and the topics chosen by each. In addition to the discussion comment and wiki page, within class face-to-face discussion in both classes occurred about which topics to select.

**Challenges with technology: Opportunities to demonstrate expertise.** The solar wiki communicated within the class about technological aspects of the project. Tammy, Shawn, and Lori discussed an issue with editing; Tammy shared her wiki expertise with her group members during class by demonstrating how to coordinate saving their changes.

Tammy: We didn't save the changes did we?
Shawn: Oh yeah it did.
Tammy: [looks at his screen] Yeah it did.
Shawn: See?
Tammy: I was afraid it erased places that I linked to...so be careful.
Lori: I need one more .... so I left a little space.

Tammy: It should be ok.

Shawn: I ... been missing [parts of the text].

Tammy: Save it and if it pops up that it hasn’t been saved then .. (Lori nods).

Tammy: It did pop that up? Ok, hold on a second. [Tammy moves to Lori’s laptop and looks at Shawn.] Do not edit. Ok - go ahead.

Tammy: (Walks to Shawn, leans, and looks at Shawn’s screen.) Ok you should be able to [save]. Alright, Lori, are you going into edit now?

Tammy utilized her expertise of working with a wiki from her previous classwork to teach Shawn and Lori her way of editing wiki pages in groups without erasing other people’s work. This echoes the process for the “work-around” technique for creating the wiki outlined by John (about Dane) in the discussion, with students creating their text in the word documents then saving into the wiki to eliminate the issue with co-authoring, saving, and overwriting another’s work. In this fashion, many of the students added content to their topics by researching and typing their information into a word document, then pasted it into the wiki page at one time, instead of typing directly into the wiki. This was not discussed in either the morning or afternoon class, or suggested by the teacher. When asked about this practice during the focus group interview, Tammy used her past experiences with the wiki from biology class the year before to explain.

Tammy: “Well, only one person can be editing on the wiki and save at a time. So if a bunch of you are working on the same part [page], it’s easier to just type it up and paste it in quick. That way you get done faster and don’t lose anything. Last year working on a project, we were all trying
to get it finished before the bell and everyone was writing over top of everyone else and no one got their stuff saved. It was a waste.”

Dane and Tammy were in the same biology class the year before; I posit that the creative methods used to solve technological problems that were inherent in wiki use became part of these students’ technological toolkit (Bruner, 1990) from the biology class the previous year and transitioned seamlessly with these students to their chemistry class. Tammy and Dane demonstrated creative methods to solve editing issues in the wiki that demonstrated their technological expertise.

**Across Both Cases: Diverging Methods of Completing the Project**

In both the nuclear and solar groups, a wiki page was created that met class requirements and could serve as a knowledge artifact; however, the methods students used in constructing their pages differed. By comparative analysis of the two case studies, four findings related to the role of the wiki to support learning and argumentation emerged. The nuclear and solar groups used the wiki as a tool to support articulation of their understandings about alternative energy by demonstrating different patterns of

(a) communication, and

(b) interaction when co-constructing the wiki.

These differences can be both be attributed to the divergent goals of the two groups:

(c) what the students viewed as their primary goal for the wiki page, and

(d) the students’ perception of ownership of the wiki page.

**Different patterns of communication.** Liccardi, Davis, and White (2007) examined communication between 30 adult professionals involved in online collaborative projects and found that even with dedicated discussion forums, communication on a wiki was perceived
as difficult. However, in my study, both groups of students utilized features within the wiki to communicate with other members within their group and the class outside of the discussion board specifically targeted for communication. They posted links to their delicious.com accounts as a way of sharing information, as well as leaving notes for other group members on the wiki page. In addition, the solar group used the discussion board on the wiki to communicate the division of labor for the project, before James moved the information to the front page, as well as to respond to critiques. Although both groups replied to the comments within the discussion board, only the solar group utilized these critiques to initiate changes in the wiki by elaborating, editing, or adding content; the nuclear group replied to a critique posted on the discussion board by referring the readers to their social bookmarking accounts for more information instead of making changes in the wiki. The nuclear group students found communication difficult, commenting that other software would make communicating easier. The solar group students, however, invented ways to communicate using the affordances of the wiki for easy editing and display of information. In this way, my study illustrates how students utilize creative ways of using technology within classroom settings. Stahl (2007) found that students used technology creatively to make sense of information. The solar students extended his work as they creatively used the affordances of wiki technology to invent new ways of communicating with others in their group and in their class.

The groups viewed and utilized communication differently during the unit on alternative energy. Students in the nuclear group found communication difficult and did not engage in communication often on the wiki or verbally in class. Instead, the nuclear group suggested other software or implementing face-to-face meetings or conference calls as an
easier way to manage the communication instead of seeking other possibilities presently available. The students in the solar group, however, communicated during the project in multiple ways. The solar group discussed the tasks and content choices of the wiki face-to-face within their group and with the students in their classroom environment. They also posted on the wiki page and discussion page. Rose and Barton (2012) observed students using a diverse set of tools and strategies to make sense of science content and communicate understandings. Building on this work, the students in the solar group invented new practices to facilitate communication and solve problems as they articulated their understandings in an online wiki environment. The multiple pathways that the solar group utilized for communication adds to research (Stahl, 2007) on how students can create new methods to not only make meaning but also to express their understandings of content, requirements, and the relationship between them.

**Interacting through individual contributions or a collaborative product.**

Research on learning in wiki environments (Fong & Wang, 2007; Larusson & Alterman, 2009) found that collaboration through editing and student interaction facilitated student learning. In addition, Peters and Slotta (2010) and Fong and Wang (2007) found that students who were actively engaged in the wiki demonstrated higher levels of learning on a knowledge-based test. In my case study, the two groups of students used different strategies and patterns of interaction to complete their wiki pages; they used different methods to create content on the wikis, add and edit text, format the page, and respond to critiques in the discussion. In the solar group, four students contributed heavily to their wiki, while the other two contributed three times. Tammy, Lori, John, and Shawn interacted with the content on the wiki that was posted by themselves and others by adding text, editing grammar, and
formatting the page. Although two students in their group participated at a minimal level, these students collaborated on every aspect of the wiki page. Within the nuclear group, only Molly added content and edited grammar throughout the entire wiki, although only superficially editing other students’ content. The other nuclear students added text to their individual sections but not anywhere else on the wiki; most did not even edit their own work. My study indicates that nuclear group students’ distaste for editing limited their interactions with the content and each other, thereby hindering their collaboration on the wiki. I posit that this lack of interaction limited the affordances of the wiki for collaboration and affected the students’ opportunities for learning. Given that research (Alavi, 1994) indicates that connections exist between social interaction and co-construction of collaborative knowledge artifacts, the in-class collaborative discourse of the solar wiki group, in addition to their collaborative work within the wiki, supported articulation of a group understanding of alternative energy. From the perspective of supporting student learning, their collaboration can be seen as evidence of student learning. This finding demonstrates how educators can examine student engagement for collaboration and evidence of learning.

**Impact of individual or group goals on co-construction.** Research on technology in the classroom indicated that students perceived efficiency (Lonn & Teaseley, 2009) and entertainment (Kay, Meyer, Wagoner, and Ferguson, 2006) as two affordances of technology. In addition, Baker, Corbett, and Koedinger (2007) found that students adopted a “gaming mindset” to take advantage of the perceived affordances of technology. The students in the nuclear group appeared to utilize these affordances and mindset as they worked individually to efficiently fulfill the requirements of the project, and then entertained themselves by playing games under the guise of working. This was demonstrated through
their patterns of non-editing, lack of discourse, and fractured communication. By working independently, these students (along with Molly) were able to quickly create a cohesive-appearing wiki page, without actually collaborating on the content. The solar group students, however, were concerned with creating a cohesive group artifact that would support the learning of all students, not just themselves or their group. In the reflections and interviews, Lori and John (as well as Emma from another group) discussed their view of the quality of the wiki pages. They saw the wiki as an important group knowledge artifact and expressed a feeling of responsibility for the entire wiki; their editing, critiques, and contributions helped create a group artifact that expressed a group understanding of alternative energy.

Lori: Because we were getting a group grade, we had to edit one another. [Commenting] made me want to fix theirs.

John: Yes, knowing that the quality of the wikis would determine our videos and tests, we commented with much thought.

Emma: You wanted to make it [the wiki] good because other groups would have to use them.

To achieve this collective goal of a “good wiki”, the solar group students edited extensively the work of all students, engaged in discourse centered on the content, and communicated in multiple ways to collaboratively create a wiki page that articulated the group’s understanding of the content. This pattern of peer-editing on the group wiki page resulted in creation of a collaborative, cohesive group artifact. Research on Wikipedia Maintainers (Thom-Santelli, Cosley, & Gay, 2009) found that active participants often exhibited ownership of the wiki page, editing other’s work to maintain their high personal standards. Extending this research to self-created wikis in high school classrooms, Tammy, Lori, John, Shawn, and Molly
exhibited an “owner mindset” as they actively edited the pages to meet their personal and group standards and achieve their goal of a “good wiki”. This finding has implications within the classroom as educators choose technologies to support collaboration and student learning; recognizing the goals that students have created for each project or task in addition to the stated classroom goal has important implications on their learning experiences.

**Impact of perceived ownership of the wiki.** Thom-Santelli, Cosley, and Gay (2009) found that Maintainers, volunteers taking responsibility for a Wikipedia page, expressed feelings of ownership towards their page through editing and providing the majority of the content. I build upon this research to expand the implications to high school students constructing wiki pages in chemistry. In each of the groups, one or more members began to function as an owner within the group (see Table 5-2). Molly in the nuclear group, and Tammy, Lori, and John in the solar group all participated at a level more than double that of most other group members. The students in all groups did not discuss one (or more) students assuming leadership of the group on video or on the wiki. Molly, John, Lori, and Tammy’s editing practices and expressed quality standards for the wiki indicated a sense of ownership of their wiki page similar to the Maintainers in Wikipedia (Thom-Santelli, Cosley, & Gay, 2009). These highly-contributing students expressed a feeling of responsibility towards the other students in the classroom as well as a need to create a high quality wiki page; this responsibility was not found in reflections or interviews from the group members who did not participate at the higher levels. Extending the research (Thom-Santelli, Cosley, & Gay, 2009) on Maintainers in Wikipedia, this study shows how multiple students taking ownership of a wiki page creates a collaborative environment in which their collective understandings can be made visible. As collaboration has been linked to improved learning (Fong & Wang,
2007; Peters & Slotta, 2010), this finding has important implications for educators as they choose technologies that support collaborative learning experiences in the classroom.

**Summary of Wiki Use in Support of Articulating Understandings**

In many settings, learners have used wikis as a support for collaboration (Larusson & Alterman, 2009) to create a shared knowledge artifact. As students work together to construct their wiki page, their thinking is made visible through articulating their understandings for the other members (Chu & Kennedy, 2011). My research elucidates on these findings; students articulated their understandings as they participated in the construction of a wiki page about alternative energy, however I found that the wiki did not automatically promote collaboration between the students.

Liccardi, Davis, and White (2007) found that professionals had difficulty utilizing the wiki for communication; my study indicates that some high school students found a multitude of creative ways to communicate using the wiki over the course of the project. This use of creative methods to communicate with group members as well as connect to students within the classes is similar to a finding from Stahl (2007) where youth utilized inventive techniques and tools to make meaning. The students in my study found multiple pathways that learners can use to communicate in wiki and other online collaborative environments. As communication is integral to articulating one’s understandings and impacts social learning (Sawyer, 2006), this finding has implications for educators as they support students working in wiki environments.

