COMPUTER-MEDIATED SCAFFOLDING FOR COLLABORATIVE ARGUMENTATION ON SOCIO-SCIENTIFIC ISSUES

by

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Abstract

Socioscientific Issues (SSI) education attempts to engage students in informal argumentation on controversial socioscientific issues. In this thesis, a computer-supported collaborative learning (CSCL) tool to support and scaffold student argumentation, called *ArgueMint*, is designed and implemented. A design research study was undertaken to examine how the software was used by pairs of students in a face-to-face setting, and to improve it's usefulness and usability. Written output and transcripts were analysed for evidence of good argumentation, aspects of socioscientific inquiry and collaboration, and usability. The students in the study tended to consider multiple perspectives and support claims made in their argument, while they did not tend to consistently identify weaknesses in their arguments. Proposed directions for further development of *ArgueMint*, as well as questions for further research, are identified.

To my family
Marianne, Kaitlyn, & Rebecca

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Contents

List of Tables

List of Figures

Chapter 1

Introduction

The role of science education in society has come under close scrutiny in the last few decades, undoubtedly as a result of the increasingly important role of science and technology in our society. Commonly, science courses seem to be designed to teach the knowledge and processes required for success in future science courses; this "spiraling" continues throughout grade school and university classes, culminating, presumably, in a career in science in which this knowledge and skill will be useful. This concept of science education as preparation for careers in science has been described as the "pipeline" (Aikenhead, 2005; DeBoer, 1991). Few students who are destined for careers outside of the field of science feel connected and comfortable with science courses in this "pipeline" model (Kozoll & Osborne, 2004). Although they may feel that they understand the material covered in the course, it does not connect with everyday life and therefore may be perceived as irrelevant.

It has become increasingly popular to use terms such as "scientific literacy" to describe a new ideal for science education (Hodson, 2003), although the precise meaning of the term is often unclear. In an early attempt at defining scientific literacy, Pella, O'Hearn and Gale (1966) identified several areas of understanding that are necessary:

- the basic concepts of science
- the nature of science
- the ethics that control the scientist in his or her work
- the inter-relationships of science and society
- the inter-relationships of science and the humanities
- the differences between science and technology

This description underlines the multi-faceted nature of scientific literacy, and goes far beyond the traditional view that would likely include only the first two points. However, more recent attempts at defining scientific literacy go even further in their emphasis on citizenship, on participation in a modern society heavily influenced by science and technology. The National Standards for Science Education (National Research Council, 1996) in the United States describes scientific literacy as the "knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity." According to this definition, scientific literacy is wrapped up in the everyday encounters with science that a citizen of our present society is likely to experience. The increasing presence of scientific issues in personal decision making, politics, culture, and economics is explicit. The Standards further describe this position:

> Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity

> of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately.

If scientific literacy is a goal of science education in our schools, then it is clear that it will require a wider scope than a more traditional view of science teaching might. All too often, science education in schools consists primarily of "knowledge about science", in which "right answers" are tidily presented to students and recalled on multiple choice tests. Seldom are students given the opportunity to question or struggle with some of the challenging real-world issues that do not appear to have simple, one-dimensional solutions. Schwab (1962) describes a science education which is "taught as a nearly unmitigated rhetoric of conclusions in which the current and temporary constructions of scientific knowledge are conveyed as empirical, literal and irrevocable truths" to be insufficient. More recently, Driver, Newton and Osborne (2000) present a similar argument claiming that the presentation of science as an unproblematic collection of facts makes actual scientific controversies puzzling events for students. If we claim science literacy as the goal, however, our students will need to be able to tap into their knowledge about science and its methods in order to further a social discourse that reaches into all aspects of everyday life.

In my eight years as a high school science teacher, I have noticed that, in addition to the curricular and pedagogical emphases on "knowledge about science" and the drive towards performance on examinations, students themselves have picked up on this emphasis and often want nothing more than what is going to help them achieve a high mark on the final exam. This emphasis on correct answers, high grades, and "keeping their options open" for future science courses has, in many cases, led students to engage only superficially in discussions about the nature of science or real-world issues, as many students surmise that the content of such discussions is difficult to convert into multiple choice questions for a final exam and is therefore unimportant. For many students, high school science education is simply seen as a stepping-stone towards further science courses in the pursuit of a better career or acceptance into higher education.

In response to the largely positivist "pipeline" approach to science education, a number of research and pedagogical approaches have emerged. One of these is Science, Technology, and Society (STS) education, which emphasizes the interrelatedness of these three domains through a widely disparate set of pedagogical and theoretical approaches (Sadler, 2004). A related approach, STSE education, adds the environmental domain to the equation (Hodson, 2003).

Another approach to engaging students in scientific controversy is found in Socioscientific Issues (SSI) education. SSI seeks to provide opportunities for students to develop their skills in decision-making around controversies, encompassing moral and ethical dimensions as well as scientific and social ones. Zeidler (2002) suggests that SSI "subsumes all that STS has to offer, while also considering the ethical dimensions of science, the moral reasoning of the child, and the emotional development of the student". SSI education promotes ethical and moral reasoning about socioscientific issues through social interaction between students (Zeidler et al., 2005). It does this by engaging students in informal argumentation and discourse on highly relevant, important issues. The SSI approach to examining morals, ethics, and questions of the nature of science within an interesting real-world situation may, in my view, be able to motivate students to engage in real science for reasons other than higher test marks or advancement to the next science course in the "pipeline".

1.1 Science Times

The Science Times website[1] was developed to address the need for current, relevant and engaging instructional resources on socioscientific issues. Science Times provides up-to-date news about science, technology, and environmental topics, with a stated goal of allowing teachers to "challenge students' attitudes about science while also promoting scientific literacy" (Science Times, 2009). Articles are provided in three different reading levels in both English and French.

The articles provided on the Science Times website are used in this research to provide background information for the socioscientific issues being considered. These articles provide information about current research in a scientific field, along with the background information about the field that is required to understand the research. These resources are used due to their relevance and usefulness as a brief and age-appropriate introduction to socioscientific issues.

In my classroom, students have used Science Times articles in a variety of settings, including whole-class discussion, small-group discussion, and individual written assignments. In my approach to using the articles, students generally read the articles (or have them read to them by a learning assistant), and are then asked to respond in various ways. Discussing the articles as a whole class has proven useful in exposing students to a large number of different

[1] http://www.sciencetimes.ca

ideas and perspectives, but whole class discussions are often dominated by a few individuals and many students may be uncomfortable with sharing their ideas with the whole class. Small group discussions have the advantage of providing a higher level of comfort for students to share their ideas, and generally result in greater equity of participation, but in my experience the students tend to consider a much narrower range of perspectives on the issue and may not engage as deeply in the issue. Individual written assignments have the advantage of being easy to assess, but in my experience result in the shallowest arguments about the issue being considered.

In this study, I chose to approach the pedagogical side of SSI inquiry from the perspective of computer-supported collaborative learning (CSCL). CSCL focusses on the use of computers and the internet to scaffold group work, using software tools that promote collaboration between group members. A more detailed description of CSCL is undertaken in the next chapter. My goal was to find a pedagogical approach to the use of Science Times articles that would promote the sort of discussion from a broad range of perspectives that can occur in whole-class discussions, while promoting participation and engagement more equally from all of the students in the class. In addition, the use of a computer-based tool to support small-group discussion could provide opportunities for assessment that may not be otherwise available.

1.2 Research Study

The focus of this study is on the design and use of a computer-supported collaborative learning (CSCL) environment to scaffold student argumentation on socioscientific issues. Scaffolding is defined as support that enables students to perform a task they could not otherwise do independently (Wood, Bruner, & Ross, 1976). Scaffolding can provide support to student argumentation in a variety of areas, such as *conceptual*, *metacognitive*, *procedural*, or *strategic* support (Belland, Glazewski, & Richardson, 2008). Conceptual scaffolding provides help in considering the right sorts of ideas. Metacognitive scaffolding helps the user to manage the process of thinking about the task. Procedural scaffolding assists the user in using the tools required to complete the task, while strategic scaffolding is useful in providing strategies for completing the task. The tool that I created, *ArgueMint*, attempts to provide conceptual scaffolding (prompting students to think of ideas), metacognitive scaffolding (helping students to notice areas which may require attention), and strategic support (prompting students to approach the issue in a somewhat systematic way).

Much of the research (Kortland, 1996; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000) on argumentation in general suggests that students without prior instruction in argumentation or without some sort of scaffolding to support the process of developing arguments produce trivial arguments that often fail to account for multiple points of view, or fail to support their claims with evidence. In my view, CSCL provides a promising avenue in which deeper and more thorough construction of arguments can be supported.

I designed this study, using *ArgueMint*, to look at how students use this tool in a face-to-face argumentation activity. The study examines in detail the following questions:

1. How do students use ArgueMint in face-to-face argumentation on a socio-scientific issue?

2. What features of the system are the most useful and useable in mediating argumentation?

In answering these questions, this study provides further understanding of how students use a CSCL tool in SSI education. In addition, this study has the potential to provide direction for the further development of *ArgueMint* or other similar software tools.

1.3 Thesis Organization

The second chapter of this thesis describes the theoretical underpinnings of the study. The design of *ArgueMint* and the pedagogy around it draws on a wide theoretical base, including socioscientific issues (SSI) education, computer-supported collaborative learning (CSCL), argumentation, and cognitive load theory. These research foci are described in Chapter 2.

Chapter 3 describes the design and implementation of *ArgueMint*. It describes the aims of the software, the constraints impacting design, and decisions made about functionality. It also details the software and environments used, and the features of the software.

In Chapter 4, the research methods are described in detail. A design research approach was chosen for this study, with two iterations of design and implementation followed by data collection and analysis. A brief description of the participants in the study is given, followed by the materials and procedure used in the research activities. Finally, the procedures employed for analyzing the data are described, giving the codes that were used along with a description and example for each.

In Chapter 5, the results of the study are presented. First, a brief analysis of the first iteration of the study and the resulting changes that were made to the software before the second iteration is described. Following this, a more thorough analysis of the two iterations, particularly with respect to argumentation, SSI inquiry, collaboration, and usability, is presented.

Finally, in the sixth chapter, the results of the data analysis are discussed in light of the research questions given above. In addition, recommendations for the continued design and development of *ArgueMint* are given, in light of the research findings. Future directions for research are also provided.

Chapter 2

Theoretical Background

In this chapter, some of the research traditions that have informed the design of *ArgueMint* are described. I begin with a brief look at cooperative and collaborative learning, with particular focus on the use of technology in computer-supported collaborative learning (CSCL). Research in the area of Cognitive Load Theory (CLT), which informed the design of the user interface and some pedagogical aspects of the learning activity, is described. A discussion of Socioscientific Issues (SSI) inquiry, which provides the theoretical framework for the approach to the socioscientific controversies used in the research, follows. Finally, I examine the research on students' informal argumentation and different types of external representations of argumentation.

2.1 Cooperative and Collaborative Learning

The use of cooperative learning strategies in the classroom has been extensively studied, and positive outcomes compared to those achieved through individual work have been consistently demonstrated. For example, in a meta-analysis of 28 field studies of various cooperative learning strategies (including Teams-Games-Tournaments, Student Achievement Divisions, Jigsaw, among others), Slavin (1980) found evidence of higher achievement on test scores, as well as improvements in social measures such as race relations and mutual concern between students. Researchers such as Slavin and Johnson and Johnson (1999) focus on *cooperative learning*, which focusses on strategies and structures designed by teachers to promote effective group work. Johnson, Johnson and Holubec (1993) identify five essential components of cooperation:

- positive interdependence
- face-to-face promotive interaction
- individual and group accountability
- interpersonal and small group skills
- group processing

They argue that when these five components are systematically structured into group work activities, successful cooperation and learning will result. A significant body of research examining the effects of cooperative learning strategies has been developed over decades. For example, a recent study of the Jigsaw cooperative learning strategy employed in undergraduate chemistry classes demonstrated that students involved in the Jigsaw group scored higher on post-testing, and demonstrated superior understanding of the concepts in open-ended questions, than groups who did not employ the Jigsaw strategy (Doymus, 2008). In an experimental study involving pre-service teachers, Hornby (2009) found that the experimental group, in which the learning activities were structured to include elements of positive interdependence and individual accountability, significantly outperformed the control group, in which the same information was presented without cooperative learning elements. In these studies, as with much of the research in the field of cooperative learning, the focus is on the design of structured interactions between group members from the perspective of the teacher or instructional designer.

Collaborative learning research takes a different approach to the study of group work. Where cooperative learning research tends to focus on instructional design of activities within the classroom, collaborative learning researchers tend to be more interested in the nature of the interactions taking place between members of groups. Stahl (2006) suggests that the differences may be deeper than just a question of focus. He argues that in cooperative learning, learning is done by individuals within a group, who then present the collection of their individual results as a group effort; by contrast, Stahl claims that in collaborative learning, the group members collaboratively construct knowledge through interactions such as negotiation and sharing. Stahl's view of cooperative learning may be unnecessarily narrow and restrictive, as many of the instructional designs from the cooperative learning tradition are based around similar sorts of interactions; nevertheless, it highlights the focus that collaborative learning researchers have on the interactions between group members rather than on the design of activity structures.

Constructivism is often cited as an underlying theory for collaborative learning (Suthers, 2006; Stahl et al., 2006). Constructivism emphasizes the learner's efforts at meaning making rather than the transmission of knowledge from teacher to student. Collaborative learning can be approached from a perspective of social constructivism, in which the meaning making process occurs through negotation of shared meanings between members of the group (Stahl et al., 2006).

2.2 Computer Supported Collaborative Learning

Computer supported collaborative learning (CSCL) adds a technological dimension to collaborative learning. Researchers in CSCL examine and design computer-based tools that support student collaboration and group meaning-making. One of the key affordances of computers for use in collaborative learning is their ability to represent dynamically changing information (Roschelle, Rosas, & Nussbaum, 2005). In the context of supporting argumentation on a socioscientific issue, this sort of external representation may be particularly important, as students grapple with a complex set of ideas and connections between those ideas.

Kolodner and Guzdial (1996) identify a number of roles that CSCL software typically supports, most of which build on this function of dynamic representation. These roles include promoting inquiry and sense-making, facilitating knowledge building, record-keeping and maintenance of external memory, enabling communication with distant communities, promoting thoughtful reflection of alternative viewpoints, and supporting teacher planning of collaborative learning activities.