Although the groups utilized different strategies and patterns of participation when constructing the wiki, the end result for each group was a complete wiki page. The wiki
pages met the classroom project criteria for content, graphics and pictures, and grammatical constructs. However, my study found that within the different groups, the level of participation between all students varied, as well as the way in which the students chose to participate. As the students in the nuclear group utilized the efficiency that the technology afforded them (Lonn& Teaseley, 2009) to co-construct their page quickly, the minimal interaction with the content between students while editing leads to lower levels of collaboration. Fong and Wang (2007) and Peters and Slotta (2010) both indicated a higher level of student interaction lead to higher levels of student learning. Therefore, this finding could have negative implications on how students learn content in wiki environments that are intended to be collaborative. Within the groups having the highest levels of collaboration, based on number of entries and edits to the page, I found that the students also collaborated face to face within the classroom. These students discussed wording, content, and formatting and grammatical edits as they entered content on the wiki page with their group, as well as with the class as a whole. Building on research by Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) with middle school students and tagging photographs, the face-to-face interaction between students in class while working collaboratively online appeared to foster a group “owner mindset” that extends to the entire group project and not just the single page. These findings illustrated as well that intergroup collaboration in the large classroom community holds importance for learning, as does the more prominently studied intragroup collaboration within small teams (Fields & Kafai, 2006).

Although wikis are purported to support collaboration (Fong & Wang, 2007; Larusson & Alterman, 2009), I found students did not often adopt collaborative strategies within their work. The majority of students articulated their understandings independently in
the wiki by pasting in sections of text, and not editing, revising, or elaborating any connecting segments (Cress & Kimmerle, 2008). This finding may have implications on the collaborative nature of the knowledge construction; it cannot be assumed that students will use the wiki as a support for collaboration -- within my study, students did not often collaborate.

Within each group, at least one student took ownership of the wiki page and took on the task of editing the group page and meeting deadlines. These students expressed responsibility and territoriality of their wiki pages, reverting changes to the original version, as well as editing text submitted by other students and implementing formatting changes. By taking ownership of the page, these students set higher standards for the content than outlined by the course requirements (Thom-Santelli, Cosley, & Gay, 2009), as well as ensuring that the page was completed. In most groups, one person adopted this role; this allowed the other group members to participate at a lower level. Some students took advantage of this position by playing games and discussing personal matters; others attempted to participate by making changes in the wiki, which were changed back by the “owner”. Because higher levels of engagement, as evidenced by number of posts or edits within the wiki, have been linked to greater learning (Fong & Wang, 2007; Peters & Slotta, 2010), this finding has implications for student learning. Wikis can support the collaborative construction of knowledge artifacts and improve student learning, however achieving collaboration between students can be difficult. Consequently, my study suggests that the use of wikis supports student’s articulation of their understandings about science content as they co-construct knowledge artifacts and engage in argumentation.
Chapter 6

Student-created Video as a Support for Persuasion

Chapter 6 addresses how students used the design and production of video artifacts to support (or not to support) argumentation related to alternative energies and how designing for an audience impacted their work to create a persuasive argument. Four data sources were used in the analyses in this section:

(i) video recordings of students designing and constructing the video during their in-class time,

(j) video recordings of the students’ focus group interviews at the end of the unit,

(k) student-constructed multimedia artifacts, and

(l) students’ individual reflections about their learning process written at the end of the unit.

These sources were analyzed to examine how the students used the design and creation of a multimedia artifact to support their participation in argumentation. Secondly, I created three case studies to focus on the argumentation between students while designing and creating their multimedia artifacts.

Video Findings

From the analyses, I developed three findings that are discussed in the remainder of this chapter. The students:

(a) used the video as a tool for persuasion,

(b) recognized the importance of counter-argument, and

(c) made use of different techniques to persuade their audience.
Videos as a Tool for Persuasion

Using the framework based on Zohar and Nemet (2002), the videos were scored based on number of argument elements: justifications, counter-arguments, and rebuttals, as well as the complexity of each argument’s elements. The total for the argument elements ranged from 4 to 12, out of a possible score of 0 to 12. The results are shown in Table 6-1. This score was calculated using Zohar and Nemet’s framework (2002) for analysis; an argument was scored as a 0, 1, or 2 for each argument element (justification, counter-argument, rebuttal, and content) up to 12 total.

Table 6-1. Total Number of Argument Elements in the Student-produced Multimedia Artifacts.

<table>
<thead>
<tr>
<th>Group</th>
<th>Justifications/Supporting reasons</th>
<th>Counter-arguments/Supporting reasons</th>
<th>Rebuttal/Supporting reasons</th>
<th>Score of student-produced argument (out of 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 12</td>
<td>3 3</td>
<td>3 3</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>5 2</td>
<td>4 2</td>
<td>1 1</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>9 6</td>
<td>3 2</td>
<td>0 0</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>11 8</td>
<td>2 2</td>
<td>0 0</td>
<td>7</td>
</tr>
<tr>
<td>5 (Case 1)</td>
<td>3 3</td>
<td>1 1</td>
<td>1 0</td>
<td>8</td>
</tr>
<tr>
<td>6 (Case 2)</td>
<td>4 3</td>
<td>5 5</td>
<td>1 0</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>7 5</td>
<td>5 5</td>
<td>1 0</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>9 4</td>
<td>0 0</td>
<td>0 0</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>2 2</td>
<td>1 1</td>
<td>0 0</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>12 2</td>
<td>3 0</td>
<td>4 0</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>7 7</td>
<td>1 0</td>
<td>1 1</td>
<td>10</td>
</tr>
<tr>
<td>12 (Case 3)</td>
<td>4 5</td>
<td>2 1</td>
<td>1 1</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>83 59</td>
<td>30 22</td>
<td>13 6</td>
<td></td>
</tr>
</tbody>
</table>

The student-produced multimedia artifacts all contained at least two valid justifications related to alternative energy. A justification was defined as a statement that contained evidence or reasons; the validity was based on environmental content within their
justification for the argument. Even with the scripting assistance provided within the provided storyboard instructional guide, one group did not provide a counter-argument. Four groups did not include rebuttals, which were discussed in class but not specifically noted on the storyboard. In addition, many groups provided justifications, counter-arguments, or rebuttals that were not backed by evidence or valid reasons.

Comparative Case Study Analysis: How We Choose to Persuade

In order to examine how the students designed and constructed the videos as tools to persuade their audience for or against a form of alternative energies, I created three case studies. Student groups were selected for three reasons that made these groups worthy of further analytical attention. First, the videos for all three groups received similar scores from the first analysis. Second, all groups discussed design choices that they made based on their desired impact on the audience. Finally, all groups utilized different methods and resources to persuade their intended audience in the video.

Case Study 1: Completing the Requirements

Andy, Matt, and Merle, were three 15-year old, male students in the morning class. Andy, Matt, and Merle formed a small group to create a persuasive video artifact about biomass energy. These three students’ social bookmarking on their delicious.com accounts met the course requirements of over 10 bookmarks with at least one social tag selected for each link. They also formed a network between each group member’s social bookmarking accounts. Just before the persuasive video artifact creation, these students had participated minimally in the construction of the Nuclear energy wiki page.
Within the group-constructed video, Matt, Andy, and Merle presented an argument supporting the use of biomass energy in their town. The group’s decision to argue in favor of biomass was selected quickly by the group with little discussion. During analysis, the score for the argument presented in their persuasive multimedia artifact was 8, which I interpret as an adequate argument. To sway the audience, the group chose five justifications (see Table 6-3): (1) low cost, (2) materials to operate it, (3) does not burn fossil fuels, (4) does not produce radiation, and (5) converts organic substances to energy with three supported by evidence that were found in the classroom wiki. This group supplied three reasons for the first justification, and one reason for two other justifications. The group presented one counterargument that contained evidence from online research, as well as a rebuttal that was backed by evidence. The score was derived from number of justifications that were presented as well as the number of reasons given, which is taken as a measure of complexity of the argument (earning a 2 score for the argument and justification) and other components.


<table>
<thead>
<tr>
<th>Component of the Argument</th>
<th>Justification selected</th>
<th>Evidence/Reasons provided to support each justification</th>
</tr>
</thead>
</table>
| Argument – Excellent alternative energy | Cost is very low. | • Cheap to operate because you can use almost any organic source to power it  
• 5.2 cents/kwh to operate  
• Vegetable oil, procurement, and storage accounts for 75% for biodiesel production costs, which is 1.30 cents  
• Extremely efficient |
<table>
<thead>
<tr>
<th>Used to operate it.</th>
<th>Does not burn up fossil fuels.</th>
<th>• No justification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Does not) produce radiation.</td>
<td>• No justification</td>
</tr>
<tr>
<td></td>
<td>Converts any organic substance into energy.</td>
<td>• Alcohols and methane gases</td>
</tr>
</tbody>
</table>

**Counter-argument**

<table>
<thead>
<tr>
<th>Biomass has serious health effects, which can be very harmful to our health.</th>
<th>• Eye and respiratory track infections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Breathing problems</td>
</tr>
<tr>
<td></td>
<td>• Bronchitis</td>
</tr>
<tr>
<td></td>
<td>• Severe asthma</td>
</tr>
<tr>
<td></td>
<td>• Cancer</td>
</tr>
<tr>
<td></td>
<td>• Premature death</td>
</tr>
</tbody>
</table>

**Rebuttal**

| Most people do recover from long term effects of the smoke. | • Although it still affects many people for short periods of time |

*Each bullet point was identified as a separate reason given within the presentation.*

**Design and construction of the video.** Andy, Matt, and Merle divided the design and production of the video into sections, with each section assigned to one student. Each team member selected the evidence used as justification for the section of content that they were responsible for – initially the group members did not collaborate on each idea.

Andy: We just picked three main topics and each researched it on the wiki, then we recorded our sections by passing around the computer.

Matt: We all, we all like pulled up scripts on our computers beside it [the computer using to record the video] and recorded it; two computers on our laps [laughs and points downward to his legs].

Andy: Then we got together to do the intro and conclusion.

Other than selecting which side of the argument to present, the introduction, and the conclusion, Matt, Merle, and Andy worked independently on the video. They selected
evidence, wrote the script, and began to record their voice-over. While recording, Merle stated that they utilized the storyboarding as a guide for their video script.

Merle: The storyboarding helped a lot because we just followed along with it, and we didn’t have to change anything.

Although Merle stated that they followed their storyboard and script while recording, changes were made. For example, while recording, Matt paused to discuss the selected pictures and negotiate wording and biomass content, which ended up with content that deviated from the script on the storyboard.

**Students selectively included counter-arguments.** Matt, Merle, and Andy selected to include or not include counter-arguments, even knowing that they were an important structure within the argument, based on the amount of information that was available. While Merle was recording a segment on the negative health effects caused by biomass, Andy interrupted to emphasize the importance of including a counterargument. After discussion, Matt, Merle, and Andy came to consensus about the script, deciding that there was not enough positive information about health effects to use as an effective counterargument.

Andy: “Are you doing the bad health effects?”

Matt: “Yes.”

Andy: “Well you should have something good in there too. It shouldn’t just be one big bad part because then its…”

Matt: “But its health effects though. Health effects are bad.”

Merle: “Yeah, bad.”

Matt: “There’s no…”
Merle: “There’s no positive health effect…this is the part where it says this energy is bad. We can do that later.”

Although the group chose to not include a counterargument for this point, in his reflection, Matt reiterated the importance of using one to tell “everything about it, and then the people weren’t getting surprised”.

**Students chose pictures to illustrate points seamlessly.** The group discussed the inclusion of photographs in their video. The pictures contained within each student’s section in the video were selected to accompany the script, to illustrate the points that were being made, and not for their visual impact (see Figure 6-1). Andy and Matt discussed the pictures that were included in their sections and how to incorporate them into their presentation, deciding to select photos or graphs that supplemented their script and did not need additional explanation.

Matt: “We have to make sure me and you put a lot of pictures in here.”

Andy: “You have to remember - we need the opening statement and the conclusion and time to put pictures in and explain each of them.”

Matt: “No we're going to have to go, we're going to have to figure out (shows laptop screen to Andy - points to computer screen and circles with finger on screen) where they all go, go with it, that’s what…”

Andy: “Oh ok.”

Matt: “…what I'm saying.”

Andy and his group discussed other script moves and their impact, eliminating pieces and moving segments within their script to best illustrate their points.
Students designed for the actual audience. Matt, Merle, and Andy were conscious of two audiences: the assigned (fictional) audience of town council members and the actual audience of their chemistry class peers. Merle felt that knowing that any audience would be viewing their presentation “made us work harder to make it better.” When asked during the focus group interviews if someone besides the teacher seeing their video influenced design decisions, Matt stated that he felt that the audience had an effect on their presentation. Because they were producing a persuasive video artifact for a class project, the boys designed their argument for their peers, while they felt that an authentic audience of town council members would have affected the elements that were chosen to convince the adults.

Matt: “If it was adults maybe, then maybe we would have more like gone at it like the [air quotes] politically correct way… [laughs]. Like with nuclear, we could have went like ‘so who cares the radiation will kill a
few people’ but that’s not right…so maybe if it was a different audience and not just our classmates.”

Andy: We could have been more creative with the pictures. I think our pictures were really boring.

The students within this group utilized the general structure of scientific argumentation when constructing their video artifact on biomass as an alternative energy resource. The photos utilized in their presentation were chosen to reinforce the justifications and evidence that were selected as the students built their argument (see Figure 6-1). Matt, Merle, and Andy selected photos of a biomass plant, a growth cycle, and trees, which illustrated their script, but did not add any emotional impact. Matt, Merle, and Andy were conscious of their actual audience of peers during selection of the pictures and recognized that the other audience of town council members would impact their selection of photographs differently, indicating that alternative methods of persuasion would be used for different viewers.

**Technological issues with the software.** The program that the students used to create the persuasive multimedia artifact was installed on all computers, but the project could only be created on one of the laptops. Matt, Merle, and Andy noted that the construction of the artifact occurred on Merle’s computer – forcing Merle to host the multimedia presentation production, while the other two switched on and off of his laptop to work on their portions of the video artifact. They viewed having only one computer as an obstacle to creating their multimedia artifact, although most did not see this as insurmountable.

Matt: With the video, we just used one computer.
Andy: We did it on Merle’s computer, so we [points to Matt and himself] did the introduction and all, and he [Merle] edited it.

Matt: Well, Merle did do a little more work than me…but the editing is not that hard on Garageband, because if we screw up we stop and just … [pokes at the desktop] delete it out.

Because of the constraints of the software and technology used, Matt and Andy felt that Merle was taxed with more of the work, specifically the editing of the final artifact, because of the project being housed on his computer. However, because Matt felt that the program was easy to use, he did not think that the extra work was overly unfair to Merle. In spite of noting the inequity in work between the group members in both the conversation and interview, all students in this group stated in their reflections that they felt that the work for the project was divided evenly.

**Case Study 2: Attempting to Sway with Humor**

Mandy and Susie were two female 15-year old students within the morning chemistry class; this group was randomly assigned biomass energy. These students participated in both the social bookmarking during the initial phase of this unit, as well as the during their group’s construction of the wiki page about hydroelectric energy.

For their multimedia artifact, Mandy and Susie chose to side against biomass energy. The decision to argue against biomass energy was difficult for this group. Mandy and Susie originally designed their script to persuade viewers to vote for biomass energy because of economic reasons. However, while recording, the girls paused and discussed the evidence they had selected, then decided to change their perspective.
Mandy and Susie’s video was constructed differently than the other groups, with the justifications first, followed by counter-arguments, then claim and rebuttal within the conclusion. Their persuasive video artifact was scored a 9 out of 12 based on the argument presented. They presented four justifications for their claim, one with multiple reasons provided and the others with no evidence (see Table 6-2). Their primary justification was health, with six reasons attached to it. They used six counter-arguments, again one with multiple reasons and the others none, and one rebuttal with a reason.

Table 6-2. Argument Presented by Susie and Mandy to Sway the Audience Against Biomass Energy.

<table>
<thead>
<tr>
<th>Component of the Argument</th>
<th>Justification selected</th>
<th>Evidence/Reasons provided to support each justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argument - We are against this form of energy</td>
<td>Because of the impacts on health.</td>
<td>• Breathing problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Bronchitis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Irritation of the eye and lungs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Asthma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Premature death</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cancer</td>
</tr>
<tr>
<td>Increased green house gases</td>
<td></td>
<td>• No justification.</td>
</tr>
<tr>
<td>More energy to produce crops</td>
<td></td>
<td>• No justification.</td>
</tr>
<tr>
<td>Space used for crops could be better used</td>
<td></td>
<td>• No justification.</td>
</tr>
<tr>
<td>Counter-argument-The advantages of biomass are</td>
<td>Fuel is cheap if available on site</td>
<td>• No justification.</td>
</tr>
<tr>
<td></td>
<td>Available around the world</td>
<td>• No justification.</td>
</tr>
<tr>
<td></td>
<td>Burning is clean</td>
<td>• No justification.</td>
</tr>
<tr>
<td></td>
<td>Alcohol is viable</td>
<td>• No justification.</td>
</tr>
<tr>
<td></td>
<td>Recycle what we would otherwise throw out</td>
<td>• No justification.</td>
</tr>
<tr>
<td>Cost</td>
<td></td>
<td>• Localized cost of energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fuel costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Operation costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Production costs</td>
</tr>
<tr>
<td>Rebuttal</td>
<td>Although this process has many advantages</td>
<td>• We believe that the effects of health are more important and outweigh the advantages of this process.</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>

- Each bullet point was identified as a separate reason given within the presentation.

**Designing and constructing the video.** When constructing their video, Mandy and Susie chose to sit with another group of girls from the same class to work. The four girls (in two groups) initially developed scripts for their two separate videos while working in a fairly cohesive, larger group. The two teams sat on the floor in the hallway with both groups intermingled; students spoke across each other when needed while reading through the wiki and formulating their initial ideas about the videos. Only when it was time to record the video did the girls on each team separate and sit beside their partner, although both groups were still sitting beside each other. In addition, when recording their actual scripted voice-over, the groups finally separated and went into different rooms or hallway areas to complete their voice-over. While researching and writing their initial script, Mandy and Susie were very social in nature, talking to friends and multitasking while working. It was not until they began to record their presentation that Mandy and Susie actually discussed the content and their point of view towards biomass energy. After beginning to record, the girls reflected on their script and stopped to discuss their actual views. They then changed their viewpoint and adjusted their presentation to show this change. However, a new script was not written; Mandy and Susie researched on the biomass wiki and verbally discussed their ideas before Mandy recorded. All pictures were selected after the recording.
Mandy and Susie each stated in their individual reflections that the work was divided evenly; although Susie expressed reservations about the division of labor during her focus group interview.

Susie: I felt like she [Mandy] was doing more work, because it was on her computer, I felt like I should…like I wasn’t doing as much.

However, in the reflections, both Mandy and Susie indicated that they felt that the work on the overall project was split evenly, with each doing her part. Although the software was housed on all computers, the video presentation was very difficult to save and transfer to a different computer; although it was a co-constructed artifact, the presentation belonged to one person.

**Changing viewpoints.** Before recording their video, Mandy and Susie evaluated evidence available both for and against biomass energy as they chose the side to argue. They chose to argue in favor of pro-biomass energy initially; they constructed their storyboard to highlight the importance of the low cost after a discussion on advantages and disadvantages. Once they started recording, however, and reading over their script, the girls reexamined their argument and decided to change their viewpoint to argue against the use of biomass.

Susie: “I’m assuming we are for?”
Mandy: “Yeah.”
Susie: “I don’t think we should be. I think we need to be against it.”
Mandy: “Why?”
Susie: “Ok, so it says the different health effects include eye and respitate…respite…res-pit-tory irritation, breathing problems, bronchitis, severe asthma, cancer, and premature death.”
Mandy: “Oh [Nods] I’m on board.”

Susie: “I mean it’s…I think we should be for…but…”

Mandy: “Does that sound right to you though?”

Susie: “I mean…it’s increased greenhouse emissions; it takes more energy to plant and cultivate crops,”

Mandy: “I know what you mean…”

Susie: “Will it be easier to do it [argue] against it then?”

Mandy: “Well…yeah. I think so.”

Susie: “Yeah. Like…it’s cheap and stuff…and I could see. I mean…other stuff too, but I think the health effects over weigh that.”

During the interview, Susie explains more their process of deciding which side they would take.

Susie: “We were for it [biomass] at first, but then we read more about it, and we thought the health was more important, so then we switched and we were against it.”

Researcher: “So you changed from your storyboard that you started with?”

Susie: “Yeah [shakes head]. Well, we looked first at the cost, at what that was and went with that. But then when we looked more…we kind…of changed our direction. We looked at everything and the cost just wasn’t…”

Mandy: “Yeah.”

Susie: “When you think of alternative energy, you think all natural. You think that it is good for you. You don’t think of the health risks.”
Even with time constraints on finishing, Mandy and Susie chose to change the point of view of their multimedia artifact in the middle of production. As the students recorded their script, they realized the seriousness of the health risks versus the costs and employment benefits that had been chosen as their primary justifications. After discussion, Mandy and Susie redesigned their multimedia artifact and scripted verbally as they worked, reading from the biomass wiki and discussing wording choices as Mandy recorded their presentation.

**The importance of counter-argument.** After refocusing their presentation to argue against biomass energy, Mandy and Susie used their initial uncertainty and understandings of the advantages and disadvantages of biomass to construct their counterarguments for biomass. They presented a balanced overview of the energy, stating the advantages, especially of low costs, and then using the disadvantages to emphasize their choice.

Susie: But we still have to show both sides. We can still say advantages….but show … um…exceptions and stuff.

They felt that counterarguments were important to persuading the audience as well as being an integral part of a strong argument. Without showing that they understood both sides of the issue, Susie and Mandy felt that the audience would believe that they lacked credibility. During the interviews, they discussed this factor.

Elle: You have to show both sides of things…everything has something negative about it.

Shawn: [telling the other side] shows why people *would* want it…

Susie: Yeah, like you *know*. It helped show that it was not *all* bad and there were some positives to it.

Shawn: …like you know what you are talking about.
Andy: And how good the good side is…

Mandy: It’s very important because it helped others to understand our point.

Their video contained more counter-arguments than justifications, pointing back to their initial scripting of the argument as pro-biomass, as well as the girls’ discussion when changing their focus to present an argument against biomass.