CSCL research has been interested in both distance learning and face-to-face interaction (Stahl et al., 2006). Projects such as CSILE (Computer Supported Intentional Learning

Environment) sought to support deeper and sustained student interaction in knowledge-building activities within a classroom environment (Scardamalia & Bereiter, 1994). Scardamalia aand Bereiter set out to create an environment that encompassed three main characteristics: a focus on deep inquiry into complex problems, a decentralized and open knowledge environment, and participation within a broad knowledge building environment. The CSILE software (and its successor, Knowledge Forum) utilize a database system for storing "notes" that are constructed by members in the community (e.g. students in a class). CSILE and Knowledge Forum are asynchronous, removing the restrictions of turn-taking within the classroom or group environment. Other features that support collaborative knowledge building include the ability to co-author and annotate notes, build on others' notes, create "rise-above" notes that synthesize ideas from other notes, and use scaffolds in the form of sentence openers. A recent study (Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007) which followed the Knowledge Forum work of 22 Grade 4 students in their study of optics, found that students showed a high degree of collaboration, frequently building on and improving each others' ideas. They also constructively incorporated authoritative resources, and built on ideas found in them to generate or synthesize new ideas on their own. Although the study was not experimental in nature, and therefore cannot be compared to a control condition, the students also demonstrated impressive individual knowledge gains through the course of the study.

CSCL technologies have also been developed specifically to support project-based learning activities. Santoro, Borges and Santos (2003), in describing a collaborative writing tool designed to support project-based learning, emphasize the importance of using technology not just to expand the amount of information available to the students, but to create environments which support knowledge construction and communication while facilitating the structuring of the project in manageable ways by the learners. Their comparative case study of a group of undergraduate students using their software, EdiTex, found that providing a high degree of scaffolding of the learning process was important in promoting collaboration between group members.

Until recently, however, a reliance on desktop computers in lab settings have left students participating in CSCL activities stuck behind computer screens that effectively prevent face-to-face interaction and conversation during the activity (Zurita & Nussbaum, 2007). Laptop computers, handheld devices and wireless networking allow students to share and store information while allowing higher social interactivity and presence between group members than afforded by desktop computers in labs. Zurita and Nussbaum (2004, 2007) have developed CSCL tools for use on handheld computers that more effectively support face-to-face interaction in collaborative learning. In their study of a classroom of Grade 2 students using a set of handheld devices to collaboratively work on mathematics problems, the students demonstrated a significant amount of learning in a pre-test/post-test design, although this was not a controlled experiment so comparisons may be difficult. They also demonstrated that the use of the handheld devices facilitated social interaction during the activity, and increased learner motivation.

The software I developed for this study, *ArgueMint*, draws on the CSCL research described here by providing an external, dynamic representation of the knowledge constructed by the group, and by scaffolding the interactions between students and the learning process itself. These features are described more fully in Chapter 3.

2.3 Cognitive Load Theory

In using computer-supported collaborative learning environments to approach complex issues, it is important to consider the cognitive demands placed on the learner. Ideally, the student should be focussing their thinking on the learning task as opposed to the user interface of the CSCL tool, and the scaffolding provided should allow the student to approach the task in such a way that they are able to think it through successfully. Cognitive load theory provides a body of research to help instructional designers consider these demands that are placed on the learner.

Cognitive load theory is a theory of instructional design based on a model of human cognitive processes that features a limited working memory capacity. In his seminal study, Miller (1956) found that humans could hold approximately seven pieces of information at a time in their working memories. The formation of schemas by experts in a particular domain may enable the expert to overcome this limitation somewhat. In their study of novice and expert chess players, Simon and Chase (1973) showed players chess boards at various game stages for 5 seconds each, and then asked them to recall the positions of the pieces on the board. The chess masters in the study were able to recall the positions of the pieces on the board with extremely high accuracy, while novices were unable to recall more than a few pieces. The chess masters' advantage, however, disappeared when they were shown boards with pieces in randomized positions. This led Simon and Chase to conclude that the chess masters were able to utilize existing schema in terms of the relative positions of pieces on the board, while novices did not have the relevant schema to draw on. However, novices may find their working memory capacity quickly overloaded when confronted with a complex learning or problem-solving task.

Cognitive load theory suggests that, in order to be effective, learning tasks must be structured to take into account the limited capacity of students' working memory (Sweller, 1988). Learning tasks may impose three types of cognitive load on students: extraneous, intrinsic and germane (Sweller, 2005). Extraneous cognitive load is described as the result of inappropriate instructional design in which limits on working memory are ignored. The resulting load on working memory is unrelated to the goal of schema formation by the learner. Intrinsic cognitive load is the result of the inherent complexity of the problem or information being presented. It represents the number of chunks of information that need to be held in working memory simultaneously in order to develop a schema. The intrinsic load of a task is dependent on the level of prior knowledge of the learner; expert learners who have developed some schemata already may be able to reduce the number of concurrent chunks required by increasing the size of the chunks. Germane cognitive load is the result of mental effort directed toward learning, resulting in the construction and automation of schemata. Cognitive load theory suggests that the aim of instructional design should be to reduce extraneous cognitive load resulting from inappropriate instructional design when the intrinsic cognitive load of a task is high, to avoid exceeding the capacity of the learner's working memory.

In a CSCL context, one particularly important source of extraneous cognitive load comes from the split attention effect (Bruggen, Kirschner, & Jochems, 2002). The split attention effect may occur when a learner is required to integrate information from multiple sources in order to understand the material (Ayres & Sweller, 2005), such as a paragraph of text and a diagram describing some information in a textbook. This mental integration of separate sources increases the extraneous cognitive load of the learner, reducing the working memory capacity available for learning. This is expected to be particularly problematic when the intrinsic cognitive load of a learning task is high, requiring more information to be simultaneously stored in working memory. For example, Sweller and Chandler (1994) studied individuals who were learning to use a piece of CAD (computer-aided design) software. The students were learning to perform tasks with the software that were highly complex and demanded the integration of several new ideas. One group in the study was provided with a conventional manual and a computer, and was required to work through the steps described in the manual on the computer; this group represented the "split-attention" condition, as they had to coordinate the information in the manual with the information on the screen. The other group was provided a modified manual in which pictures of the screen and computer keyboard were provided with textual information from the manual integrated directly onto the diagrams. The students in this group performed higher on a written test and in a practical test than the students whose attention was split between the conventional manual and the computer screen. Split attention can occur when sources are separated temporally as well; for example, when verbal explanation is provided before or an animation or diagram is displayed in a multimedia learning situation. In one experiment, Mayer (Mayer & Anderson, 1991) took students who were novices with mechanical devices, and presented them with information about how a bicycle pump works. One group was given a recorded verbal description of how the pump works, before being shown diagrams of the pump in action; this group represented the "temporal split-attention" or the "words-before-pictures" group. The other group heard the same verbal description while looking at the pictures simultaneously ("words-with-pictures"). The words-with-pictures group showed a significantly higher proportion of correct responses on a written test that required the students to solve problems with the information that had been presented, supporting the hypothesis that temporal split-attention may impede learning. This result was repeatedly supported in various other experiments using other content domains and experimental designs (Mayer & Anderson, 1991, 1992; Mayer & Sims, 1994).

2.4 Socioscientific Issues and Informal Argumentation

One of the main purposes of the learning activity carried out in this study is to engage students deeply in discourse about a socioscientific issue. Socioscientific issues (SSI) deliberately employs scientific topics that require students to engage in discourse. These topics are generally controversial, and require moral and ethical reasoning to arrive at possible solutions (Zeidler & Nichols, 2009). The goal is to provide issues that are engaging and meaningful for students, require evidence-based reasoning, and provide a context for understanding science content (Sadler, 2004; Zeidler & Nichols, 2009).

Socioscientific issues can be viewed from multiple perspectives, resist straightforward solutions, and require complex decision-making processes based on scientific knowledge, individual values, and social discourse. Zeidler (2005) proposes a model for SSI with the goal of promoting functional scientific literacy through focus on personal cognitive and moral development (see Figure 2.4). This model suggests that explicit attention needs to be paid to four key areas in support of scientific literacy: *nature of science* issues, *cultural* issues, *discourse* issues, and *case-based* issues. By focussing on deepening students' appreciation of the epistemology of science, developing awareness of the cultural and gender-based differences between individuals involved in SSI issues, teaching the informal reasoning and dialogue skills relevant to SSI discourse, and providing real-world cases that engage the students in meaningful discourse, science educators can contribute to the cognitive and moral development of their students, which in turn promotes a "functional" scientific literacy.

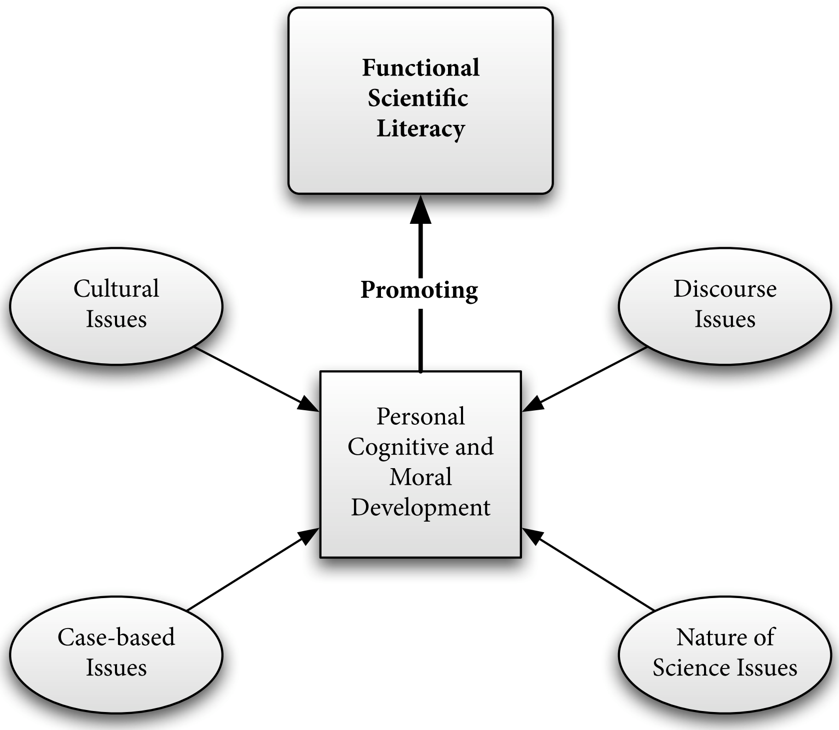

Figure 2.1: A model of Sociocientific Issues education. After Zeidler et al., 2005.

A great deal of the research in socioscientific issues-based education is concerned with informal argumentation. Kuhn (1962), through his examination of the history of scientific discovery, can be credited for drawing attention to the notion that scientific knowledge is developed in a highly social environment, rather than a strictly formal, rational one. While a great deal of science education has traditionally concerned itself with the orderly presentation of well-defined scientific knowledge, there has been a growing interest in incorporating argumentation into the process of learning science. Tied to Kuhn's reconceptualization of the processes of science, a shift of focus from formal argumentation and reasoning to informal argumentation has taken place. Formal argumentation in science education is often characterized by the presentation of a well-defined problem, which can be solved by using the given information through deductive reasoning or statistical inference (Evans & Thompson, 2004). The problems of informal reasoning, by contrast, are ill-structured and lack clear-cut solutions (Wu & Tsai, 2007).

There is a large body of research on informal argumentation. A seminal work, although not directly aimed at an educational audience, was Toulmin's *The Uses of Argument*. In this work, Toulmin describes a model of informal argumentation that has been widely used to examine arguments in educational and other research. Toulmin's model describes the following aspects of argument (Toulmin, 2003):

- A *claim* is the position that is being argued for, or the conclusion of the argument.
- *Data* is the grounds or factual basis that we employ to establish a claim.
- A *warrant* is an assertion that links the data to the claim, or justifies the use of the data in support of the claim.
- A *qualifier* expresses a degree of force (e.g. "probably" or "perhaps") for a claim.
- A *rebuttal* limits the claim by stating situations in which the warrant would not apply.
- *Backing* is support that is given for the applicability of a warrant.

There are some notable deficiencies in Toulmin's model that should be addressed. First, the role of discourse in argumentation is more or less ignored in this model. As a result, Toulmin's model applies better to arguments made by an individual, for example, in a persuasive writing activity, than to what occurs in argumentation between individuals, which is generally the focus of SSI pedagogy. In addition, many researchers have noted the absence of the *counter-argument* from this model (Voss & Means, 1991; D. Kuhn, 1991). Means and Voss

(1994) redefine Toulmin's qualifier to include statements that open other lines of possibility, or alternative arguments. Other work emphasizes the importance of evaluating claims and supporting evidence in good argumentation (Driver et al., 2000). Chang and Chiu (2008) synthesize Toulmin's model with some of the concerns mentioned previously, to provide the following indicators of informal argumentation:

- *Making claims* – taking a position or drawing a conclusion.
- *Providing supporting reasons* – giving information that supports one's claim.
- *Presenting counter-arguments* – stating the limitations or weaknesses of one's claim, or presenting the opposing argument.
- *Showing qualifiers* – providing limitations or alternative solutions for one's claim.
- *Evaluating arguments* – weighing or determining the truth value of one's own or another's arguments.

I used these indicators in this research to evaluate the quality of argumentation, as described in Chapter 4.

Research on student informal argumentation has demonstrated that, in general, students do not display high quality informal argumentation in the context of socioscientific issues. Common features of weak argumentation include the tendency to make claims without providing adequate support, and a nearly complete lack of attention to opposing arguments or weaknesses in their reasoning, demonstrated by a lack of rebuttals and counter-arguments (Sadler, 2004).

In a case study in which no explicit instruction in terms of argumentation was given, Jimenez-Aleixandre et al. (2000) found that the quality of student argumentation on a socioscientific issue relating to human genetics ranged widely but overall was quite weak. They focussed on one specific group of four students who they felt were typical of much of the class of grade 9 students they were observing. They found that two of the students contributed very little to the group discussion, while the other two made very rudimentary arguments, failing to consider other points of view completely, and arriving at conclusions which were nearly unsupported by any justification.