**Using humor to persuade their audience.** The girls recorded their video using Mandy’s voice for voice-overs for the entire project, other than the Looney Tunes, “That’s all folks” at the end of the video. Mandy chose to use a funny voice to record the presentation for aesthetics because she “hates how my voice sounds.” As Mandy and Susie were recording, they asked for peer feedback from several students who passed them in the hallway and stopped to listen to their work on the project. Mandy asked the students for their opinion on the video, “Pretty funny? Or not?” While recording, Susie voiced her thoughts on potential scripting, and Mandy repeated segments multiple times to get the effect that they wanted, without themselves laughing. Susie, as well as people walking by, laughed at the voice Mandy was using when recording. During the interview, Susie explained this choice.

Susie: Mandy’s voice…[laughs] I had to sit there and try to stop laughing.

Elle: Yeah it was [laughs]

Andy: She’s so funny.

Researcher: What made you think of …

Susie: Well, we wanted to grab people’s attention…

As the girls recorded their script, they stopped repeatedly to gather information or facts to use within their video as supporting details. The girls continued to add details until they reached “2:02 minutes” (the project required their video to be between two and three
minutes), and then decided to “sum it all up”. They discussed how to best reemphasize their main point, make an impact on the audience, and stay within the time frame, renegotiating and articulating their argument as they worked. Susie also verbally discussed with Mandy her thoughts about editing the video’s conclusion, suggesting scripting and edits.

Mandy: “I think that’s it. Its 2 minutes and 2 seconds. Then I’ll just wrap it up. We are manual…we are against this.”

Susie: “We should’ve said like at the end, should have put that at the end instead of where we have it…you can move it can’t you?”

Mandy: “Probably…” [works at the computer a moment] “We are supposed to say why and then just at the end we can be like ‘Although there are benefits to this costs, there are multiple health effects’…”

Susie: “that we think is more important than…”

Mandy: “I think this is ok…” [starts to record on the laptop again] “Even though this process is very beneficial to the economy…” [stops recording] “that didn’t make any sense at all…” [both laugh] “Even though this process has many benefit….even though this process is cheaper [laughs]…is less expensive to operate than other sources…or these types of energy.” [sighs and runs fingers through hair].

Susie: “Even though this has its advantages…”

Mandy: “Even though this process has its advantages, it also has many health effects that we believe are more important than the advantages.”

Susie: “That was good though. But just go … that we think are more important. That *outweigh*.” [italicized to show verbal emphasis]
Mandy: “Even though this process has its advantages, it also has many health effects that we believe outweigh the advantages of this process. [stopping the recording and laughing] I just repeated myself about ten times.”

Susie: [laughs] “It’s ok. It’s fun. Now all we have left is adding in pictures, right?”

Mandy: “Yeah, and we can do that quickly tomorrow.”

Even with the presentation purposefully laced with humor, Mandy and Susie required many takes to get the sound and wording that they wanted; the girls’ attempted to collaboratively wordsmith their video to best convey the exact nuances they felt were needed to emphasize their viewpoint. This attention to nuance within their script illustrated their focus on the audience. Not only did they envision their actual audience, Mandy and Susie asked peers for feedback, allowing them to verify that the humor in their presentation resonated with others similar to the intended audience of classmates.

**Pictures expressed humor.** The pictures chosen for the video aligned with Mandy and Susie’s theme of humor. The photographs chosen to accompany their final script were of grass, wood chips, cows, a smiling “thumbs up”, trash burning (cartoon), a recycle symbol, a frowning thumbs down, crops, a cartoon doctor with person (two different), a money tree, gas pumps, a truck, diesel and gas cans, and the cartoon doctor/patient a second time. The photographs matched the content and attitude evidenced in the script; they do not appear likely to excite, entice, or upset someone. Even the doctor and patient images, chosen to accompany the dire health consequences, were non-threatening cartoon images (see Figure 6-2). The final scene of their video was a famous cartoon of Porky Pig stating, “That’s all folks.”
With this, Mandy and Susie created a video that was structured differently than most, with the advantages and disadvantages given, then the claim – against biomass energy. They supplied justifications as well as counter-arguments, both with a set of reasons to support one of the justifications, and their rebuttal had supporting evidence supplied. Their photographs accompanied the script, and supplemented their facts, but did not provide additional visual emotional appeals targeted at persuading the audience against biomass. The voice used during the video is specifically chosen to engage the listeners because of its humor, as well as the pictures. Although the numerous takes and voice show their dedicated attempts at engaging the audience, the girls’ video did not utilize the typical scientific structure of an argument or appear to provide additional persuasive techniques to sway others to align themselves against biomass energy.

Case Study 3: “You got to grip at the heart, man.”

Tanner and Fredrick were two male 16-year old students within the afternoon chemistry class. Earlier in the unit, Tanner and Fredrick participated in minimally both the social bookmarking during research as well as the construction of the wind wiki page. Their
social bookmarking accounts showed activity, with Tanner selecting ten, the required (by the instructor) number of bookmarks, and Fredrick selecting six. Tanner and Fredrick chose more than one tag for some of their bookmarks, with a total of 14 and 13. Neither of the boys chose to form networks within the social bookmarking site.

When constructing their persuasive multimedia artifact, Tanner and Fredrick chose to argue against nuclear energy because, as Tanner stated, “it’s a no-brainer. I mean, after Japan”, referring to the 2011 tsunami incident. Their argument was scored as a 10; it contained four justifications (a) health effects, (b) pollution, (c) spills, and (d) can melt down or explode. The first three justifications were each supported by two reasons, the fourth had no supporting evidence (see Table 6-3). Tanner and Fredrick chose counter-arguments that focused on costs and locations for the plants, with the placement of plants also factoring into the rebuttal. Tanner and Fredrick’s rebuttal tied a current event (at the time) of the tragic tsunami in Japan to their argument against alternative energy.

Table 6-3. Arguments and Justifications Used by Tanner and Fredrick to Argue Against Nuclear Energy.

<table>
<thead>
<tr>
<th>Component of the Argument</th>
<th>Justification selected</th>
<th>Evidence/Reasons provided to support each justification</th>
</tr>
</thead>
</table>
| Argument: Against nuclear energy | Health effects | • Radioactive material can cause health issues for animals and people  
• Cancer, deformation, death |
| Pollution | | • Lasts millions of years |
| Spills | | • Leak out you must vacate  
• Kill off endangered or specialty species for life |
Design and construction of the persuasive multimedia artifact. While writing the script, Tanner and Fredrick sat at the lab desk together. Tanner worked steadily, occasionally asking Fredrick questions. Fredrick, on the other hand, played a game—sometimes hidden behind a browser window open to the nuclear wiki page. During the interviews, Tanner stated that his group utilized the storyboard and followed the suggestions closely for the structure such as two justifications and evidence for each. When selecting evidence to use in their persuasive artifact, Tanner stated that he and Fredrick worked independently.

Tanner: So we, I kind of read the disadvantages off. What I thought were the worst possible things. Then Fredrick, he read off what he thought were good things about it. Then we stopped and talked back and forth about what we thought were going to be more convincing to the general public, you know.

Tanner and Fredrick each focused on selecting evidence that was convincing to them personally before discussing how to present the content accurately as well as make it convincing to the general public.

In addition to utilizing the suggested structure for their argument, Tanner and Fredrick also added elements of their everyday understandings of persuasion to their
multimedia artifact. Tanner felt that persuading someone required more than just facts and structure.

Tanner: “You shoot for the heart, ((pounding fist on the table)) you grip at the heart, man, because that will get you anyone!”

Tanner, like others during the interview, discussed the use of facts and additional elements to persuade someone. By referring to ‘getting’ the heart, Tanner was adamant during the interview that mere facts would not convince someone. A persuasive artifact needed additional appeals to emotion: music, pictures, and even color.

**Photography as a tool to persuade.** When designing and constructing their persuasive multimedia artifact, Tanner and Fredrick chose photographs to specifically to help sway their audience. During the interview, Tanner, Ethan, and Dane discussed using pictures within their presentations.

Ethan: You need lots and lots of colorful pictures. Pictures really turn people on. It’s pictures over what you say sometimes.

Tanner: Yeah. Color…pictures have an impact. It’s like the commercials, sometimes. You know, the dog ones. [Referencing ASPCA commercials.] You see its sad eyes and …

Dane: Ohh…The song too, the Sarah McLachlan song…

Tanner: Yeah. ((clutches chest)) It grabs you …

Tanner and Fredrick deliberately chose pictures for their persuasive multimedia artifact with emotional impact to persuade the “town council” to vote against a nuclear energy plant. This was evidenced in student dialog between Tanner and Fredrick while designing their presentation and writing the script. Fredrick selected a photograph of a child
with radiation poisoning, and Tanner chose a picture of a “mushroom cloud” shaped as a clown (see Figure 6-3).

Tanner: “I’m using the clown cloud for the EXPLOSION (laughs)…”

Fredrick: “Clown? Why clown?”

Tanner: “People are afraid of clowns.”

Tanner used deep seated fears held by many, including clown phobias, sick children, and nuclear explosions, to supplement his argument against nuclear energy with his everyday understandings of the techniques of persuasion.

![Figure 6-3. Photographs selected for the nuclear video.](image)

(Left) Photograph of the “clown cloud” chosen to illustrate the word “EXPLODE”. (Right) Photograph of an ill child selected to illustrate dangerous health effects caused by nuclear energy.

**Importance of counterarguments.** Tanner and Fredrick felt that counterarguments were imperative to providing the audience with all possible facts to enable them to make informed decisions.
Tanner: [counterarguments] Provide the audience with both sides of the story, so they could form an opinion.

Fredrick: [they] Audience to know more.

Tanner and Fredrick included two counter-arguments, one being supported by evidence, and one rebuttal in their presentation. Tanner and Fredrick stated their claim, vote against a nuclear energy plant, and supplied a counterargument (from the artifact script):

Tanner Nuclear energy’s output is 3 million times greater than that of fossil fuels, so in other words, for energy, nuclear kicks fossil fuels' butt!

We shouldn't [build the plant]. It can melt down or [displays picture of “clown explosion”] even worse EXPLODE!

Their counterargument and rebuttal contained evidence from the wiki and website links, as well as utilized dramatic voice and visual effects in order to further persuade their targeted audience. Their rebuttal, however, dramatized the final effect of recent nuclear disasters (using the word “explode”) instead of relying on straight factual, scientific data or evidence. These students also selected information about current, tragic events occurring at the time of the project (the tsunami in Japan) to utilize within their persuasive multimedia artifact as evidence against the use of nuclear energy.

**Influence of the audience on the video design.** Tanner and Fredrick felt that the actual versus “intended” audience influenced their scripted argument design. When discussing selection of evidence for the artifact, they considered who was going to be viewing the artifact.
Tanner: …Then we stopped and talked back and forth about what we thought (justifications and evidence) were going to be more convincing to the general public, you know.

Tanner and Fredrick discussed during the design phase which factors, costs, health issues, or safety, would make their presentation more convincing, showing attention to the selection of evidence based on audience. This consideration of the viewer was also evidenced in the word choices and tone. As stated by Fredrick and Tanner:

Fredrick: We had to simplify the info so anybody could explain it.
Tanner: Yeah, and it took a while to get it [the voice over] right, so (I) read it off a lot.

The boys were careful to script their presentation and read for the voice-overs in such a way that their words and content were easily understood; in addition, they even utilized the tone of their voice as a technique to sway the audience.

Tanner and Fredrick used the accepted structure and elements of scientific argumentation within their presentation, but felt that actually persuading the audience required more than facts. Thus, their presentation utilized photographs, voice, and other visual effects to emphasize factors that held emotional appeals for their targeted audience.

Across All Cases: Persuasion Can Take Many Forms

Through this case study analysis of the three groups, two biomass groups and one nuclear group, three findings relate to the role of video as a support for the sub-practice of persuasion and learning emerged. These groups of students:
(a) understood the structure of scientific argumentation, including the importance of counter-argument,
(b) considered the audience in their design, and
(c) utilized different persuasive techniques to sway their audience.

Creating a *Good Argument*

The student groups in my study each created a multimedia presentation that contained the accepted elements of scientific argumentation (Zohar & Nemet, 2002): claim and justification, and in most cases counterargument and rebuttal. In my study, all groups of students used evidence or reasons to support at least one of their justifications in their presentation; many also supported their counterarguments and rebuttals with evidence. This finding extends research by Zohar and Nemet (2002) with high school biology students on student use of scientific content in their justifications to a new setting: high school chemistry students. For Zohar and Nemet, students used specific scientific evidence within justifications only when they understood the material, indicating a connection between content knowledge and engagement in argumentation (Sampson & Clark, 2008). Given this research, as the students in my study used evidence within their justifications and engaged in argumentation through the design and construction of their videos, they demonstrated a deeper understanding of content. This relates to research of Zahn, Hesse, Finke, Pea, Mills, and Rosen (2007) where high school students who engaged in both designing and creating video artifacts developed argumentation skills as well as content knowledge. I found that the students engaged in both the alternative energy content and practices of argumentation through the design and construction process of their multimedia artifact. This finding has
implications for educators creating learning experiences for students; by structuring assignments that encompass both design and construction elements, students have the potential for deeper learning as well as participation in practices of science.

Given that research (Felton, 2009) on 7th grade students considering alternative energy found that students constructing arguments in an environment that was teacher-focused on the elements of argumentation over an environment that was focused on persuasion led to improved learning and argumentation skills, my study provides a new perspective. The high school chemistry students in my study were repeatedly given instructions that the intent of the video was to sway the town council members to vote for their proposal, demonstrating a teacher-provided focus on persuasion. In their reflections or interviews, however, the students discussed the importance of counter-arguments. They indicated that showing both sides of the argument added to its validity, as well as establishing credibility and expertise of the group members presenting it. In addition, the students felt that counter-arguments were imperative to educate the audience about both sides of the argument, so that the viewers could make an informed decision. Although the structure of argumentation was suggested through the storyboards, as well as discussed briefly in class, this attention across all student groups to the element of counter-argument provides insight into factors that high school chemistry students found compelling within an argument. As noted by Rose and Rose and Barton (2012), when middle school students made sense of socioscientific issues, the researchers gained insight into the students’ process of decision-making by examining which evidence they chose to foreground. Extending both of these findings to high school students, these students in my study found great value in the counter-arguments within their constructed and viewed multimedia presentations, even with a
classroom focus on persuasion. I posit that this emphasis by the students on the importance of counter-arguments provides insight into how students prioritize the components of argumentation as they construct arguments and participate in argumentation, as well as indicating that emphasis on persuasion did not impede the students’ learning the components of an argument.

**Consideration of the Audience**

Driver, Newton, and Osborne (2000) viewed argumentation as discourse in which participants used collaborative discussion to persuade peers. The students across my study considered the unknown viewers when designing their videos, but placed differing emphasis on the effect that audiences had on their design. This finding adds to research by Dawson and Venville (2010) who found that with 10th grade students studying genetics, the perceived context of the overall study affected the argumentation produced by the students. Matt, Merle, and Andy, when faced with an audience of their peers and not a “real audience”, felt that their arguments could simply structurally align with principles of scientific argumentation in order to be effective. Although their video contained justifications and counterarguments, they did not choose to incorporate wording or pictures that added additional, everyday elements of understandings persuasion (Rose & Barton, 2012). Mandy and Susie also designed and constructed a video that contained the appropriate elements of argumentation, although in a different order than typical. Within their video, however, they utilized humor as a strategy to persuade the audience members of their peers. The girls’ elicitation of comments from students who were passing in the hallway indicates that their main goal for the video was to entertain the other students. This finding aligns with research
by Kay, Meyer, Wagoner, and Ferguson (2006) who found that a perceived affordance of technology is entertainment. Tanner and Fredrick perceived their audience as the “general public”. As such, they utilized all possible resources, both scientific argumentation and everyday persuasion strategies, to reach their audience through the use of facts and evidence, tone of voice and color, and graphic photographs. Research (Ferretti, MacArthur & Dowdy, 2000; Nussbaum & Kardash, 2005) found differences in students’ argumentation and learning based on classroom goals of persuasion versus attending to the elements of the argument. I posit that in my study, these groups of students set goals for each of their persuasive multimedia artifacts based on their personal desires or understandings about persuasion. These goals of efficiency, humor, and everyday persuasive techniques were chosen by the students and based on their perceived audience. Each group adapted their scripts and persuasive techniques as needed while constructing the artifact to meet their goal.

My study adds to the body of work on the effect of student-selected goals for persuasive, multimedia projects. This finding has implications for educators as they choose technologies to support content learning and argumentation within science classrooms; the techniques of persuasion selected by the students are dependent on the students’ goals, which can impact student participation in argumentation and content learning.

**Different Paths to Persuasion**

Research (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000) indicates that attending to persuasion in argumentation can help shift students from “doing school” to “doing science”, leading to greater participation in science practices. The nuclear group of Andy, Matt, and Merle felt that the facts alone should be convincing. Their pictures, charts, and
choices of topic were selected to convey a knowledgeable tone that they felt would be
enough to convince their classmates. Mandy and Susie appear to make the same choices,
although they themselves changed perspectives during the construction of the video. The
students used humor as well as common fears and phobias when choosing evidence for their
videos; youth value emotion and personal beliefs as legitimate factors in decision-making
(Ekborg, 2005; Zeidler & Sadler, 2007). They made an attempt to engage listeners through
humor but with funny pictures and emotional appeals of nostalgia in the final scene to further
entice the viewers to be swayed towards their side of the argument, utilizing the
 technological affordance of entertainment (Kay, Meyer, Wagoner, and Ferguson, 2006).
Tanner and Fredrick, however, used both the framework of scientific argumentation and
emotional appeals to persuade their viewers and sway them against nuclear energy. Adding
to research by Rose and Barton (2012) that found that students draw upon their everyday
understandings to make sense of science content, my study examines the students’ everyday
understandings of persuasion as they participate in argumentation. Tanner and Fredrick
utilized all possible techniques to make sure that their argument made an impact logically,
emotionally, and psychologically through appeals based in scientific content, fact, visual
elements, and innate phobias.

Summary

The students understood the structure of scientific argumentation and used claim,
justification, and counterargument within their persuasive video artifact to provide basic
content about the energy resource. In alignment with research in socioscientific issues
(Calabrese Barton, 2012, Rose & Barton, 2012; Sadler, 2004; Simonneaux & Simonneaux,
2009), the students enriched their persuasive video artifacts with their prior, everyday understandings of persuasion by using emotionally-charged appeals, rather than presenting “only” scientific facts, when selecting images pictures and writing scripts for their persuasive video artifacts. Students also challenged their personal views and perspectives while writing the scripts and filming – changing positions on their views of some forms of alternative energy. The discussion surrounding the girls’ choice to prioritize negative health effects in place of economic benefits also illustrates the tension that often exists in low socio-economic areas between finances and environmental effects (Rose & Calabrese Barton, 2012). The audience factored into students’ design and construction of the arguments, as shown in the case of Mandy and Susie’s choice to utilize humor as a medium for their presentation and Tanner and Fredrick’s selection of photographs to evoke fearful emotions. In alignment with Berland and Forte (2010), the design process strengthened student appropriation of practices of argumentation through consideration of their potential audience: students said they carefully chose their claims in anticipation of counter-arguments and rebuttals that could be used. In particular, students, such Matt, Merle, and Andy, felt that their classmates and adults warranted different persuasive techniques. The use of authentic audience in students’ presentation of scientific work, particularly as students engage in argumentation, has important implications on how they choose to view their work. Given the Sadler (2004) found that [high school] students past experiences influence decision-making in socioscientific issues, this student use of everyday understandings as evidence adds to this perspective; including color, music, and pictures can be seen as a way to expand what a student views as evidence.
Chapter 7

Discussion

This dissertation explored one science practice, argumentation, which has been advocated as essential component of K-12 education in the United States (Duschl & Osborne, 2002; NRC, 2011). As stated, earlier, argumentation is the dialogic process by which knowledge is produced by connecting evidence to claims. Scientific arguments, the central focus of my study, are a means by which both scientists and the learners being apprenticed into science, explain scientific phenomenon as well as convince others’ of logic of their conclusion (Duschl & Osborne).

For this dissertation, I investigated how high school chemistry students used Web 2.0 tools to support their participation in science practices of argumentation: sensemaking, articulating, and persuading. I found that the tools of social bookmarking and tagging, wiki, and design and construction of a persuasive video did support students as they participated in argumentation. As the students utilized the tools to support argumentation, they also used their perceived affordances of the technologies in multiple ways. Students used social bookmarking to communicate and manage the work of others. They also used the wiki to communicate; others took ownership of the wiki, performing the majority of the edits and expressing feelings of responsibility for the page. Groups of students used the design and production of the video as a tool to persuade using different goals of efficiency, humor, and emotional appeals. For the analysis, I adopted multiple frameworks that provided me with insight into student actions and participation in practices. The wiki, however, raised methodological concerns about typical analysis procedures that rely on numbers of transactions and counting editing moves. Other avenues for research were discovered over
the course of the project including how educators can support students collaborating in wiki environments to more fully engage the students and encourage ownership of the page.

As in the prior three chapters, I first discuss the study’s findings by each individual research question. In this final section, I reflect how this dissertation adds to our understanding of technologically-enhanced science learning related to argumentation across all three analyses completed (see Figure 7-1). In this final section, I make implications to:

(a) science education’s understanding of argumentation,
(b) learning sciences’ perspectives on socioscientific issues creating relevance for student learning,
(c) educational technology’s understanding of computing tools in science classrooms, and
(d) computer supported collaborative learning’s methods for the study of computer tools that support human learning.
Figure 7-1 Theoretical framework.
Alignment of the Sub-practices of Argumentation, Technological Supports, and Student Actions.

Findings from this Study Contributing to the Literature

Students’ Use of the Social Bookmarking Tool

Through the analysis of social tagging from the two classes, students used social bookmarking as a tool to support argumentation and other academic work in a multitude of ways. The first findings about the ways in which the students utilized delicious.com (i.e., the social bookmarking website) aligned to the prior literature as students participated in the practice of social tagging with their peers (and in rare cases other delicious.com users).

Social bookmarking and tagging served as a sensemaking tool related to alternative energy and a communication tool between students. Based on research and the description of social bookmarking and understandings of what tagging entailed (Heer & Agrawala, 2008; Weick, Sutcliffe, & Obstfeld, 2005), these two student uses of social bookmarking were somewhat anticipated.