In an attempt to address the quality of argumentation on socioscientific issues, Kortland (1996) carried out a 2-year study with two classes of middle school students. In the first year, he interviewed students in one class to attempt to understand what their capabilities in argumentation were, and to inform the design of an intervention for the following year. He found that students generally produced valid but rudimentary arguments, focussing on justifications that provided support for their claims and failing entirely to consider counter-arguments or rebuttals. The following year, he worked with another class over 10 45-minute periods, teaching argumentation skills as well as content related to the socioscientific issue being addressed. In a classroom discussion which followed the intervention, he found that, while students' arguments on the issue were better than those from the previous year, this was primarily due to their increased content knowledge. Kortland suggested that the students did not improve their skills in argumentation as a result of the intervention. In another study, however, Zohar and Nemet (2002) found that a 12-week intervention lead to an increase in the number of students formulating complex, valid arguments. These students had received explicit instruction in argumentation, and had practiced argumentation in the subject domain (human genetics) being considered. The students who received this intervention were more likely to make explicit conclusions (rather than implicit claims) and to provide more thorough justification for their conclusions than the control group, who received no such instruction and practice.

In addition to the work on informal reasoning and argumentation in SSI, a significant amount of research on socioscientific issues-based education highlights the difficulty that students face in evaluating evidence, considering multiple points of view, and formulating and expressing their own positions on the issues being studied. Sadler, Barab and Scott (2007) attempt to operationalize a concept of "socioscientific reasoning", providing a rubric containing four dimensions that have emerged as critically important in their research:

- Recognizing the complexity of socioscientific issues.
- Examining the issues from multiple perspectives.
- Recognizing the need for ongoing inquiry and research into these issues.
- Demonstrating appropriate skepticism when given information that may be biased.

In their study, a researcher interviewed 24 middle school students individually, presenting them with two different socioscientific issues to address over a period of 15 to 20 minutes. The transcripts from these interviews were analyzed with respect to the four dimensions described above. They found that the majority of students failed to fully appreciate the complexity of the issues they were presented with, offering simplistic solutions based on direct, causal reasoning. The vast majority of students demonstrated the ability to consider multiple perspectives when prompted to do so by the researcher, but very few considered perspectives without being prompted. Many students recognized the need for more information, but few were able to provide suggestions as to what ongoing inquiry might look like. The data on the fourth dimension (skepticism) was less compelling, due to the differences in the method used to obtain data between the two issues presented, but students nonetheless showed significant differences in their ability to critically consider the validity of the data or arguments being presented. I employed the four dimensions used by Sadler, Barab, and Scott (complexity, perspectives, inquiry, and skepticism) in the study of *ArgueMint* to evaluate the quality of inquiry by the students, in addition to the evaluation of their informal argumentation.

2.5 External Representations of Argumentation

The use of external representations to support argumentation, which is one of the roles that I intended for *ArgueMint* to perform, has been studied extensively in the past 15 years. External representations support argumentation by providing a persistent representation of ideas and the relationships between them, acting as an external memory and a reference-point for the arguers. Larkin and Simon (1987) discuss two types of external representations: diagrammatic representations and sentential representations. These two types of representations encode information about the argument differently. Diagrammatic representations are good for encoding geometric or topological relationships between components of a problem, while sentential representations may encode information about the logical or temporal sequence and a natural language description of the components of the problem.

Zhang and Norman (1994) studied how external representations are employed to solve well-defined problems (in this case, the Tower of Hanoi problem and related variants). They carried out a series of experiments involving undergraduate psychology students, in which they presented variations of the Tower of Hanoi problem with a variety of different external representations. They measured the efficiency of the students in solving the problems, in terms of the number of steps that they required to complete the tasks, the number of errors they made, and the total time it took to find the solution. They found that four functions of external representations were particularly important in allowing students to complete the puzzles more efficiently. First, external representations are used as a sort of external memory, or memory aid, helping the participants to recall facts or conditions previously arrived at. Second, representations encode certain types of information that may be used directly rather than formulated by the participant. For example, rules for the Tower of Hanoi problem may be "built in" to the representation. Third, external representations may structure cognitive behaviour, such as by constraining the actions of the participant. Finally, an external representation may actually change the task itself, because it reduces the amount of rule-processing that the participant has to do.

In another study, Zhang (1997) points out that the characteristics of the external representation leads to biases in how the problem is processed. He used four variants of Tic-Tac-Toe which could all be solved using the same strategy, but involved different external representations, which made various aspects of the strategy more or less obvious. In four seperate experiments involving undergraduate psychology students, he demonstrated that students were able to master the strategy (e.g. play to a draw in every game, when the researcher moves first) for those representations that made aspects of the problem or strategy more salient. For example, students were quicker to discover the strategy for representations that made the symmetry of possible games more explicit (like in a regular tic-tac-toe board) rather than representations that were devised to appear assymetrical. Zhang concluded that the perceptual saliency, or the sort of information that is made obvious, of the representation can dramatically affect the approach of the user.

While the context of Zhang's work is significantly different from SSI activities in that they are studying well-defined problems with closed problem spaces, van Bruggen (2002) has argued that these functions can be applied to external representations in argumentation tasks as well. A particular challenge arises when multiple users share a single external representation, such as when more than one person works on a problem together collaboratively. This challenge arises from the need for the participants to coordinate and at least partially integrate their own internal representations of the problem, which could impose significant cognitive load (Boshuizen & Schijf, 1998). This load may be somewhat diminished by the use of scaffolding. For example, sentence openers have been shown to support student discourse and collaboration in the context of ill-structured problems and argumentation, by constraining the types of utterances they can make. Oh and Jonassen (2007) studied the online discussions of 58 undergraduate pre-service teachers, who were asked to solve behaviour-management problems. The students were assigned to three groups – a control group, in which no online discussion took place, a threaded discussion group using regular message board software, and a scaffolded discussion group in which each posting was constrained to begin with one of a set of sentence openers such as "I believe...", "Research shows...", or "I don't agree because...". Researchers in the scaffolded group were found to be more likely to back up their claims with evidence, and demonstrated better individual problem-solving skills in a post-test than the other groups.

I considered Zhang's work with perceptual saliency and Oh and Jonassen's work with scaffolding discourse through the use of external representations of argumentation in my design of *ArgueMint*, which are described in the next chapter.

Chapter 3

Design and Implementation of *ArgueMint*

In this chapter, the design of a tool to support student argumentation in a face-to-face environment is described. The design and implementation decisions that I made in the development of *ArgueMint* have their base in the theoretical background described in the previous chapter. My goal in creating *ArgueMint* was to create a flexible computer-supported collaborative learning environment that would help students to engage deeply in argumentation in relevant socioscientific controversies. While the scope of this study was restricted to supporting face-to-face interactions between small groups, I hope that *ArgueMint's* design provides tools that could also be used in other settings, such as widely distributed groups on the internet.

In the following sections, the goals and constraints that guided my design of *ArgueMint* are described, with reference to the various research areas that were described previously. In the latter half of the chapter, the process and tools used in implementing the software itself are described.

3.1 Pedagogical Scenario

I designed the software described in this chapter to be flexible enough to support a variety of use cases or pedagogical activities. I considered two primary types of scenarios in the design of *ArgueMint*. The first scenario, and the one that I employed in the research described in upcoming chapters, was a face-to-face small group activity in which the software supports verbal dialogue. The second scenario that I considered was a distributed activity in which collaborators work from separate locations on the same issue.

In the first scenario, small groups (likely two to four students) work together to explore a socioscientific issue. This issue would be introduced briefly by a teacher or facilitator, either in a whole-class discussion or as a written piece. The students then have a period of time to discuss the issue together. It is during this period that *ArgueMint* would be used to support the discussion. Each student in the group has a computer in front of them with the *ArgueMint* web application available. Students are able to record important points of their discussion in the software, and refer to it as they continue their discussion. The activity would be focussed on discussion and argumentation, rather than research. The intent is that enough relevant information would be presented in the introduction that students do not need to do a large amount of fact-finding during the activity, instead concentrating on constructing well-reasoned arguments and evaluating them.

In the second scenario, students from different geographical locations work together over the internet to explore a socioscientific issue. In this case, the issue is introduced by a web page containing text, pictures, and perhaps video. After viewing the introductory web page, students are assigned into small groups (again, two to four students) to work on developing an argument around the issue. In this case, students use some sort of chat tool (either text-based or audio-based) to carry out their discussion while using *ArgueMint* to record the key points.

In both scenarios, the central feature of the activity is a period of open-ended discussion about the socioscientific issue in question, supported by the use of *ArgueMint*. For the purposes of this study, I chose the face-to-face scenario, as it was directly applicable to my current science classroom. In addition, face-to-face discussion enabled me to focus on the use of *ArgueMint* without having to deal with the technical hurdles and user interface issues of incorporating an online chat or conferencing tool at the same time.

3.2 Promoting Socioscientific Reasoning

As described in Chapter 2, good SSI inquiry has at its core several ideals, such as the consideration of multiple perspectives and the recognition of the inherent complexity of the issues. My own classroom experience and the body of SSI research has shown that it is often difficult for students to consider things from multiple points of view, and to construct high-quality arguments about socioscientific issues. Given these challenges, I articulated the following goals for *ArgueMint* in terms of promoting deep inquiry into socioscientific issues:

- The tool should prompt students to consider more than one perspective
- The tool should help students develop thoughtful and evidence-based arguments
- The tool should allow students to engage in "big picture" inquiry into the issue

In this section, the ways in which I attempted to realize these goals in the design and implementation of *ArgueMint* are described.

3.2.1 Scaffolding Perpsectives

Sadler et al (2007) stress the importance of examining issues from multiple perspectives. In order to help students think about their issue from different perspectives, *ArgueMint* provides visual differentiation between different, explicitly named perspectives.

Perspectives in *ArgueMint* are represented by a box that can contain statements entered by the students. Each perspective has it's own box, which is bordered and titled with the name of that perspective. In the first version of *ArgueMint* tested in this research, I identified four perspectives as being particularly relevant to the issue being discussed. These perspectives appeared on the blank page that the students start with at the beginning of their activity. The perspectives used were titled "Ethical Perspective", "Scientific Perspective", "Political Perspective", and "Economic Perspective". In addition, I included a section titled "Other Perspectives" to give the opportunity for students to identify other potential perspectives that would be relevant to the issue. Each perspective box contained links for creating statements about the issue from that perspective.

In the second version, I replaced the four pre-determined perspectives with a menu containing a larger list of options, including "Cultural Perspective", "Economic Perspective", "Ethical Perspective", "Historical Perspective", "Legal Perspective", "Political Perspective", "Religious Perspective", "Scientific Perspective", "Social Perspective", and "Other Perspective". Users are able, at any time, to select a perspective from this menu and add it to their page. Once the perspective has been added, a titled box appears for that perspective, containing buttons to add statements about the issue from that perspective. The reasons for this change will be described in Chapter 5. A screenshot of a sample argument containing several perspectives is shown in Figure 3.1.

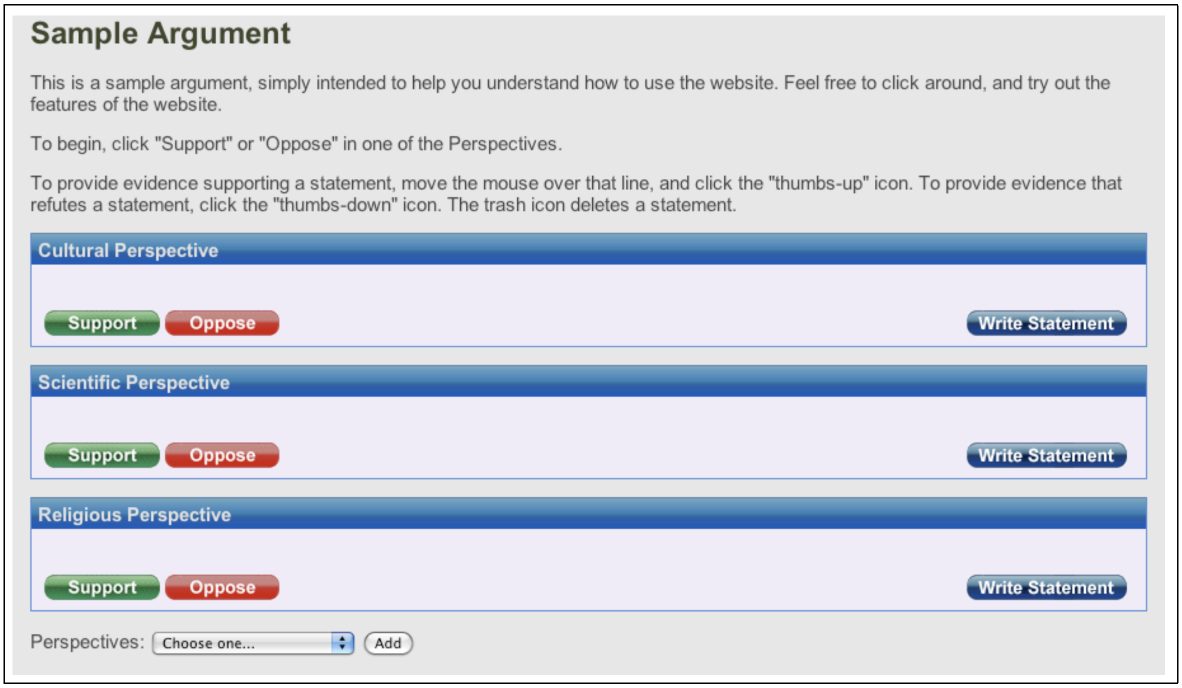

Figure 3.1: A screenshot of *ArgueMint* showing a sample argument with some blank perspectives.

3.2.2 Scaffolding Argumentation

In deciding how *ArgueMint* would scaffold the informal reasoning and argumentation between students, I considered both the model of argumentation and the type of representation that would be employed. Many prior examples of CSCL software for argumentation employ Toulmin's model of claims, data, warrants, qualifiers, and backings, or some variation on that theme. For example, Belvedere provides a graphical representation using different shapes to represent the different types of propositions or statements, and lines to show the logical relationships between them (Suthers, Weiner, Connelly, & Paolucci, 1995).