Although research indicates that students perceive efficiency as an affordance of technology (Lonn & Teasely, 2009), the next two findings of uses of the social bookmarking website were unexpected. Although researchers (Hsu, Ching, & Grabowski, 2008; Stork, 2007) found that social bookmarking promotes organization of resources, and Farwell and Waters (2010) found that organizing information through the use of bookmarks improved understanding, in my study the students used the organization afforded by the social bookmarking site as a time-saving tool in order to quickly locate new informational websites and to sort through previously selected websites to find targeted information. In a similar fashion, the students utilized the affordances of communication and collaboration of social
bookmarking like Hsu, Ching, and Grabowski (2008). However, the students also used the social bookmarking site as a project management tool to monitor other group member’s progress by tracking the number of websites saved and tags applied. In addition to the use of social bookmarking as a tool, the students used social bookmarking and tagging as a support for face-to-face collaborative sensemaking much like Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) in their study of Zydeco in a museum.

**Social bookmarking to make sense efficiently.** Students have made sense of content through classifying and labeling information (Golder & Huberman, 2007; Heer & Agrawala, 2008; Weick, Sutcliffe, & Obstfeld, 2005), aligning evidence and claims (Berland & Reiser, 2009; Duschl, 2000), and engaging in collaborative discourse (Cahill, Kuhn, Schmoll, Lo, McNally, & Quintana, 2011) to make sense of information. Through social sensemaking behaviors of annotation (Kuhn, Cahill, Quintana, & Schmoll, 2011) and organization (Weick, Sutcliffe, and Obstfeld, 2005), students were able to make their thinking visible (Bell, 1997).

Students have utilized technology as well to better make sense of new content. Zydeco (Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana, 2011) provided a platform for tagging of resources to support inquiry. My study indicates that Delicious.com, a social bookmarking website, also functioned as an online support for sensemaking. As students collected, organized, and annotated bookmarked links, the students extended the research of Cahill, Kuhn, Schmoll, Lo, McNally, and Quintana (2011) by using delicious.com to provide support for these sensemaking practices. In addition, several students utilized the social affordances of communication and collaboration of the bookmarking process while selecting links, bookmarking, and applying social tags as a support for collaborative sensemaking activities (Cahill, Kuhn, Schmoll, Lo, McNally, & Quintana, 2011; Fisher, Counts, & Kittur,
Like the students using Zydeco (Cahill, Kuhn, Schmoll, Lo, McNally, & Quintana) as a tagging platform, these students collaborated online through sharing of tags as well as face-to-face within the classroom as they discussed the merits of each website before saving the site and tags on delicious.com.

Lonn and Teaseley (2009) found that students considered efficiency a valuable affordance of most technology in the classroom; in my study, the students perceived social bookmarking as a way to work efficiently. The students made use of this affordance of efficiency in multiple ways. They utilized the social bookmarking tool creatively (Stahl, 2007) as they drew upon their everyday understandings and strategies (Rose & Barton, 2012) to make sense of the tools and perceived affordances of technology (Lonn & Teaseley, 2009) in new ways. Students in my study used the affordances of social bookmarking to save time, monitor progress of other students, support each other’s work, and collaborate both face to face and online through the social bookmarking site.

**Students’ Use of the Wiki**

This study found that the students used the wiki in three ways: (1) a tool to support co-construction of knowledge and articulating understandings, (2) support communication, and (3) facilitate project management. The first two findings in which students utilized the wiki were anticipated based on the affordances of the wiki as outlined by researchers (Cress & Kimmerle, 2008; Fong & Wang, 2007; Larusson & Alterman, 2009). However, several challenges to wiki use also emerged through the analysis. Attribution of collaborative work to individual students is difficult (Trentin, 2009); as shown by the case of Emma and Brandi, often students enter work collaboratively by utilizing one account, leading to over-attribution
to one student and under-attribution to another, resulting in the need for new methods of analysis compared to transaction analysis (Peters & Slotta, 2007). In addition, in opposition to studies in which communication using the wiki was an affordance, the students in this study found that communicating through the wiki was a challenge. Although the solar group invented creative ways of communicating on the wiki, the students in the nuclear group simply did not communicate often, as noted in research by Liccardi, Davis, and White (2007). Another challenge was found to be technological issues within the wiki design that limited the ability of students to co-author effectively; Tammy, John, and Dane, however, utilized prior experiences to not only find personal solutions to this issue, but also share their expertise with others. Given these findings, I suggest methodological considerations for future research with wikis later in this chapter.

**Utilizing wikis for communication and articulation.** Research indicates that student use of a wiki can improve content knowledge and support collaboration (Fong & Wang, 2007; Larusson & Alterman, 2009). As students articulated their understandings of alternative energies on their wiki page, they make their thinking visible, much like an argument map (Bell, 1997). Through collaboration with other students online, students can create knowledge artifacts that demonstrate group understandings. In addition, as students utilized the affordances of the wiki for communication, the group’s process of coming to consensus can be made visible. Although research (Cress & Kimmerle, 2008; Liccardi, Davis, & White, 2007) indicates that communication can be difficult even with the presence of discussion boards in most wikis, the students in the solar group created inventive ways to utilize the affordances of the wiki to communicate with group members and others.
Ownership appears to support collaboration. Wikis have been purported to support collaboration and co-construction of knowledge artifacts (Larusson & Alterman, 2009). Studies have reported that students with high levels of editing and communication showed evidence of collaboration; collaboration has been linked with increased understandings of content (Fong & Wang, 2007; Peters & Slotta, 2010). As such, wikis should function along the lines of Scardamalia and Bereiter’s (2006) knowledge building society. In contrast however, I found that even when students are tasked to work together and prompted to peer-edit and collaborate, collaboration between students when using a wiki can not be assumed. Many of the students in this unit only added content or edited the wiki minimally. In my study, however, small numbers of students (one to three per group) such as Molly, Tammy, Lori, and John contributed highly to the content and editing on the wiki, assuming responsibility of the page by taking ownership of it (Thom-Santelli, Cosley, & Gay, 2009). Examining the students’ patterns of interaction leads to the conclusion that although most students co-constructed the page, they did not collaborate but rather divided-and-conquered the task. This illustrates the difficulties that are inherent with collaboration as a learning strategy in the classroom. Utilizing a wiki as a collaboration platform (Larusson & Alterman, 2009) does not guarantee that all students will collaborate. Because students who interacted at a higher level within the wiki did exhibit patterns of collaboration, however, this finding adds to empirical studies on wiki use within classroom settings as teachers utilize technology to support students articulating their group understandings.
Students’ Design and Construction of the Multimedia Artifact

Through my analyses of recordings of students creating their artifact, interviews, and students’ persuasive artifacts, I found that the students used the design and construction of their multimedia artifacts as tools to support their engagement in argumentation around the topic of alternative energy as they made sense of the information (McDonald and Kelly, 2012). In addition, after participation in the design process for the multimedia artifact, the students recognized the importance of counter-argument (Sampson & Clark, 2011) and made use of different techniques to persuade their audience of their viewpoint. By attending to the audience during design (Zahn, Hesse, Finke, Pea, Mills, & Rosen, 2007), students focused deeply on the construction of the multimedia argument in conjunction with their unknown audience, including providing ample numbers of counter-arguments to combat potential counter-claims. As the use of counter-arguments and rebuttals has been linked to increased understandings about scientific content (Sampson & Clark, 2008), this finding has implications for how students can learn science content during participation in argumentation.

Differences in goals lead to different products. The students in this study created persuasive multimedia artifacts that contained the elements of an argument (Zohar & Nemet, 2002) with a claim and valid justifications. The design and construction of the persuasive artifact provided an additional support for students to engage deeply in the content (Bielaczyc & Blake, 2006) and improve argumentation skills (Zahn, Hesse, Finke, Pea, Mills, & Rosen, 2007). I posit that the design process enhanced development of both argumentation and understandings of alternative energy through the added interaction not only with the students within class, but also with the unknown audience (Zahn, Hesse, Finke,
Pea, Mills, & Rosen), as students considered possible rebuttals and counterarguments and constructed arguments that anticipated the audience’s responses.

In addition, research (Ferretti, MacArthur & Dowdy, 2000; Nussbaum & Kardash, 2005) found that classroom goals focused on identifying or creating elements within the structure of argumentation such as counter-arguments improved student argumentation skills, whereas focusing on persuasion alone does not improve argumentation. In my study, however, the students created arguments that contained the elements of counter-argument, justification, and rebuttals (Nussbaum & Kardash, 2005), indicating stronger arguments, even though the project was focused on the teacher’s intended goal of persuading the audience. In addition, the students created personal goals or understandings (Stahl, 2007) for their multimedia artifacts: efficiency, humor, and emotional appeals. They added creative elements and utilized persuasive techniques that drew upon argumentation strategies, affordances of the technology, and everyday understandings (Rose & Barton, 2012) of persuasion to meet their goals for the video.

Discussion across the Analyses: Implications from the Three Study Aspects

Research on Argumentation

Studies (Driver, Newton, & Osborne, 2000) have examined student participation in the practices of argumentation within the science classrooms. Others have examined artifacts to identify components of arguments (Kuhn & Reiser, 2006; Zohar & Nemet, 2002). Still others have tried to improve student discourse (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Kuhn & Udell, 2004; Osborne, Erduran, & Simon, 2004) with hopes of
When designing this unit, I posited that students would be engaging in argumentative discourse over the length of the unit as they researched materials, co-authored the wiki page, and constructed their persuasive multi-media artifact; research on argumentative discourse has found that students used collaborative discussion to persuade peers (Driver, Newton, & Osborne, 2000) or resolve issues (Andriessen, 2007). However, that was not apparent in the classroom video; the argumentation that was present was primarily found within the final segment of the unit – within the multimedia artifact not during construction of it. I found that the majority of the groups did not argue over perspectives taken or evidence selected to use in the presentation. As such, I take the multimedia artifact as the actual argumentative discourse that exists between the group members and their unknown, future audience. Within this presentation, the students engaged in argumentative discourse with a silent audience by examining the content and selecting justifications, counter-arguments, and rebuttals that they felt would outweigh any counter-arguments presented by their audience in the future.

This present work builds on research that bridges student use of components of an argument and their argumentation skills. Zohar and Nemet (2002) found that students’ use of scientific content as evidence in their justifications had implications for their understanding of the content. In a similar manner, my work suggested that students prioritized the importance of counter-arguments within argumentative discourse, even with the instructor’s focus on persuasion and not the elements of the argument (Ferretti, MacArthur & Dowdy, 2000; Nussbaum & Kardash, 2005). Students viewed counter-arguments as imperative to producing a valid argument (Zohar & Nemet, 2002) as well as providing credibility and an
assumption of expertise for the authors. In addition, attending to the goal of persuasion (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000) helped shift participation by students from “doing school” towards “doing science”. Understanding how students valued counter-arguments both in construction of persuasive artifacts and while viewing arguments being presented to them can provide insight into how students select evidence when constructing arguments and the way in which students interpret arguments that are presented to them.

**Research on Socioscientific Issues**

The use of socioscientific issues in science education classrooms more deeply engaged students (Zeidler, Sadler, Simmons, & Howes, 2005) through discourse and connections to their everyday lives. As such, student use of evidence when arguing about socioscientific issues contained everyday knowledge from multiple fields and ways of knowing. The case study of Mandy and Susie illustrated the how students draw upon everyday knowledge as well as the tension described by Rose and Barton (2012) and Jones (2008) in low socio-economic households when making decisions about environmental issues. The girls’ initial selection of evidence of jobs possible and the lower cost of biomass energy were used to persuade someone to vote for biomass energy. However, after beginning construction of their project, the girls changed their perspective and completed their presentation by persuading against biomass energy because of health reasons. The initial choice of a monetary argument, which was later changed to health, illustrated this economic tension. Everyday understanding of evidence was brought into the classroom by students to use as data and form warrants (Rose & Barton, 2012; Osborne, Erduran, & Simon, 2004; Sampson, Simon, Amos, & Evagorou, 2011). Building on research by Rose and Barton (2012), this study examined ways in which students utilize their everyday
understandings of science processes and examples, as well as tools and technological solutions (Stahl, 2007), to make sense of science content and argumentation.

In this manner, this study’s findings also add to understandings about student selection of evidence when constructing arguments for socioscientific issues. Research (Rose & Calabrese Barton, 2012; Sadler, 2004; Sampson, Simon, Amos, & Evagorou, 2011; Simonneaux & Simmoneaux, 2009) on this matter was contradictory. Students have selected evidence from information provided to them by educators over personal beliefs (Sampson, Simon, Amos, & Evagorou, 2011). Other studies indicate that students selected personal values over scientific data to use as evidence for their justifications (Rose & Barton, 2012; Sadler, 2004). Within this study, however, students chose evidence from everyday understandings of persuasion, from scientific data or information presented on the wiki, and from both avenues. I found that the students’ choice of what to prioritize for evidence depended on the goal for the argument chosen by the students. This study’s findings extend research in socioscientific issues (Ekborg, 2005; Zeidler & Sadler, 2007) where youth were found to value emotion and personal beliefs as legitimate factors in decision-making. Participating students used neutral facts and humor, selected evidence that met the project criteria, and attempted to sway using phobias and fear. This illustrated that the group’s choice of evidence was dependent more on personal goals for their presentation than scientific evidence, even when evidence was selected as a part of the presented argument.

**Research on Technology within Science Classrooms**

Integrating technology within the science classroom has often been costly as well as topic specific in order to support discourse or argumentation (Bell, 2004; Linn, Davis, &
Bell, 2004; Slotta, 2004) or support communication. On many occasions, costly technological adoptions lead to wasteful spending or budgetary cuts. Through freely available Web 2.0 technologies, I added to the understandings of how scientific practices can be supported in the high school classroom with social bookmarking for sensemaking, wikis for articulating understandings, and design and construction of video to support persuasion—in ways that are scalable due to the low cost for districts and classroom teachers. Implications from this dissertation study support the use of inexpensive Web 2.0 technologies function as supports for student learning and participation in the scientific practices of argumentation.

**Design Principles for Inquiry Supported by Technology within Classrooms**

The design of this unit utilized Technology-Enhanced Inquiry Tools for Science Education as a pedagogical framework (Kim, Hannafin, & Bryan, 2007) to support and explore the interactions among the macrocontext (educational standards), the teachers’ community, and the microcontext (classroom). Specifically, this analysis focused on the microcontext portion of this framework (Kim, Hannafin, & Bryan, 2007) and the interactions between:

a) teacher and tool while selecting the inquiry tools,

b) teacher and student through the creation of project guidelines, deadlines, and other requirements, and

c) student and tool as the youth utilized the Web 2.0 tools to create artifacts and solve problems.
Based on this study’s findings, I propose a revised model for this Technology-Enhanced Inquiry Tools for Science Education framework that incorporates a peer within the interaction patterns (See Table 7-1). By adding a second student (a peer), the collaborative interactions within the classroom are addressed, as well as the interactions between teacher, tool, and student. In addition, the interactions between the tool and each individual are shown in the original model; a second implication to this model comes from findings from this study related to the influential nature of the teacher-student and student-student interactions. To emphasize the interactions between the individuals, I have modified the visualization through providing a prominent arrow.

Figure 7-2. The revised Technology-Enhanced Inquiry Tools for Science Education framework, adapted from Kim, Hannifin, and Bryan (2007), based on findings from this dissertation study.
In conjunction with the revised Technology-Enhanced Inquiry Tools for Science Education framework, I distilled design principles from my study findings for each set of interactions within the microcontext or learning environment to better support teaching and learning with inquiry tools in a technology-enhanced setting.

1. **Teacher – Student interactions**
   
a. Provide clear examples of noticing when researching and participating in inquiry activities to direct students’ attention to key words, features, and details.
   
i. Using questions and modeling behavior can help students attend to features and details that would be easily overlooked when using the technology.

b. Ask questions and provide examples that are open ended and require student articulation of their understanding of the question as well as the answer.
   
i. Supporting student engagement that is extended over a period of time, as well as utilizing deeper questioning techniques can

2. **Teacher – Tool interactions**
   
a. Carefully align tool use with objectives, outcomes, and standards.
   
i. With the plethora of tools available for use, ensuring that the affordances of the tool align with the requirements of the project is imperative.

3. **Student – Tool interactions**
a. Scaffold inquiry activities by identifying appropriate activities and/or targeting research and providing guiding questions for their use.
   
   i. Often students engaging in technology-supported inquiry can be overwhelmed by the amount of information available. By targeting key links or activities initially, students can identify factors that are present in valid or helpful resources.

b. Train students in tool and technology use and provide checklists of procedural steps for suggested troubleshooting of problems.
   
   i. Students can become very frustrated by technological problems when working. Although many are adept at solving their own problems, but providing support for issues, students can work through technology problems with less frustration.

c. Ask multi-part, probing questions that require deep engagement with the content supported by the tools when providing guidance.
   
   i. Students often quickly find “answers” that satisfy requirements and utilize the technology for their perceived affordance of entertainment. By eliminating the need for straightforward answers with no dilemma attached and incorporating tool use in the construction of the answers, students are more likely to engage in the content, tool use, and inquiry.

d. Allow students to demonstrate expertise by incorporating everyday understandings of tool and technology use, as well as content and practices (Rose & Barton, 2010; Stahl, 2007).
i. Students’ perceived affordances of tools are not always aligned with the teacher’s or developer’s intended use. By allowing students to not only demonstrate their prior knowledge and expertise, but to also develop their own methods and techniques, student engagement could be affected.

4. **Student – Student interactions**

   a. Provide opportunities for face-to-face/online conferencing when collaborating on projects that span different times or settings.

      i. By eliminating contradictions or confusion about division of labor, students can make more valuable use of their time.

   b. Utilize tools that provide a record of student-student interactions.

      i. Scripts, recordings, and wiki histories, for example, can be used as evidence of responsibilities, shared procedural or technical expertise, and a history of the construction of knowledge developed during the interactions.

**Methodological Implications**

Within this dissertation, I utilized two coding schemes for the social bookmarking data; I offer suggestions for others studying technologically-enhanced science learning based on the utility of these analytical tools. The first, based on Kuhn, Cahill, Quintana, and Schmoll, (2011), examined the website titles and social tags found on delicious.com for support or annotation. This strategy supported my analysis of how the students made sense of the content, by copying words or summarizing, indicating deeper understanding. Secondly, I
analyzed the social tags for content using the topics organizing the wiki as initial codes. I also added codes for position and evaluation. These additional codes were rarely used. Other codes were added as needed, for example -- communication. This dual coding scheme allowed me to examine the strategies that students used for creating their social tags, as well as the content of the tags.

Coding the wiki content was also a two-fold process. The initial codes for the wiki analysis were based on Weinberger and Fischer (2006). These supported my analysis of the four dimensions of computer-supported argumentative knowledge construction, however I did not find work on the wiki that was coded as argumentative. Additional codes were added for communication, organization, delete, and management strategies. These codes allowed me to examine how the students utilized the wiki in unexpected ways. The second wiki analysis was based on Peters and Slotta’s transaction analysis (2010), which focused on tracking all transactions made by students through each time-stamped entry in the wiki. Time-stamped entries alone do not provide the detailed information about peer editing that I needed. Therefore, I examined classroom video in addition to the wiki transactions to better understand student wiki use.

Importantly, this dissertation analysis brought to the forefront a concern about the current accepted methods of analyzing students’ contributions to a collaborative wiki that needs to be addressed. In the case of Brandi and Emma, they collaborated to post content and comments that were then verified by the video. These two learners shared the duties of finding information and posting it to the wiki collaboratively, with one student’s laptop being used for research and the other for wiki construction. While both students contributed to the research and authoring of the wiki —only one student’s name appears in the wiki revision
history. This finding raises methodological concerns about measuring student contributions to the wiki by only using the data analytics from the system. Therefore, I used transaction analysis—as well as asked the students about entry methods in the interview—to gain an awareness of how entry data could be compromised. Only three pairs of students admitted that they had shared computers during the wiki construction portion of the project, limiting the number of students with incomplete data. This finding has significant implications on the analysis of individual contributions to a collective wiki. Counting transactions and editing moves cannot always provide complete data on how students use the wiki when constructing a knowledge artifact. Video provides an additional tool for a more complete analysis. Others using transaction analyses that rely solely on data analytics from the computer system will miss students’ contributions when students are collaborating face-to-face, in addition to the online portal.

The video analysis was also divided into two parts: the persuasive multimedia artifact analysis and the analysis of classroom video and interviews. The student-constructed, persuasive artifacts were analyzed using a framework by Zohar and Nemet (2002). This framework simplified the structure of the arguments. However, it was sometimes difficult to classify statements into the categories, particularly when it concerned a socioscientific issue. Determining what to count as evidence, whether scientific information or everyday understandings of persuasion, was also a problem in some multimedia artifacts.

The classroom video was analyzed for argumentation and then open coded using interpretive analysis. Tool use was observed and noted during the classroom video; student interviews were coded in the same manner. Emerging categories were utilized when analyzing the written reflections.
**Directions for Future Research**

Several directions for research presented themselves over the course of this study. First, as a result of this study, I see new areas of investigation for myself. A secondary analysis of this data set could be used to investigate the other groups within the classroom by utilizing the same research questions. This could potentially enrich the present findings with additional verification or present pathways to investigate and triangulate with the current data. I could also use this data set to investigate other related research questions such as, “the other roles that students appropriated within the groups in addition to the ownership/Maintainers on the wiki”. This question could impact research on identity development and provide insight into the non-engaged/participating students’ behaviors. As the groups changed over the course of the project, another possible path for additional research would be tracking the “wiki owners” over the entire duration of the project and examining their engagement on all portions of it.

Moving into newer concepts, I believe future iterations of this study could also inform the following questions as well as how these questions and findings tie to theory. “Do the wiki owners only deeply engage in the wiki format with their previous group, or do they also become owners when grouped with other students?”, “How do these behaviors correlate with their in-class behaviors?”, and “What relationship exists for highly engaged owner’s production on the wiki and evidence of their learning?” A final question, “How can educators support all students to reach this level of engagement when working in an online collaborative environment?” reaches beyond the use of tools for this study to other online environments.
In addition, this study has implication to others’ research. From both my literature review and new findings, areas of additional research were identified. First, more focus is needed in the design of learning environments to acknowledge both everyday and disciplinary ways of knowing—leaving space for students’ meaning making with multiple cultural tools. As students creatively utilize technology within classroom settings, examining their perceived affordances and prior experiences can help bridge their everyday and scientific understandings and lead to deeper learning. Other related questions could examine the evidence that students select and their reasons for its selection, as well as how this evidence is interpreted by other students. In addition, examining student use of Web 2.0 technologies as tools to support participation in science practices as well as their perception of the affordances of the technologies and subsequent uses.