ArgueMint takes a different approach, in that it employs a textual approach to representation rather than a graphical one. It employs a standard, familiar "outline" style in which sub-points can be built beneath main points and appear indented on the page (see Figure

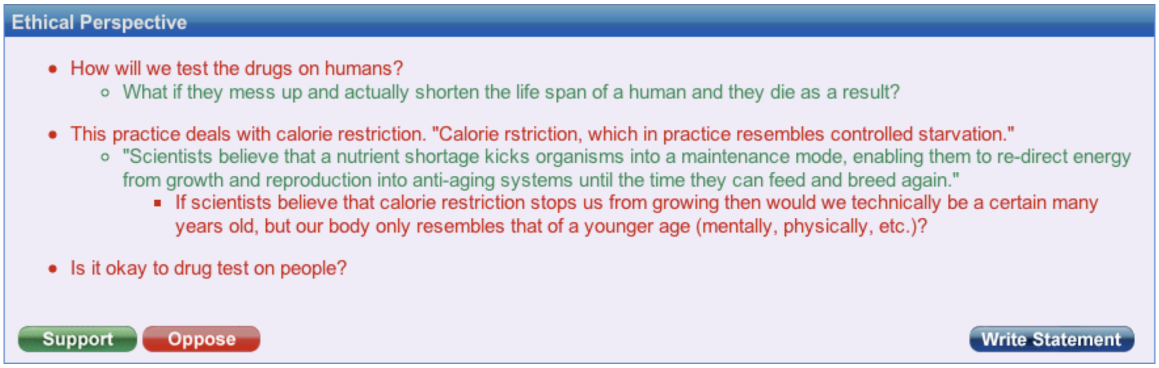

Figure 3.2: A screenshot of *ArgueMint* showing the outline representational structure.

3.2). I chose this approach because students are already familiar with outlining, minimizing the cognitive demands of learning a new representational style while engaging in an already complex and demanding task such as argumentation in SSI. In addition, graphical representations result in a much smaller amount of information being immediately visible on the screen at any given time. This necessitates remembering where in a virtual space certain information is stored, and requires the user to scroll around to search for information. An outline allows more information to be displayed without scrolling, which may reduce the need for search in representations containing more than a minimal amount of information.

In choosing a model of argumentation itself, I considered the pedagogical scenarios in which *ArgueMint* might be used. *ArgueMint* is intended to be used by students with little or no previous experience in CSCL argumentation, and with little prior instruction in informal reasoning. Toulmin's model, while perhaps useful as a tool for assessing the resulting arguments, was considered too complex to employ directly. Students with no prior background would not be expected to understand what a "warrant" is, or how it might differ from "data" or "claims". As the research discussed in the last chapter shows, students struggle significantly with two main problems in argumentation: supporting their claims with adequate reasons, and considering counter-arguments or possible rebuttals to their arguments. In order to explicitly draw attention to these two features, while keeping the scaffolding simple enough to understand with a minimal amount of background information or prior instruction in argumentation, I employed a simple scaffold in *ArgueMint* that requires students to make statements that either “support” or “oppose” previous statements or implicit claims. Buttons for these actions allow students to build these sorts of statements either at the perspective level, or underneath existing statements within a perspective.

One of the advantages of using an external representation to store information about an argument is that it can provide “perceptual salience” to features of the argument (Bruggen et al., 2002). The outline-style indentation of statements draws attention to the amount of support given to a particular statement; claims with four or five statements beneath them in the outline are likely well-supported, while those without any statements beneath are likely not. In addition, I implemented a colour scheme; “supporting” statements are coloured green, while “opposing” statements are coloured red. This allows the student, at a glance, to see places where they may not have thought of rebuttals or counter-arguments, simply by the absence of red-coloured statements.

3.2.3 Scaffolding Inquiry

Much of the work in promoting deep inquiry into socioscientific issues may in fact be done before the student ever reaches the computer. Perhaps most important is the selection of the issue to be studied. An issue that is relevant and of immediate interest to students will be far more likely to engage them than something that is perceived to be irrelevant or boring; further, it is unlikely that even the best-designed CSCL tool will be able to provide the motivation and interest to the student if the issue itself is uninteresting.

To a large extent, the design of *ArgueMint* is intended to "get out of the way" to allow students to engage in material they are already interested in. As discussed in previous sections, a minimalist approach to modelling argumentation and a simple interface for selecting perspectives of interest to the students are key features of the design. While a good deal of CSCL literature deals with the value of "scripting" interactions between students and involving the computer, I made the decision to avoid a rigid, prescriptive script. I felt that a more scripted approach to any particular socioscientific issue would have to be directly tailored to that issue in order to be of any value, which would then prevent *ArgueMint* from being applied to other issues. As a result, students start interacting with *ArgueMint* on an empty template.

Suthers (1995) reports that, in their initial research, they found that students sharing a single computer may become frustrated because frequently a single student will dominate the use of the keyboard. This can lead to a sort of "censorship" of the ideas of the other student based on ownership of the keyboard. To avoid that issue, I designed *ArgueMint* to be used concurrently on multiple computers. Each student, as a result, is free to enter information, make changes to existing information, or scroll to different parts of the page independently of the other during the discussion.

Decisions about the nature of this concurrency were based on technical limitations of the platform, and also on the desire to minimize the amount of distraction for users as they engage in discourse. For example, when one student begins to type a statement, rather than showing each character as it is typed, updates are displayed on the other student's screen when the statement is completed. I did this primarily to allow the students to continue concentrating on their line of thinking or discussion, rather than leading them to stop thinking and watch a flow of characters as it appears on their screen.

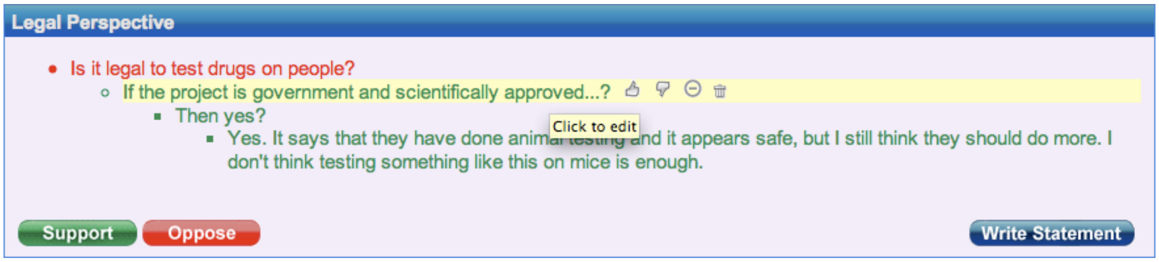

Figure 3.3: A screenshot of *ArgueMint* showing rollover buttons for actions on statements.

3.3 Managing Cognitive Load

My primary goal with respect to cognitive load in the design of *ArgueMint* was to minimize the imposition of extraneous cognitive load on the students participating in the argumentation activity. Argumentation in SSI would be characterized as having a high intrinsic load, due to the complexity of the problems discussed. Arguing about a socioscientific issue involves finding information in provided resources, recalling information from previous experience, integrating information from different sources, and evaluating information for relevance, bias, and importance. These activities place high demands on the working memories of students. As a result, *ArgueMint* was carefully designed to minimize distractions from the task at hand, and to support the cognitive tasks required. My choice of argumentation model ("support" and "oppose") and visual representation style (outlines) is intended to minimize the amount of thinking and remembering that is required to use the interface.

My goal of minimizing cognitive load influenced various other aspects of the user interface design. One key example is the use of rollover buttons for each statement. There are a number of actions that the user may wish to carry out on a particular statement. They may wish to edit the statement, delete it, and support or oppose it with additional statements. Providing buttons for each of these actions is necessary, but would have the negative effect of adding to the visual clutter on the screen. This would make the external memory function of the visual representation less effective, as students would have to search through superfluous user interface elements to find the relevant information. The technique that I employed to mitigate this effect was the use of rollovers; the buttons (small icons showing "thumbs up" for supporting statements, a trash can for deleting statements, etc.) only appear next to a statement when the user hovers their mouse over the statement (see Figure 3.3).

3.4 Maximizing Usability

Jakob Nielsen (1994), a leading expert in usability, identifies five key components of software usability:

- Learnability
- Efficiency of Use
- Memorability
- Few and Non-Catastrophic Errors
- Subjective Satisfaction

Learnability can be measured by the amount of time it takes to become proficient in using the software's features. I considered this to be particularly important for the design of *ArgueMint*, since the software is intended to be used by novice users in a classroom, while working on complex learning tasks. In addition, it is foreseeable that, in many scenarios, the students may also be learning about the structure of arguments or critical thinking skills at the same time. One of my key goals was to create software that is easy to learn, in order to minimize the amount of time spent in the classroom teaching tool use and maximize the time spent attending to the socioscientific issue being considered. As discussed previously, the representational style, model of argumentation, and user interface elements were each designed to require the minimum effort in remembering how to use them.

Efficiency of use refers to the amount of time and mental effort spent carrying out common functions. Due to the nature of the activity, I anticipated that there would be a relatively small number of tasks, but these tasks would be repeated frequently throughout the activity. For example, a student may wish to add a sentence to their argument, edit or delete a sentence, or classify a statement as a particular part of their argument structure. The frequency of these actions necessitates having a quick and intuitive way to carry them out. I implemented this through the use of rollover buttons as described previously.

The *memorability* of a piece of software is the ease with which a user can return to the software and resume using it at the level they were at in their prevous experience. For the scope of this study, the primary emphasis is on novice users who are using the software for the first time; however, many of the design decisions that make the software highly learnable will likely serve to make it memorable as well.

It is inevitable that users of a complex piece of software will make errors at some point. Nielsen, however, stresses the importance of ensuring that there are *few and non-catastrophic errors* during normal use. In *ArgueMint*, users have the ability to make changes to statements after they were created, including the ability to change a statement from "supporting" to "opposing" if the wrong button was pressed.

Subjective satisfaction refers to the overall level of comfort the user experienced while working with the system. It is, in many ways, a composite of the other factors; a user who found the system difficult to learn, or made a catastrophic error resulting in the loss of their entire argument, is likely to be overall quite dissatisfied with the software. The subjective satisfaction of the users was considered in the data collection and analysis, as will be described in the following chapters.

3.5 Implementation

3.5.1 The Implementation Process

The classic approach to software engineering is the 'waterfall model' (Joy, 2005). This model describes a sequential progression through the following steps:

1. the requirements of the 'customer' are determined
2. a formal, detailed specification or description of the finished product is written
3. a design is created using the requirements laid out in the specification
4. the software is implemented from the design in a specific programming language
5. the software is tested to ensure that it works correctly and meets the requirements

In some cases, after the testing phase is completed, the process may begin again as further requirements are added or flaws in the original design are exposed. As a result, this process is often described as the 'software life cycle' (Oualline, 1997). A major issue with this process is the amount of effort which is spent on producing thorough specifications and designs before ever finding out if the design is effective or the specification is adequate in actual real-world testing.

For this project, I chose a more "agile" approach to software development. Agile software development is characterized by an effort to minimize the amount of documentation produced in the planning stages, and to increase the degree of flexibility of the programmer when challenges are encountered. Some of the features of agile methodologies (Beck, 1999) that were employed in this process include:

1. *Planning game* – an approach to planning the features and implementation schedule of the project. The game involves recording "user stories" of desired functionality, estimating the time required to implement the story, and prioritizing the stories to determine which ones will be included in the current release.

2. *Small releases* – rather than completing all of the features of the finished product at once, iterative 'releases' of the product occur regularly, having implemented the features specified as priorities in the planning game. The released product is then tested to ensure that it meets the requirements.

3. *Simple design* – only the code that is required to implement the current user story is developed. The design may later be revised and improved through refactoring when it becomes apparent that further features are required.

4. *Refactoring* – improving the design of the code is done continuously as opportunities for improvement are noticed. The programmer may modify algorithms, improve performance or restructure the entire architecture of the program, without changing functionality, when new requirements or user stories make it apparent that modifications are required.

By employing these concepts, development is broken into manageable pieces, and the flexibility to change aspects of the software in response to emerging issues is available. In addition, agile methods integrate effectively into a "design-based research" paradigm in which multiple iterations of research and further development of the software are undertaken (Sandoval & Bell, 2004).

A typical development session for *ArgueMint* would begin with a "planning game", in which I added "user stories" describing a particular feature to a database. User stories tend to be short, often no more than a single sentence, which describe the functionality as the user would see it, for example:

- The user logs in to *ArgueMint*, and creates a new argument by clicking on a link
- The user realizes that her last statement should have "supported", rather than "opposed", so she changes it by clicking on a button in the rollover.

Following the planning game, I would choose a user story for development. The feature would be implemented, tested, and incorporated into the *ArgueMint* code base, and "released" or committed to the code repository. I would then choose another user story, and development would continue.

3.5.2 Software Used

Ruby on Rails – a Web Application Framework

Development for *ArgueMint* was done in Ruby on Rails[1]. Ruby on Rails is a web development framework written in the programming language Ruby[2]. Ruby is an open-source dynamic programming language, which has gained popularity due to its simple, readable syntax and high productivity. Ruby on Rails is also open-source, and has garnered a great deal of attention over the past few years. Rails is described by its developers as "opinionated software",

[1] http://rubyonrails.org

[2] http://www.ruby-lang.org

based on the principle of "convention over configuration"; Rails assumes there is a best way to do things, and makes it extremely easy to do things that way. As a result, development of database-driven web applications in Ruby on Rails is highly rapid and productive.

Ruby on Rails includes two JavaScript frameworks which were heavily employed in *ArgueMint*: script.aculo.us[3] and Prototype[4]. These two frameworks provide rich user interface elements and efficient methods for updating web pages using AJAX.

Ruby on Rails is able to use several different databases for data storage and retrieval. As a result, *ArgueMint* is not tied to a particular database server. In this study, SQLite[5] was used as the database backend, as it is well-suited to small database projects and makes it very easy to back up data. SQLite is available in the public domain.

Juggernaut – a Real-time Collaboration Protocol

The hypertext transfer protocol, which is the basis for communication via the World Wide Web, follows a basic model in which the client makes a request for information, and a server responds with the information requested (Berners-Lee, Fielding, & Frystyk, 1996). In practice, this has limited the types of communication possible via the web, as the server is unable to initiate communication to the client. Recently, however, techniques in which the server can send information to clients without the client initiating with a request have been developed. One popular technique for this is known as "Comet"; in this technique, the client makes an initial request when the page is loaded, and the server's response is held open for a long period of time, during which additional information can be sent without further requests (Mahemoff, 2006). In practice, this technique works quite well, but some web

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[3] http://script.aculo.us/

[4] http://www.prototypejs.org/

[5] http://www.sqlite.org/

browsers tend to become unstable after a long comet session.