Conclusion

This study provides perspectives on student use of Web 2.0 tools within a science classroom environment to engage students as they participate in science practices and increase the potential for student learning. By focusing on the alignment of affordances of technology, scientific content, and the sub-practices of argumentation, I was able to examine how students used the Web 2.0 tools:

(a) to support their learning and participation in ways that were expected from prior literature,
(b) in unexpected ways to solve problems, and
(c) in new, inventive and creative ways to communicate, collaborate, and reach goals that were set by the instructor as well as themselves.
By examining how students perceive the affordances of technology for learning and supporting participation in science practices, we can use these technologies to bridge students’ everyday and scientific understandings of sense making, articulating understandings, and persuading others of their point of view. Utilizing technology as a bridging strategy within the classroom can help deepen students’ understandings of science content, as well as support students as they learn to participate in the practices of argumentation.
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Appendix A: Pilot Study

A pilot study was conducted in 2009 as an attempt to measure the effects of
(a) using social bookmarking to support the practice of argumentation and
(b) creating podcasts about alternative energy on student understanding of alternative
energy resources.

The goal of this study was to investigate how content learning and scientific
argumentation could be facilitated by Web 2.0 technology within a classroom setting.
Specifically, I answered two research questions to better understand this issue:

3. How can social bookmarking and podcasts be used to support youth’s construction of
group and individual scientific content knowledge?

4. How can social bookmarking and podcasts be used to support student selection and
use of evidence when constructing scientific arguments?

Pilot Study Demographics.

The study was conducted at a small, rural, public high school situated in Northeastern
United States. The demographics of the school show it to be mainly White with a higher than
average proportion of students who are economically disadvantaged, as determined by the
percentage of the population receiving free or reduced lunches. The school is a one-to-one
computer school, with all students in grades nine to twelve receiving a MacBook laptop
computer in September to use in and out of school until the end of May for the duration of
their high school career. The students receive training on use of the computer, software, and
applications in required technology classes as well as within core subject area classes on an
as needed basis.
In addition, the teachers at this district are highly qualified instructors within their field of study, as well as receiving additional training on the use of technology within the classroom setting. For this specific study, the teacher was an experienced high school chemistry teacher with over seventeen years of classroom experience who had taught this unit before utilizing other design strategies, as well as having taken classes in the use of educational technology.

**Pilot: Study Design, Data Collection, and Data Analysis**

**Pilot study design.** To this end, the pilot study was structured as a static group comparison to allow both a treatment and a control within the confines of one teacher’s classroom in a high school setting. Four classes of students were used for this study, two academic chemistry and two general chemistry classrooms, which were taught by the same experienced chemistry teacher. One academic and one general classroom were selected without bias from the two possible choices for both the experimental and the control group.

All students were assigned the task of forming an argument for one viewpoint either for or against an assigned alternative energy source (wind, hydroelectric, solar, nuclear, and geothermal) and creating a Podcast to convince others of their position. The students in both groups researched and organized Internet resources through either traditional methods or through the use of delicious.com [a social bookmarking website]. The students were required to use a storyboard when constructing their argument in order to scaffold and promote their structure used for scientific argumentation. The groups used this research and storyboard to construct a video Podcast that presented their argument either for or against the energy source.
All students in the classroom watched all podcasts. A discussion followed in each class about the strength and structure of the arguments presented as well as the content material. The students were given a content assessment that included an open-ended response in which students were required to read a scenario concerning their town, make a decision about “building an alternative energy source” near the town, and construct an explanation supported by evidence. Students were allowed to access their collected research materials and podcasts during the construction of the essay.

Materials provided to all students were project guidelines and timelines, grading rubrics for the podcast and essay, storyboard scaffolds, and a checklist of research materials needed for construction of the podcast. All students had access to Garageband or iMovie, as well as previous instruction in the use of these programs, to construct their podcast. The control group was given instruction about research methods prior to research beginning, with directions to save and share their resources found with their group in any way that they were comfortable. The experimental group was given general instruction concerning research methods as well as specific instructions on the use of delicious.com.

Data collected for the pilot study included the student storyboards, podcasts and rubric scores, essays and rubric scores, delicious tags, list of bookmarked links from delicious, and a questionnaire containing both Likert scale and free-response items. This multifaceted data collection strategy allowed for triangulation of multiple data sources as well as between control and experimental groups, increasing the validity of the study. The researcher-constructed rubrics were checked by high school science department members for content accuracy and by a university faculty member for validity of constructs.
**Pilot Data Analysis.** The analysis for the pilot study focused on the overall impact of delicious.com use on the arguments produced by the students in the podcasts and the individual essays. In order to do this, I analyzed the data from delicious.com, the knowledge artifacts (podcast and essay), and student responses to the questionnaire. The knowledge artifacts were scored using a rubric by the researcher with approximately 10% of the scores cross-checked by a science teacher for reliability. Descriptive statistics (mean and t-tests) were used to compare the control and experimental group scores on the rubrics for podcasts and essays, and the Likert scale values from the questionnaires.

The essays and questionnaires were open-coded using atlas.ti for responses concerning the process of argument construction, technology support, and student attitude surrounding the use of technology. Coding categories for argumentation within the individually written essays and free-response segments of the questionnaire were based on the work of Zohar (2004) and Zohar and Nemet (2002): justification, counter-argument, rebuttal, structure-simple, and structure-complex. Simple structure was used for evidence without an explanation, and complex structure was taken as evidence used in the construction of an explanation. The open codes were then examined for themes and categories in order to discern possible trends and relationships between student-constructed arguments in the podcast and essay, student attitudes about the project, and their ideas about the use of delicious when structuring their arguments.

**Pilot Findings**

**Differences in Content Knowledge.** Statistical analysis of the science content segments of the rubric scores for both the podcast and the essay had no significant findings at
p<0.05 for any area. Based on Cohen’s recommendation (1994) for the use of p<0.10 for significance when analyzing exploratory data, further investigation into the topic is warranted. The p-values of p=0.092 for the podcasts and 0.079 for the essays indicate that the use of delicious positively affects content knowledge acquisition.

**Differences in argumentation.** When looking at student construction of arguments in the individually written essay, the statistical analysis shows one area of significance, the component “Support for position”; this segment was found to be significant at the p<0.05 level. This component is directly related to the development of an argument through the use of evidence and counter-examples. Thus, it can be concluded that the use of delicious.com supports student use of evidence when constructing an argument. In addition to the statistical analysis, qualitative data shows agreement, with Shawn stating that “[delicious helped] find a reason to go argue the statement by searching for it in the tags”. Another student, Julie, stated that the tags “made us thing of what we needed”, and Amy concurred by stating that delicious “showed us information that would prove an argument”. Furthermore, analysis of the open coding of the essay indicates that the students using delicious.com used more evidence when constructing arguments, although not at a statistically significant level.

Another area of significance at p<0.10 (Cohen, 1994) showing delicious use impacting argumentation is in the area of organization. Not only did students enjoy organizing their information with delicious.com (rubric components for “Enjoying organizing with delicious”, p = 0.010 and “Made organization easier”, p = 0.066), but also organization could be considered to have an impact on student argumentation. When constructing scientific arguments, thoughts and evidence must be structured in a logical
progression of ideas. By making organization of materials and resources easier and more enjoyable, delicious.com supported students in their construction of arguments.

**Pilot Implications**

The use of delicious.com in a classroom has potential to support student construction of content knowledge. The act of creating tags [summary words] uses reflection and categorization as students read and then summarize the articles or websites in a few brief words (Hsu, Ching, & Grabowski, 2008; Or-Bach, 2005). This summarizing process requires students to organize the information, thereby possibly constructing content knowledge. Furthermore, when students sort the resources using the tags as key words, delicious functions similarly to a database, allowing students to see connections between topics that might not have been previously apparent.

When looking at student construction of arguments, the use of delicious.com was also shown to have potential in supporting selection and use of evidence. By providing students with a visual method of organizing their materials, the students appear to be more likely to search for more evidence to support their arguments. In addition, using the tags as keywords when searching allowed resources that students may have missed to be brought to the forefront, providing them with more information to use when constructing their argument.

**Pilot Implications for Future Research**

With the recent publication of the K12 Framework (National Research Council, 2012), teachers need to incorporate science practices into the science classrooms. This pilot study highlights the potential for technology to facilitate this process. Specifically, Web 2.0 technologies such as social bookmarking and podcasting are important tools that allow for integration of the practices of communication and collaboration into content areas. However,
more research is needed into how using Web 2.0 tools of social bookmarking and wikis affect content learning, collaboration, and specifically in science, how they can support the acquisition of scientific practices.
Appendix B: Task

Alternative Energy Project

TASK:

Our classes will develop an online resource about alternative energy. Each page or set of pages will be dedicated to one specific type of alternative energy. In order to form a non-biased view, you should incorporate both perspectives, pro-energy and anti-energy, into your work.

OVERVIEW:

Each page should provide an overview of each of the following areas (these are the categories generated in class):

- Name of energy and description
- Science behind the energy
- Advantages
- Disadvantages
- Cost to build/install
- Cost to operate
- Are there geographic factors that are unique to this type of energy?
- What is the impact on the population?
  - Health
  - Jobs
  - Space required

The page must include at least 5 pictures or graphics that illustrate points that you feel are crucial to understanding the energy resource. Each picture or graphic must include a caption.

All work must be cited.

GRADING:

- The group pages will be graded on completeness, content (correct information), and grammar. You may not copy and paste segments of text from other sources.
- Individuals will be graded on their page contributions (significant addition of material and/or editing).
- In addition, each person is required to post at least one question on two pages OTHER than their assigned topic. These questions are to ask about the content, clarify a point that was made, or contribute material that might help the page authors improve their work. This can include grammatical issues or formatting that makes the
page difficult to read or understand. These comments must be constructively framed. Comments such as "good job", "I don't like this", or "I think we are done" are not acceptable.

- Finally, each person must respond to two questions or comments. These can be on their page or on another. The responses must be a significant contribution: answering a question, elaborating on a response, or rebutting a response.
## Appendix C: Story Boards for Podcast

<table>
<thead>
<tr>
<th>Introduction</th>
<th>State problem, point of view, and purpose of the podcast</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>State fact</td>
</tr>
<tr>
<td></td>
<td>Impact on your group</td>
</tr>
<tr>
<td>2</td>
<td>At least 2 reasons/pieces of evidence to support</td>
</tr>
<tr>
<td>3</td>
<td>State fact</td>
</tr>
<tr>
<td></td>
<td>Impact on your group</td>
</tr>
<tr>
<td>4</td>
<td>At least 2 reasons/pieces of evidence to support</td>
</tr>
<tr>
<td>5</td>
<td>State fact</td>
</tr>
<tr>
<td></td>
<td>Impact on your group</td>
</tr>
<tr>
<td>6</td>
<td>At least 2 reasons/pieces of evidence to support</td>
</tr>
<tr>
<td>7</td>
<td>Statement against your position</td>
</tr>
<tr>
<td>8</td>
<td>Evidence for it</td>
</tr>
<tr>
<td>9</td>
<td>Why it doesn’t matter</td>
</tr>
<tr>
<td>10</td>
<td>Concluding statement</td>
</tr>
<tr>
<td></td>
<td>References/Credits</td>
</tr>
</tbody>
</table>
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