For *ArgueMint*, I used a slightly different technique to achieve multi-user realtime collaboration. In this technique, after the client makes its initial request, the server responds by sending the client a small program written in Adobe Flash (Adobe Systems Incorporated, 2009). This program opens a separate connection to an external server, which can then communicate to the client via this connection indefinitely. The implementation of this technique that I used in *ArgueMint* is Juggernaut[6], which is open source software and is designed to integrate with Ruby on Rails web applications.

In *ArgueMint*, the Juggernaut connection is used to initiate AJAX requests from the client whenever a statement or perspective in the current argument is edited. For example, if one user were to delete a statement from the argument, a message would be broadcast via Juggernaut that would cause all of the client computers currently viewing that argument to remove the statement from the page. If another user edited a statement, the server would message each client, prompting them to request an updated version of the statement from the web server, and display it on the page. In this way, updates to the page occur in real-time, allowing each connected user to view the most up-to-date version of the argument all the time.

Other Software

ArgueMint was tested in several different web browsers, including Apple's Safari, Mozilla Firefox, Microsoft Internet Explorer and Google Chrome. During the research study, the two laptops were running Safari (on Mac OS X) and Chrome (on Windows Vista). These browsers were chosen for their stability and their compliance to the CSS standards with which *ArgueMint* was developed.

[6]http://juggernaut.rubyforge.org/

During the development of *ArgueMint*, the source code was stored using a version control service known as GitHub[7]. GitHub is based on the open-source version control system Git[8], and allows the secure storage and retrieval of source code and other documents. Most importantly, it maintains a version history of each file stored in the system, allowing developers to "roll back" changes that turned out not to be beneficial, or recover from serious errors.

Deployment

For the purposes of this study, the *ArgueMint* server was run on one of the laptop computers used in the study. This laptop was running Mac OS X, and had Ruby on Rails and SQLite pre-installed. For a more permanent deployment, the server software is portable, and can be deployed on Windows, Macintosh, Linux, or other UNIX systems, as long as they are able to meet the minimum requirements of the Ruby on Rails framework.

[7] https://github.com/
[8] http://git-scm.com/

Chapter 4

Methods

The research study that I carried out to examine the use of *ArgueMint* was based on design research methodology. Design research attempts to "engineer innovative educational environments and simultaneously conduct studies of those innovations" (Brown, 1992). As is typical in design research, the design of *ArgueMint* and the collection and analysis of data took place in an iterative cycle (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). In this study, two iterations of design, data collection and analysis were undertaken and described. Figure 4.1 shows the flow of this research design in general terms. This chapter describes the participants involved in the study, as well as the procedures used in the data collection and analysis stages.

4.1 Participants

The participants in this study were four Grade 10 students from a private Christian school in the Metro Vancouver area of British Columbia. These students ranged in age from 15 to

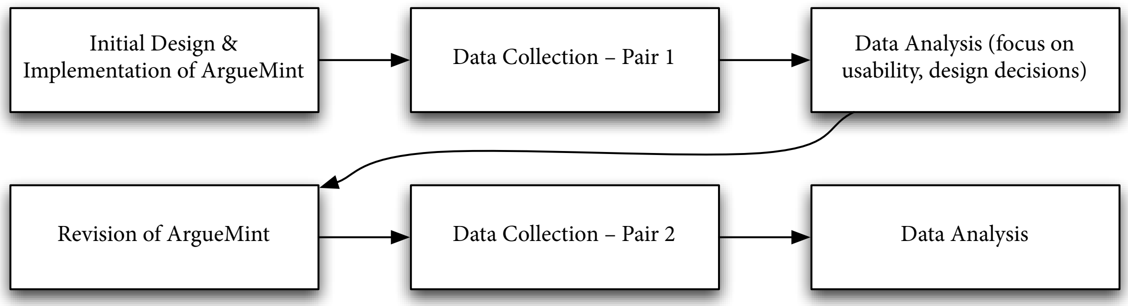

Figure 4.1: The research design used in this study.

16 years old. Each of the students had substantially completed the Grade 10 science curriculum by the time the research was carried out. All four of the students achieved above-average marks in their science courses. In addition, the students had all had some prior experience arguing controversial issues. In another course, each of the students had completed an assignment in which a complex ethical issue was examined, discussed, and presented to the rest of the class.

The students were assigned into pairs prior to their participation in the research. In order to maintain anonymity, aliases were assigned to each participant in the study. Throughout the results and discussion, the first pair of students will be referred to as Stephanie and Steven, and the second pair will be referred to as Angela and Adrianne.

4.1.1 Participant Selection and Research Ethics

As each of the subjects in this study was a high school student, written consent from their parents was sought to allow the students to participate in the study. The students in one of the author's classes were first informed of the nature of the research, and measures to maintain confidentiality were described. The students were told that there were no anticipated risks from participating in the study, that their participation was completely voluntary, and that they were free to withdraw at any time. A full copy of the script as it was verbally presented to the students is given in Appendix D. Seven of the students volunteered to participate, and they were then given a copy of the consent form shown in Appendix C to have signed by their parents. Only four of the forms were returned, and those four students became the participants in the study.

In order to maintain confidentiality, collected data from this research was stored on a password-protected laptop. The data was backed up onto an external hard drive stored in the author's home. After the completion of the data analysis, the information was deleted from both the laptop and the external hard drive, and transferred to a USB thumb drive which was then placed in a locked filing cabinet.

4.2 Materials

For the activities carried out in this research, two articles from the *Science Times* website[1] were selected. The first article is entitled *Singing the Praises of Wind Energy* (Science Times, 2008a), and describes some of the issues surrounding the use of wind energy. In particular, it focusses on the negative impact on songbird species, which often fly into the turbines and are killed. The second article is entitled *Who Wants to Live Forever?* (Science Times, 2008b). This article outlines some recent research into two genes which have been found to significantly affect life span in a variety of organisms. For example, yeast life spans have been increased by approximately 10 times, while mice life spans have been shown to increase by about 30%. It also describes plans for research on humans. These articles were selected because they were felt to be likely to generate discussion both for and against the scientific

[1] http://www.sciencetimes.ca

or technological developments described in them, and because they invite argument from a wide variety of perspectives (scientific, social, economic, ethical, etc.).

Each student had access to a computer while they were using *ArgueMint*. As *ArgueMint* is web-based, they were able to use any available computer that had a web browser. In this study, two laptops, one running Safari on Mac OS X and the other running Google Chrome on Windows Vista, were used. For written work, students were provided with several sheets of lined paper and pens.

The server software that runs *ArgueMint* was installed on the Macintosh laptop, and was accessed through a direct network connection from the other laptop. The Macintosh laptop also ran a software programme entitled *Screen Mimic*[2] which captured a video recording of the screen during the activity as well as an audio recording of the verbal discussion through the laptop's microphone. A video camera was also used to capture the verbal discussion.

Following the activities, students were given a survey designed to give them an opportunity to voice issues with usability. This survey included the following questions:

1. How did you feel about this activity?

2. Describe how you used the software tool to develop your argument.

3. What aspects of the software tool did you find the most useful?

4. What frustrated you about the tool?

5. Was there anything that you wished you could do with the tool that you currently couldn't?

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[2] http://www.decimus.net/ScreenMimic.php

4.3 Procedure

Each pair of students participated in two activities. The first activity was a pen-and-paper individual assignment, in which the students were asked to write about a socio-scientific controversy. First, the students were given the article *Singing the Praises of Wind Energy*, and given about 5 minutes to read the article. Then, the students were asked to write a short essay. They were instructed to write one to two paragraphs summarizing the article, and three or four paragraphs to answer the question "What is your position on wind energy as an energy source?". This question was written on a whiteboard in the room for them to refer to throughout the activity. The students were then prompted to explain the factors (e.g. social, scientific, ethical, etc.) that they considered in answering the question. The students were given approximately 60 minutes to complete the writing task.

In the second activity, the pairs of students worked together to construct an argument about a socio-scientific controversy using the ArgueMint web application. To begin this activity, the students were seated at laptop computers that were already logged into ArgueMint and displaying a sample argument page. The researcher gave a brief demonstration of the web application, lasting about 5 minutes. During the demonstration, each of the features of the ArgueMint were demonstrated, such as adding and removing statements to the argument, adding sub-statements in support or opposition of existing statements, editing statements, and deleting statements. During the second trial, changing the type of existing statements (e.g. from supporting to opposing), adding perspectives, and writing position statements for a given perspective were also demonstrated.

The students were then given approximately five minutes to read over the article *Who Wants to Live Forever*. During this time, the researcher loaded a blank argument page in the ArgueMint application for the students to work on, and turned on the video recorder and screen capture software. When the students indicated they were finished reading the article, they were asked to discuss the question "What is your position on research intended to increase human life spans?". The students were then given time to discuss their argument and enter statements into ArgueMint. They were instructed to take all the time they needed to have their discussion, and to inform the researcher when they were ready to move on. During the discussion, the researcher was present as an observer, and also contributed clarification when the students asked a procedural or factual question. The pairs took approximately 30 minutes to complete this part of the activity.

Following the discussion, a print-out of the pair's argument was provided to the students, and they were asked to individually write a short essay describing their position on research intended to increase human life spans. They were instructed to write approximately five paragraphs. When the students indicated they were finished writing their essays, they were given the survey, and asked to complete it. Following this, the students were dismissed.

4.4 Data Collection

During the first activity, each of the four students produced a written essay on the wind energy issue. These essays ranged from one to two pages in length, handwritten.

During the *ArgueMint* activity, the participants were videotaped as they discussed the *Who Wants to Live Forever?* article and entered data into ArgueMint. The camera was placed in the corner of the room, behind the students, with both students in the field of view. This provided a record of verbal and non-verbal communication between the students in each pair. While the students were working in ArgueMint, a screen capture utility was used to record activity on one of the laptops. This provided an accurate record of the sequence in

Procedure	Data Collected
Initial individual assignment	Written essays from each student
ArgueMint activity	*ArgueMint* outline Video recording of students Screen capture recording
Final individual assignment	Written essays from each student
Survey	Survey responses from each student

Table 4.1: Data collection activities showing the nature of the data collected.

which data was entered into ArgueMint. The utility created a digital video file which was then synchronized with the audio from the video tape recording, so that verbal communication and data entry into ArgueMint could be properly sequenced.

At the end of the activity, each of the students again produced an individual written essay on the issue, ranging from one to two pages. In addition, they filled out a short written survey. The outlines that they produced in *ArgueMint* were also recorded to be used in the data analysis. The data collection is summarized in Table 4.1.

4.5 Analysis

In order to analyze the data collected in this research, verbatim transcripts were prepared from the video recordings of the *ArgueMint* activity. These transcripts were then edited to remove non-meaningful words. In addition, the hand-written materials such as the essays and survey responses were typed verbatim. This data, along with the finished outlines from *ArgueMint*, were imported into a qualitative analysis software program, ATLAS.ti, to be coded. The unit of analysis was a complete thought; this may have been a single sentence, but in some cases more than one thought appeared in a sentence, or more than one sentence made up a single thought.

Prior to coding, a codebook was prepared, following the approach of Creswell (2009). Codes were pre-determined based on several theoretical perspectives: *argumentation*, *SSI inquiry*, *collaborative argumentation*, and *usability*. After listing and defining codes, an initial examination of several of the written essays, transcripts, and *ArgueMint* outlines was undertaken, to find examples of each of the codes, and to refine the definitions of some of the codes. For example, it became apparent that the definitions for "supporting reason" and "claims" that were initially given contained some overlap. Also, initially there was a code entitled "evaluation" in the argumentation section, and a code entitled "evaluating arguments" in the SSI inquiry section. These were intended to be subtly different, but it became apparent that they could not be distinguished between in the actual documents.

Following the development of the codebook, each of the documents was coded. Following this, lists of all of the quotations for each code was prepared. These lists were checked to ensure that the code was being applied consistently in every instance. Following this, definitions in the codebook were revised if necessary to clarify any issues. Each of the documents was then recoded using the revised codebook.

Table 4.2 shows the *argumentation* codes as they were used in the final recoding, along with definitions and examples of each code. Tables 4.3 and 4.4 give the revised codebook for the SSI inquiry and collaborative argumentation perspectives.

Code	**Definition**	**Example**
claim	a statement (value, decision) that is to be accepted as true	"Wind energy is better for the environment than fossil fuels."
supporting reason	data, warrant, or other reasoning to provide support for a claim	"Not only is it drastically less pollutant, it is a unlimited resource we will never run out of."
counter-argument	opposing argument, limitation or weakness in a claim	"Although it doesn't provide as much power as fossil fuels ..."
qualifier	statement of limitation of the claim, or alternate lines of inquiry	"However, *if the changes were to produce negative side-effects* then people wouldn't have the ability to process and grow normally."
evaluation	making a judgment or weighing a claim	"However, comparing the consequences that wind energy and fossil fuels have on our environment today, it is obvious that wind energy is the greener choice."

Table 4.2: Argumentation codes with definitions and examples

Code	Definition	Example
identifying perspectives	naming or describing a point of view or stakeholder in the issue	"If this research were to succeed in finding a way to have people live longer lives, it could benefit those people economically."
recognizing bias	questioning or expressing skepticism in the reliability of a source of data	"This article tells how the wind turbines used to create wind energy are killing nocturnal birds and bats, but I'm sure there is other research available on how hydro electricity is affecting fish populations, water cleanliness, and the surrounding towns and houses."
reference to research	explicitly or implicitly drawing on external source of information	"Several methods have been suggested for reducing the harm to these birds, including night vision cameras and microphones for conducting research and assessing more of the impacts of wind energy facilities on birds and bats."
need for information	identifying situations in which an important piece of data is missing, or a question is unanswered, that would help to support or refute a claim	"Unfortunately, this article doesn't present much actual information, so it's difficult to tell whether or not wind turbines are an actual threat to wildlife."

Table 4.3: Socioscientific inquiry codes with definitions and examples

Code	**Definition**	**Example**
elaboration	one student adds something to a line of reasoning of the other	S1: "Without illness doctors wouldn't be needed" S2: "Loss of jobs, people without jobs leads to homelessness"
negotiation	discussion that resolves a disagreement between the students	S1: "There's already so much being done about stuff like global warming and pollution." S2: "True, but they could do more." S1: "That's one of the things where it's more our responsibility, so there's not much that the government can do." S2: "That's true..."
rebuttal	one student provides a counterargument to a statement made by the other student	S1: "Obesity is a big problem, though." S2: "Maybe in America. I don't know too many obese people."
incorporation	a student uses information or reasoning provided by the other student in their own statements	

Table 4.4: Joint argumentation codes with definitions and examples

Chapter 5

Results

At the outset of this study, the following research questions were posed:

1. How do students use ArgueMint in face-to-face argumentation on a socio-scientific issue?

2. What features of the system are the most useful and useable in mediating argumentation?

In this chapter, an analysis of the data collected in the two iterations of the study is undertaken in an effort to answer these questions.

In the first section of this chapter, a brief analysis of the data from the first iteration of the research is presented, with a focus on usability and design issues that were then addressed before the second iteration. Following this, sections detailing the analysis of data collected in each of the three stages (Initial Essays, Scaffolded SSI Inquiry with *ArgueMint*, and Final Essays) of the research activity are presented.

5.1 Iterative Analysis and Design

This research employed an iterative approach to data collection and design. After the first pair of students completed the activity with *ArgueMint*, the data collected, including video recordings, screen captures, and a transcript of the verbal discussion, was analyzed in order to find usability and design issues which could be addressed before the second iteration began. In this section, these findings will be described, before a more thorough analysis of the argumentation and socioscientific inquiry that took place is given in a later section.

5.1.1 Self-defined Perspectives

One of the key findings in the initial analysis of the data from the first pair of students was the focus on the provided perspective titles. The goal of providing the headings, such as "Ethical Perspective", "Economic Perspective", among others, was to encourage students to consider a variety of perspectives in their deliberations. What emerged from reading the transcripts and watching the video footage, however, was that this list proved to be a limiting factor in the perspectives that were considered.

In the survey that was completed immediately following the session with *ArgueMint*, Steven described how he used the software as follows:

> I began by picking which aspect of the issue I wanted to cover first and put my main arguments regarding that issue in first ... Once I felt I had nothing more to add to that perspective of the argument, I moved on to another perspective.

This "point-by-point" approach to the use of the provided perspectives was supported by the verbal discussion that occurred. For example, following the conclusion of a line of thought, both students used the titles of the perspective to begin a new area for discussion.

For example, following a discussion of implications of overpopulation, Steven began a new thought with: "Oh, umm... ethical perspectives... They say, so far there are no apparent side effects." At the end of a brief discussion of the ethics of drug testing on human populations, Stephanie began a new topic with: "Umm... for the scientific perspective, learning more might benefit other fields of science." Later in the conversation, Steven lists the perspectives they have covered, before launching into their next line of discussion: "Okay, so we've got ethical, scientific... Political perspective. So..."

While it is perhaps unsurprising that the students used the given perspective titles to guide their discussion, what was particularly interesting was the absence of any lines of reasoning outside of the given perspectives. For example, although the students had both attended a Christian school for much of their academic careers, the religious perspectives on the issue was completely absent from their work in *ArgueMint*. Interestingly, after the camera was switched off and they began writing their essays individually, some discussion of religious perspectives ensued at that point. In addition, no statements were added to the section entitled "Other Perspectives", and no discussion about what those other perspectives might be was undertaken during the activity.

These findings led me to make a change in the implementation of *ArgueMint* before the second round of data collection. Instead of providing a pre-made template with four perspectives and an "Other" category already on the page, the software was redesigned to provide a menu at the bottom of the template with a longer list of potential perspectives. Students were then free at any point during their use of *ArgueMint* to select a perspective from this list and add it to their template. I hoped in this way that students would be less restricted by an arbitrary choice of four perspectives, and would be encouraged to consider a wider variety of perspectives, and also perspectives that are of more interest or relevance to them.

5.1.2 Collaborative Position Statements

Another important finding in the initial analysis of the first pair's activity was the weakness of the collaboration that took place. As discussed in Chapter 2, in collaborative learning, students collaboratively construct knowledge through interactions such as negotiation and sharing (Stahl et al., 2006). While some collaboration certainly took place, it was apparent that the collaboration was not as strong as it could have been.

First, there was a clear domination of one student in the group. Steven typed 11 of the 14 statements, accounting for 63 out of 75 words that appeared in the final *ArgueMint* output. An initial look at the transcript of the verbal communication between them appeared more balanced; Steven contributed 116 utterances, while Stephanie made 91 of her own. However, when looking more carefully at the types of utterances made by Stephanie, many of them were simple statements of agreement ("Yeah." "Mmmhmm..." "Okay, makes sense.") or other utterances that were not germane to the discussion ("You spelled population wrong." "Umm, can I delete that, then?"). In fact, when looking at word counts of the utterances made in the session, Stephanie uttered 532 words, while Steven spoke 2191, nearly four times as many.

In addition, there was a tendency of the students to "own" their own statements in *ArgueMint*. Six of the 14 statements entered into the software were edited at least once. Of those six edits, all but one were edited by the original author of the statement. When writing the written essays, Steven showed a strong tendency to only use his own work from *ArgueMint*. Seven key ideas were noted in his essay, of which three were his own statements from *ArgueMint* and the other four were new ideas that hadn't appeared in the *ArgueMint* outline they had generated. This tendency was less obvious, but still present, in Stephanie's

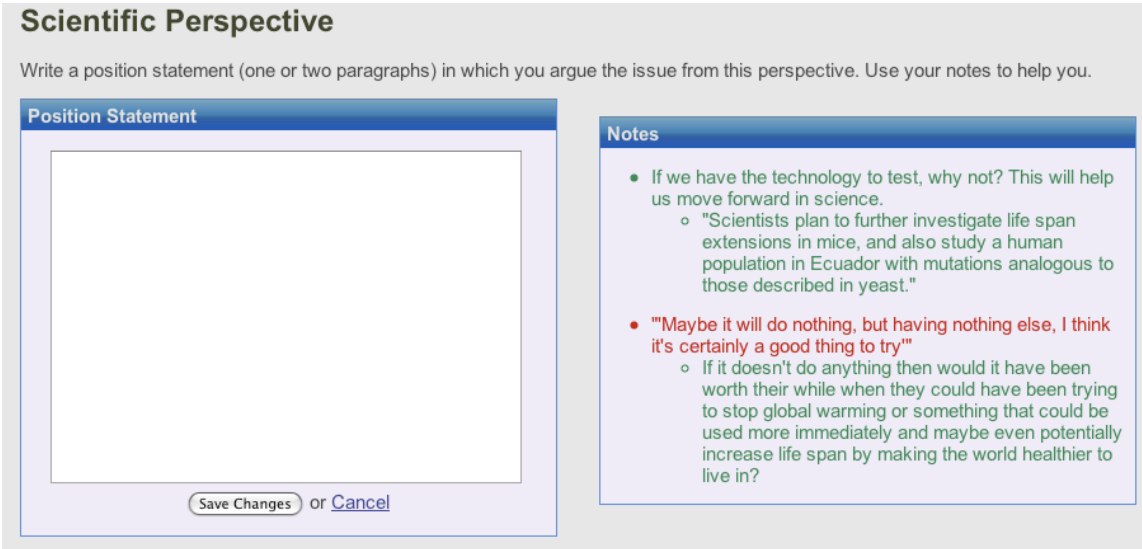


Figure 5.1: A screenshot of *ArgueMint* showing the "position statement" feature.

work - she incorporated all three of her own statements from *ArgueMint*, but also 6 of the 11 statements from Steven in addition to six new ideas that had not appeared in *ArgueMint*.

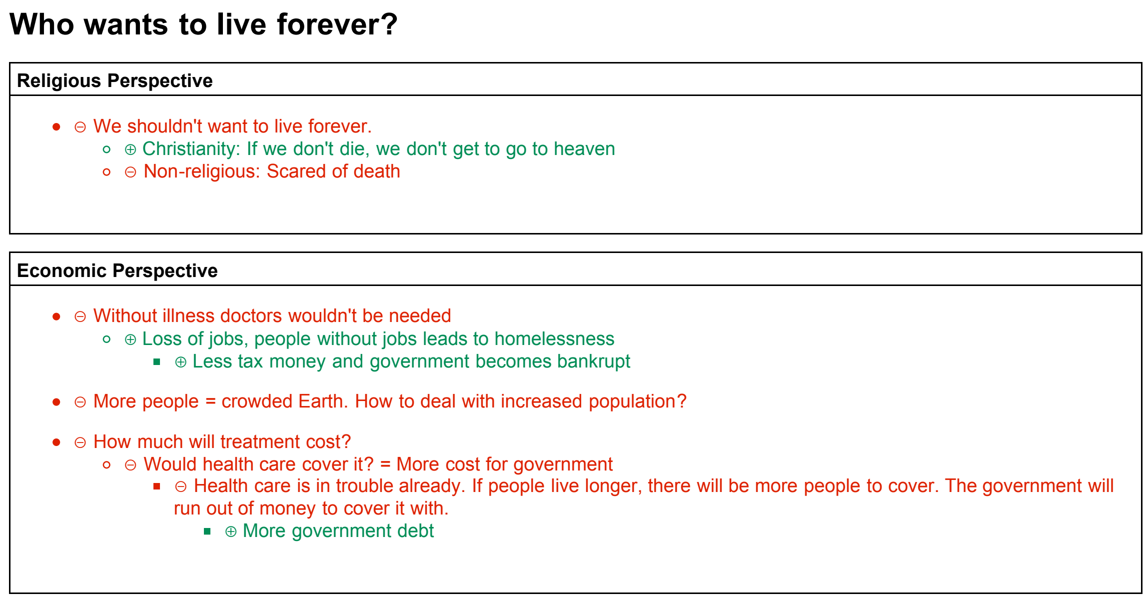
In order to promote the collaborative aspects of the inquiry activity, I added a new feature to *ArgueMint* for the second iteration of data collection. In the bottom-right corner of each perspective's box, a button was added entitled "Write Statement". Clicking this button takes the user to another page, in which they can see the statements they have made for that perspective already, while writing a "position statement" about the issue from that perspective (see Figure 5.1). The intention is for the students to work together to create this position statement, hopefully resulting in a higher degree of collaboration and incorporation of both students' ideas.

5.1.3 Usability Issues

Several issues affecting usability were noted while watching the video recordings and while reading through Stephanie and Steven's survey responses, mostly relating to efficiency of use.

First, in response to the survey question "What frustrated you about the tool?", both students mentioned that the font size was difficult to read. While in part this was due to the screen resolution settings on the computers employed in the data collection, checking the screen resolution on multiple other computers and screens revealed that, on many computers, the font size was rendered small enough to require extra effort to read and find information. In the second version, I increased the font size by about 20%. In addition to changing the font size, other user interface elements, such as "Support" and "Oppose" buttons, were increased in size and also redesigned visually to make it more immediately clear that they were buttons to be clicked, distinct from the text entered by the students.

Another issue affecting efficiency of use was the difficulty involved in moving a statement to a different part of the argument, or in changing a statement from supporting to opposing the position. In four cases, statements were deleted and retyped in order to move them into a different perspective, or to become a sub-point of another existing statement. In another case, a statement was originally typed as a support statement. Following some verbal discussion, it was decided that it should actually be an oppose statement, so Stephanie deleted the original statement and retyped it as an opposing statement. In the second version of *ArgueMint*, the ability to change a statement from opposing to supporting or vice versa was added, simply requiring a click of an icon when rolling over the statement with a mouse. Moving statements from one location to another, however, required that I make more elaborate modifications to *ArgueMint*, and I did not have time to do this before the second round of data collection commenced. This feature is planned for implementation in



Who wants to live forever?

Religious Perspective

- ⊖ We shouldn't want to live forever.
    - ⊕ Christianity: If we don't die, we don't get to go to heaven
    - ⊖ Non-religious: Scared of death

Economic Perspective

- ⊖ Without illness doctors wouldn't be needed
    - ⊕ Loss of jobs, people without jobs leads to homelessness
        - ⊕ Less tax money and government becomes bankrupt
- ⊖ More people = crowded Earth. How to deal with increased population?
- ⊖ How much will treatment cost?
    - ⊖ Would health care cover it? = More cost for government
        - ⊖ Health care is in trouble already. If people live longer, there will be more people to cover. The government will run out of money to cover it with.
            - ⊕ More government debt

Figure 5.2: A portion of the printed output from the second version of *ArgueMint*.

a future version.

The final change that was introduced before the second round of data collection was to provide a separate Cascading Style Sheet (CSS) for printed output from *ArgueMint*. Although neither of the students commented on the printed output that was provided for them to use during the final essay writing, the author noted that, on black and white printers, the visual distinction between support and oppose statements (coloured green and red on the screen, respectively) was lost. This could potentially contribute to misunderstanding by students, particularly of statements that were not their own ideas to begin with. To fix this issue, the print CSS used in the second version inserted a '+' or '–' symbol at the beginning of each statement. In addition, user interface elements such as buttons were hidden in the print CSS to minimize the visual distractions on the page. Figure 5.2 shows a portion of the *ArgueMint* outline from the second round of data collection, as it would appear when printed.

Code	Stephanie	Steven	Angela	Adrianne	Mean
word count	339	392	466	238	359
sentence count	16	18	19	10	16

Table 5.1: Document statistics for unscaffolded essay

Code	Stephanie	Steven	Angela	Adrianne	Totals
claim	2	4	2	2	10
supporting reason	5	6	5	4	20
counter-argument	0	1	0	2	3
evaluation	2	2	1	2	7
qualifier	1	0	0	1	2
Totals	10	13	8	11	

Table 5.2: Argumentation codes for unscaffolded essay

5.2 Initial Essays

In both data collection sessions, the first activity was to write a short essay on the article "Singing the Praises of Wind Energy" without the use of *ArgueMint*. These essays were examined to find evidence of good argumentation and SSI inquiry. Table 5.1 shows some basic statistics about these essays. Three of the four students produced essays with 16 or more sentences, while the fourth student (Adrianne) produced only 10 sentences in her essay.

5.2.1 Argumentation Codes

Table 5.2 shows the frequency of the argumentation codes as they appeared in each of the essays. Each of the students made explicit claims and backed them up with supporting reasons. In fact, there were no claims identified in the essays that were not followed by at least one supporting reason for that claim.

Only two of the students incorporated counter-arguments into their essays. All three of the counter-arguments given consisted of a single phrase which offered a reason why the respective claim may not be true. Both students mentioned that wind energy produces "less energy than fossil fuels", and Adrianne also mentioned the negative impacts on birds with reference to a claim that wind energy was "better for the environment". Significantly, each of these two arguments were directly stated in the article the students were provided with, so no novel counter-arguments were developed.

Each of the essays included one or two sentences that were coded as evaluation statements. An evaluation involves making a judgment or decision about the truthfulness or relative value of a claim. In four cases, the evaluation code appears in either the same sentence or an adjacent sentence to a claim. In the other three occurrences, the evaluation is in a separate paragraph or concluding statement. In these three cases, the students synthesize several of the claims, and try to reach a position on the issue as a whole, based on their arguments. For example, Angela concludes her essay by contrasting the advantages of wind energy as a green energy source with the possibility harm to endangered species to suggest a policy:

> "Wind energy is a fantastic source of energy that should be harnessed wherever possible, but until the effects on nocturnal birds and animals has been thoroughly investigated and solutions have been found, wind energy should not be used. We do not want to start a cycle that leads to the deaths of many animals, some as a direct result of the wind turbines, others as a indirect response."

The argumentation code that appeared the least in the essays was "qualifier". In both appearances, the qualifier was a single word ("overall" in one case, "may" in the other), that limits the strength of the claim being made. The other type of qualifier, in which an alternate line of inquiry is suggested that may affect the value of the claim, did not appear in any of the written essays on wind energy.

Code	Stephanie	Steven	Angela	Adrianne	Totals
identifying perspectives	1	0	0	0	1
reference to research	6	2	4	4	16
need for information	0	1	1	1	3
recognizing bias	0	1	0	1	2
Totals	7	4	5	6	

Table 5.3: SSI codes for unscaffolded essay

5.2.2 SSI Codes

Table 5.3 shows the frequency of SSI codes in initial essays. Perhaps the most notable feature of the essays from an SSI perspective is the nearly complete lack of "identifying perspectives" codes. Stephanie was the only student to explicitly identify a specific perspective, writing "Even though using wind as an energy source may seem good for the environment, ...". Each of the students focussed their arguments around the issues of pollution and protection of endangered species, which were brought up in the article, without considering other possible viewpoints.

Each of the four students referenced the original article in their essays between two and six times. Most of these references occurred in the introductory paragraph(s), in which the student was providing background to the issue before making their claims. Once the students had begun arguing their position, direct references or quotes from the article appeared only twice in support of their claims.

Three of the students noted deficiencies in the information provided. For example, Steven and Adrianne both pointed out the lack of adequate information for comparison purposes. Steven writes:

> "Unfortunately, this article doesn't present much actual information, so it's difficult to tell whether or not wind turbines are an actual threat to wildlife. For all

> this article tells me, more birds may die by flying into windows than turbines. Therefore, my position on wind energy is not influenced by this article."

This was coded both as "need for information" and "recognizing bias", as he points out that the information provided doesn't provide balance due to the lack of comparative information. Adrianne presents a similar objection, when she writes:

> "This article tells how the wind turbines used to create wind energy are killing nocturnal birds and bats, but I'm sure there is other research available on how hydro electricity is affecting fish populations, water cleanliness, and the surrounding towns and houses."

5.3 Scaffolded SSI Inquiry with *ArgueMint*

The remainder of the chapter provides a detailed look at how the two pairs of students (Stephanie and Steven, and Angela and Adrianne) used *ArgueMint* to engage in a discussion of the article "Who Wants to Live Forever". A description of how the activity took place for each pair will be provided, and a discussion of the analysis of the activities follows.

5.3.1 Pair 1: Steven & Stephanie

Steven began the discussion with Stephanie by asking her to give her position on research into extending human life spans: "Okay, Stephanie, so let's start with the basics. Are you for or against it?" Both students agreed that they were "against". Following this, each of the students presented what they considered to be their main objections to the research. Steven pointed out issues to do with overpopulation and the economic impact on social security, after which Stephanie mentioned land availability and food supply, especially in third world countries. During this initial exchange, the pattern of dialogue was that one student would talk, and the other would respond affirmatively with phrases like “makes sense” or “yep”.

At this point, about two minutes into the conversation, Steven went to enter some statements into *ArgueMint*. His first verbal comment was to determine which perspective the ideas they had discussed belonged to: “Okay, so would that be political perspective then, if we’re talking about overpopulation, or would that be just...” Stephanie responded that it would be “Economic”. A brief dialogue about how to enter the information and who was doing what ensued:

Steven:	“So, then I click “oppose”, right?”
Stephanie:	“Uh huh...”
Steven:	“You do that one.”
Stephanie:	“Am I doing that?”
Steven:	“Yep... I’ll click something else.”

At this point, the students typed in one statement each: Stephanie entered “Overpopulation in places” and Steven entered “Social security would go further into debt”, both as “opposing” statements under the heading Economic Perspective. At this point, even though they had mentioned details such as the impact on land use and food supply, these details were not entered into *ArgueMint*.

Following this, a general pattern began to form in their discussion. Steven would begin a new section of the discussion by naming one of the perspectives given in the template, as shown in the following examples:

> “From a scientific perspective, I think it’s a good thing.”
>
> “Ethical perspectives... They say so far there are no apparent side effects...”

> "Okay, so we've got ethical, scientific... Political perspective. So..."

A discussion would then follow, usually lasting about a minute. Most of the conversation was carried by Steven, with Stephanie responding affirmatively (e.g. "Mmm hmm...", "Alright...") or asking clarifying questions (e.g. "What do you mean by other fields of science?"). Following the discussion, they would decide who was going to type in *ArgueMint*, spend a few seconds doing the typing, and then begin again on another line of reasoning.

The data that was entered into *ArgueMint* was generally a very brief summary of the discussion – often only a single sentence. For example, during the discussion on the scientific perspective, the students discussed the value of basic cell research, the implications in medicine for cures of cell-related diseases such as cancer, and a possible link to stem cell and cloning research. However, all that was entered into *ArgueMint* was "Learning more might benefit other fields of science."

Nearly half-way through the session, Stephanie initiated a new line of discussion:

> "And, health reasons? If they were able to make us live longer, once you get past 80 or 60 or something, you're body's gonna be frail I guess; you won't be able to [do] the things you were doing back when you were younger, and so you'd be living an extra, I don't know, 200 years of your life as old, I guess."

Notably, this was one of the few sections of the discussion that did not begin with naming one of the perspectives given in the template. A lengthy dialogue about what effect an extended life span would have on a person from the perspective of biological aging followed, where they concluded that most likely a person wouldn't just "hit 100 and now you just keep getting older and older until you're walking bones" (Steven), but rather it would slow the whole process of aging. This lead them back to the economic perspective, when Steven suggested that people could be in the workforce for longer. This lead to a discussion on the implications for pensions and immigration policies, which had been a subject discussed in a recent Social Studies class. Steven, at two points in this part of the conversation, alludes to the complexity of the economic perspective:

> "I guess you could have pros or cons for people leaving the workforce later, or people retiring later."
> "So this would be good for... okay, so if Canada and America... it's good for the economy and bad for the economy."

Towards the end of this part of the discussion, Steven enters four statements in summary of the discussion:

- People ready for the workforce sooner
  - Older generations retiring, younger people filling empty jobs
- People retiring later
  - Jobs wouldn't be empty for longer periods of time

Again, these served as a very broad summary of the discussion, failing to capture much of the detail of the conversation. In addition, Stephanie didn't enter anything into *ArgueMint*, even though she had initiated this particular discussion. Her original point, which was about quality of life for the elderly, was not represented in *ArgueMint* at all.

After entering his statements, Steven began again with: "Anyway, I think what we've got looks good. So let's shift gears. Let's think more... political, ethical, scientific perspective. Because I think we've got the economy... we've got lots there." Stephanie raised the question of the health consequences of extending human life spans through a process involving controlled starvation, as described in the article. A brief discussion on obesity, dieting, and levels of fitness followed, but this time nothing was entered into *ArgueMint*. Steven seemed to feel that this point was weak:

Stephanie:	"yeah, obesity is a big problem, though"
Steven:	"Maybe in America. I don't know too many obese people".
	...
Steven:	"Wow, we're really pulling stuff... we're scraping the bottom of the barrel. 'This will help fight obesity' is our latest... Nothing too deep going on here right now"

Following this, Steven initiated a brief discussion on the costs of this sort of research, and whether it is worth the expense. After about 20 seconds, they decided they didn't have enough information on costs and budgets, so Steven concluded the session with "There we go... can't say. I guess, with that we're done!"

5.3.2 Pair 2: Angela & Adrianne

The second pair of students, Angela and Adrianne, began their session with a blank template and a menu from which they could choose a perspective to discuss. Both students immediately clicked on the menu to see what options were available to them.

Adrianne:	"Want to do 'Religious' first?"
Angela:	"Sure."
Adrianne:	"Because I'm pretty sure I know what I think of that one."

Following this brief exchange, the students lapsed into silence for about 40 seconds. Adrianne added the "Religious Perspective" to the template, and typed the statement: "We shouldn't want to live forever". Angela broke the silence when she responded verbally by saying "Okay, yeah. I'm just trying to think how to respond to that." At this point, the author clarified that they could talk to each other, and write down their thoughts after having a discussion first. This resulted in a brief exchange in which each of them made one statement about religion, before they returned to typing into *ArgueMint*.

Over the remaining half an hour on which they worked on the issue, their pattern of communication remained similar: while the first pair tended to "talk first, write later", Angela and Adrianne preferred to "write first, talk later". During most of the session, they either worked in silence, or spoke briefly about a point that had just been typed.

One of the other features of their session was the tendency to pose questions and leave them unanswered. For example, Adrianne typed "More people = crowded Earth. How to deal with increased population?", Angela responded by saying "Yeah, they're already having problems dealing with that." However, rather than discussing the issue of overpopulation further, Adrianne then added a sub-point to another statement. Other examples of questions which were posed and typed into *ArgueMint* but not discussed further include:

> "How will we test the drugs on humans?"
> "What if they mess up and actually shorten the life span of a human and they die as a result?"
> "If scientists believe that calorie restriction stops us from growing then would we technically be a certain many years old, but our body only resembles that of a younger age (mentally, physically, etc.)?"
> "Is it okay to drug test on people?"

In one verbal exchange, the students posed a whole series of questions which were also not explored further, or even entered into *ArgueMint*:

Angela:	It says it stops us from growing, so would that stop all aspects of growth?
Adrianne:	So would it just slow growth?
Angela:	Yeah, but then...
Adrianne:	But would you mature at the same rate?
Angela:	Yeah...
Adrianne:	Would you be smarter, as smart or...
Angela:	Because that could lead to like having to redo school systems, and... all that too.
Adrianne:	Would they start giving the drug at an early age, or...
Angela:	I don't know... yeah.

Angela and Adrianne also showed a tendency to use *ArgueMint* to store quotes from the article that they thought were important. Five separate quotations were included, four by Angela and one by Adrianne, in three different perspectives. These quotes were generally used to back up other statements. For example, Adrianne typed "This practice deals with calorie restriction. 'Calorie restriction, which in practice resembles controlled starvation.' " In support of Adrianne's statement that "this will help us move forward in science", Angela typed this quote:

> "Scientists plan to further investigate life span extensions in mice, and also study a human population in Ecuador with mutations analagous to those described in yeast."

Perhaps due to their tendency to "type first, talk later", Angela and Adrianne were significantly more verbose in their *ArgueMint* outline than the first pair of students. In addition to posing questions and storing quotes, they tended to use the software almost like a discussion forum. For example, in the "Legal Perspective" section, a written conversation developed:

- Is it legal to test drugs on people? (Adrianne)
  - If the project is government and scientifically approved...? (Angela)
    - Then yes? (Adrianne)

      Yes. It still says that they have done animal testing and it appears safe, but I still think they should do more. I don't think testing something like this on mice is enough. (Angela)

After about 35 minutes of working with *ArgueMint*, Adrianne asked "How much of this are we supposed to do?". They were told that they could stop at any time, and that they didn't have to do all of the perspectives in the menu. Angela replied, "That's just like us to go through everything, though." At that point, they decided to end the activity.

5.3.3 Coding

The codes described in the previous chapter were divided into four categories, which will be represented in the following sections. Data from both the transcripts of the sessions and the written *ArgueMint* outlines will be considered, as well as the individual essays written by the students following the session.

Argumentation

Table 5.4 shows the frequency of the argumentation codes as they appeared in the transcripts and *ArgueMint* outlines for each pair. There is a marked difference between the relative number of codes in the transcripts and outlines between the two groups. As mentioned in

	Pair 1		Pair 2		
Code	**Transcript**	**Outline**	**Transcript**	**Outline**	**Totals**
claim	4	2	3	2	11
supporting reason	26	12	4	20	32
counter-argument	6	0	2	6	14
evaluation	8	0	2	0	10
qualifier	2	0	2	0	4

Table 5.4: Argumentation codes for *ArgueMint* data

	Pair 1		Pair 2		
Code	**Transcript**	**Outline**	**Transcript**	**Outline**	**Totals**
identifying perspectives	12	0	3	2	17
recognizing bias	1	0	0	0	1
reference to research	6	1	5	6	18
need for information	6	0	5	1	12

Table 5.5: SSI codes for *ArgueMint* data

a previous section, Pair 1 (Stephanie and Steven) tended to talk a great deal and write down relatively little in *ArgueMint*, whereas Pair 2 (Angela and Adrianne) tended to "type first, talk later". As a result, Pair 1 shows many more argumentation codes in the transcript, while Pair 2 had most of their argumentation written in their *ArgueMint* outline. For example, Stephanie and Steven made twice as many claims and gave more than twice as many supporting reasons for those claims in their verbal discussion than they wrote down. Angela and Adrianne verbalized only four supporting reasons, while twenty appeared in their outline. Stephanie and Steven made six counter-arguments in their verbal discussion, but none of those appeared in *ArgueMint*. Two of the codes, *evaluation* and *qualifier*, appeared only in the transcripts of the two pairs, and never in the *ArgueMint* outlines.

Socioscientific Inquiry

Table 5.5 shows the frequency of codes related to socioscientific inquiry in the transcripts and *ArgueMint* outlines. Both groups verbalized the perspectives that they were considering on multiple occasions. Pair 1's verbal references to identifying perspectives were generally focussed on determining which of the provided perspectives a particular point they were discussing fit into. Significantly, they made no mention of any other perspectives than the ones provided in the template (Ethical, Scientific, Political, and Economic), even though a heading for "Other Perspectives" was provided. In their outlines, no explicit reference to perspectives was made, but each statement entered into *ArgueMint* was placed under a particular heading representing one of the four given perspectives. Of the three occurrences of the *identifying perspectives* code in Pair 2's transcript, two of them were also focussed on determining which perspective was most appropriate for a statement that had been made. The third code occurred when Angela and Adrianne were discussing which perspective to chose first from the pop-up menu of perspectives that was provided. In their written work, Angela and Adrianne categorized their work into six different perspectives, which were selected from the provided pop-up menu: Religious, Economic, Ethical, Scientific, Legal, and Other. The two occurrences of the code in their outlines occurred when they were subdividing the Religious perspective to contrast the different perspectives of Christianity and non-religious people.

The *recognizing bias* code only appeared once, in the transcript of Pair 1's discussion. Steven expressed skepticism that the researcher's claim in the article that life spans could be increased with "no apparent side effects" would hold up under further research. Aside from this one instance, the students in both pairs expressed no other concerns about potential bias in the reported data or the articles themselves.

	Pair 1		Pair 2		
Code	**Transcript**	**Outline**	**Transcript**	**Outline**	**Totals**
elaboration	0	2	1	11	13
negotiation	4	0	2	2	8
rebuttal	2	0	2	4	8
incorporation	-	12	-	10	22

Table 5.6: Joint argumentation codes for *ArgueMint* data

Both groups referred several times to the articles provided in the activity. The *reference to research* codes were generally applied to times where phrases or sentences of the article were read out loud in support of a point that had been made. Pair 2 also typed several quotes directly into *ArgueMint*, seemingly as a way to keep track of those quotations for use in the individual writing assignment that would follow. Both groups also verbalized the need for more information than was provided in the article. This was generally in the form of a recognition that there were gaps in the existing research, but on one occasion Steven also indicated that he wished he could see the original research, since the summary of data in the article was not sufficient to answer his questions.

Joint Construction of Argument

Table 5.6 shows the frequency of codes that relate to the joint construction of the argument, as described in Chapter 4. Both the transcripts and *ArgueMint* outline were coded for *elaboration*, *negotiation*, and *rebuttal*, as these codes reflect the process of collaborative argumentation. The fourth code, *incorporation*, was coded in the *ArgueMint* outlines only. This code could be thought of as an outcome of argumentation (statements which were taken from the outline and utilized in the final essay), measuring the usefulness of *ArgueMint* as a sort of external memory.

The *elaboration* code, which reflects instances in which one student built on the idea or statement of another student, occurred only once in the transcripts of the verbal discussion between the two pairs of students, but it appeared 13 times in total in the written outlines. For the first pair, the lack of elaboration of each other's points matched the tendency of one student (Steven) to dominate much of the conversation. The two occurrences of the code in the written outline occurred where Steven added sub-points in the outline to a statement which had been typed by Stephanie. Angela and Adrianne did not elaborate verbally on each other's points very frequently either, as they tended to type first and talk later (or not at all). However, many of the statements they typed into *ArgueMint* built on each other, providing evidence that they were collaborating in developing lines of reasoning about the topic.

The *negotiation* and *rebuttal* codes appeared less frequently than *elaboration*. Stephanie and Steven tended to verbalize their points before entering them, and on two occasions discussed disagreements about various points, resulting in four *negotiation* and two *rebuttal* codes from the transcript. Near the end of the discussion, for example, a conversation took place about the health consequences of "controlled starvation" (one of the procedures that contributed to the longevity gains described in the article) with respect to obesity:

> Stephanie: It would encourage dieting.
>
> Steven: People would be more fit? I honestly wonder.
>
> Stephanie: They'd be more fit, but they wouldn't be as healthy.
>
> Steven: No, they wouldn't be more fit, they'd just be skinnier. There's a difference, right? Like, fit is "[I'm] going to work out."

Interestingly, although this discussion continued for a minute or so, no entries were made into *ArgueMint* on the topic as a result of this conversation. In fact, none of the points on which the *negotiation* or *rebuttal* codes occurred in the verbal discussion found their way into the written output, perhaps implying that either consensus was not reached or that, because there was a difference of opinion, the point was not considered strong enough to include.

In the last phase of the activity, students were provided with a printed copy of their *ArgueMint* outlines and asked to write a brief essay describing their position on the topic. All four students referred to the written outline and incorporated statements from it into their essay, to varying degrees. The first pair (Stephanie and Steven) wrote 14 statements in their outlines, of which 12 were incorporated into written work. Stephanie incorporated 9 of the statements into her work; of these, she used all three of the statements she had authored, and six of the 11 statements authored by Steven. By contrast, Steven incorporated only three statements in total from the outline. These were all statements which he had authored; he did not reference any of the points that had been raised by Stephanie.

The second pair (Angela and Adrianne) wrote a total of 36 statements in their outline, but only 10 of these were used in their essays. Both students preferentially used statements they had authored themselves, with five appearing in each students' essays; they both, however, included statements authored by the other student, with Angela using two of Adrianne's statements and Adrianne using one of Angela's.

5.3.4 Usability

As described in Chapter 3, several components of usability were considered in the design phase of *ArgueMint*:

- Learnability
- Efficiency of Use
- Memorability
- Few and Non-Catastrophic Errors

- Subjective Satisfaction

Several usability concerns that stemmed from the Pair 1 activity were addressed earlier in this chapter. In the second iteration, after increasing the font size and modifying the appearance of buttons, the video recording and transcript showed no evidence that students were still struggling to read text in the user interface. In addition, there were no concerns about the printed output; the students correctly recognized the icons showing “supporting” and “opposing” points in place of the colour scheme used on the screen.

Another change that was implemented before the second iteration was a “change disposition” button, which was intended to allow students to change a statement in *ArgueMint* from “support” to “oppose”. However, this button was not used by Angela or Adrianne. Instead, on two separate occasions, when one student pointed out to the other that perhaps they had chosen the wrong disposition for the statement, the students copied and pasted the text into a new statement with the correct disposition, and then deleted the original statement.

From notes taken while watching the video recordings, the following observations can be made about the overall usability of *ArgueMint*. First, the learnability and memorability of the software seem to be very high. Both pairs of students asked questions or “talked aloud” about interacting with the software in the first few minutes of the activity, but the frequency of such questions or comments dropped off dramatically after they had entered a few statements. Video screen captures showed that students worked with the user interface confidently and quickly, without spending a lot of time thinking about how to carry out an operation. The main concerns around efficiency of use were the inability to efficiently move a statement from one part of the outline to the other, and to change the disposition of a statement (e.g. from “support” to “oppose”). In both iterations, these operations led to copying and pasting into new statements, or retyping entire statements, before deleting the original statement. One other observation from the video recording was that in one occasion, both students went to edit the same statement at the same time, resulting in some confusion and discussion about who was doing what.

The video recordings showed no evidence of catastrophic errors. The errors that were made were of two types: spelling and grammatical errors, or errors in positioning or classifying statements. All four of the students fixed errors at some point during the activities, and in only one case was there a momentary hesitation in which a student tried to figure out how to edit an existing statement; even in this particular instance, the pause was only approximately 2 seconds in duration. In no cases did either pair of students lose anything they had typed, either by software error or accidental user actions.

In terms of subjective satisfaction, the students seemed generally satisfied with the software. Two questions on the survey were designed to deal specifically with subjective satisfaction. For the first question, “What frustrated you about the tool?”, the two students in Pair 1 answered that the font was too small to read, while the second pair of students each answered “Nothing”. The other question asked, “Was there anything you wished you could do with the tool that you currently couldn’t?” Two students answered with a simple “No” or “Nope”, while the other two each suggested ways to make categorization of their ideas more flexible. Stephanie wanted to be able to “name our ‘other perspectives’ ”, while Adrianne wished that she could have “different coloured fonts to classify my points more”.

5.4 Final Essays

Following the *ArgueMint* activity, students in both data collection sessions were asked to write an essay to address the following question: “What is your position on research intended

Code	Stephanie	Steven	Angela	Adrianne	Mean
word count	393	344	413	210	340
sentence count	17	18	18	14	17

Table 5.7: Document statistics for final essay

to increase human life spans?" Table 5.7 shows basic word and sentence counts for each essay; a comparison with 5.1 reveals that the essays were similar in length for each student to the ones written before the activity. In this section, these essays are examined for evidence that the *ArgueMint* activity had an influence on their thinking about the topic.

The first pair, Stephanie and Steven, began their activity by stating their overall opinion on the issue of longevity research:

Steven:	Okay, [Stephanie], so let's start with the basics. Are you for or against it?
Stephanie:	Against it.
Steven:	Yeah, me too.

When they wrote their essays following the discussion, however, their positions seemed to have changed or at least softened somewhat. Stephanie's essay began with the following:

> I think that the research being put into extending the life span of humans may be beneficial in some aspects such as expanding our knowledge in other areas of science. However, I think that overall, the well-being and environment that will result from extended life may not be as good as we might think.

Steven's essay demonstrated an even stronger change of opinion:

> Research intended to increase human life spans is a good idea that could potentially help solve the problems this worlds [sic] younger generations face.

Code	Stephanie	Steven	Angela	Adrianne	Totals
claim	2	2	1	1	6
supporting reason	14	8	9	13	44
counter-argument	1	0	0	0	1
evaluation	3	2	1	5	11
qualifier	3	0	0	0	3
Totals	23	12	12	19	

Table 5.8: Argumentation codes for final essay

Table 5.8 shows the frequencies of each of the argumentation codes for the final essays. Each of the students articulated at least one well-defined claim, and supported it with a large number of supporting reasons. Not all of the supporting ideas came from the written outlines or the verbal discussion; each of the students incorporated between three and six statements in their final essays that had not been articulated in the group activity. In Steven's case, four of his 8 supporting reasons were new ones that he had thought up independently. The new ideas were generally extensions or elaborations on ideas that had been discussed previously; for example, in writing about the issue of overcrowding, Adrianne added that increased population would have an effect on the demand for goods. In another example, Stephanie further explored the "long term effects [on] people" by suggesting that "if nutrient reduction on your body were to slow down the way your muscles or bones grew, then any tasks involving physical labor would be difficult to accomplish".

Only one counter-argument appeared in the final essays. In dealing with the food shortages as a result of over-population, Stephanie pointed out that death as a result of starvation would counteract the over-population problem. However, other counter-arguments which were raised in the verbal discussion and written outlines did not appear in the final essays. Only a few qualifiers were present in the final essays as well, and these all appeared in Stephanie's essay.

Code	Stephanie	Steven	Angela	Adrianne	Totals
identifying perspectives	0	1	0	4	5
reference to research	3	1	4	2	10
need for information	0	0	0	0	0
recognizing bias	0	0	0	0	0
Totals	3	2	4	6	

Table 5.9: SSI codes for final essay

Code	Stephanie	Steven	Angela	Adrianne	Totals
own statement	3	3	5	5	16
partner's statement	6	0	2	1	9
new idea	6	4	3	4	17

Table 5.10: Origins of ideas found in final essay

As Table 5.9 shows, only two students explicitly identified different perspectives in their final essay. Steven focussed his entire essay on the economic perspective, which he identified in his first paragraph, without referencing the other perspectives at all. Adrianne organized her essay around some of the different perspectives that had been addressed in the *ArgueMint* activity, with paragraphs on the religious, economic, legal, and ethical arguments that had been discussed. The other two students each implicitly utilized several different perspectives in their writing without naming them. For example, Angela referred to unemployment concerns in the medical field and the potential economic impact, the effects on the criminal justice system, and the ethics of this type of research.

Each of the students made at least one reference to the research presented in the article, but none of the students articulated the need for more information or the potential for bias in the research. Throughout the pair activity, Steven repeatedly identified areas in which they needed more information, stating one occasion about his own argument about population dynamics: "I'm just hesitant to use that, because I actually don't know the numbers of our generation versus everybody else." In his final essay, he simply omitted this line of reasoning.

The essay content showed that students incorporated a significant amount of material from the written outlines produced in *ArgueMint*. Table 5.10 shows the origin of the ideas used in the written essays for each student. With the exception of Stephanie, the students used more of their own statements from the written outline than those of their partner. In Stephanie's case, however, she used all three of the statements that she had authored in *ArgueMint*, and then used Steven's statements to complete her essay.

In comparison with the initial essays that the students wrote before the *ArgueMint* activity, it is interesting to note that the students tended to give a larger number of supporting reasons in their final essays. While the "supporting reason" code appeared 20 times (a mean of 5 times per essay) in the initial essays, it appeared 44 times (a mean of 11 times each) in the final essays. Similar gains, however, were not seen in the other argumentation codes. The number of explicit claims was actually less in the final essays, with no student making more than two claims. Only one student, Stephanie, mentioned a counter-argument, while two students had made counter-arguments in the initial essay. In the final essays, the students explicitly identified perspectives five times compared with one in the initial essay; however, only one student accounted for four of the five instances of perspective-taking. Other codes referring to SSI inquiry, including "reference to research", "need for information", and "recognizing bias", appeared less frequently (or not at all) in the final essays.

5.5 Summary

Both pairs of students who worked with *ArgueMint* in this study showed characteristics of good socioscientific inquiry, while taking different approaches to how they worked in the activity. The first pair tended towards verbal discussion, talking through a line of reasoning before typing out a brief summary of their discussion into *ArgueMint*. The second pair tended to use *ArgueMint* as the medium for communication, even though they were sitting face-to-face in the same room. Their verbal discussion was oriented more towards questions of process – who was doing what, and what perspectives to work on next.

The scaffolding provided to encourage consideration of multiple perspectives was utilized effectively by both pairs. The design change towards allowing students to pick from a more extensive list of perspectives rather than work from a shorter, predefined list allowed Angela and Adrianne to consider a broader range of perspectives than Stephanie and Steven. Although students still tended to use more of their own ideas, three of the four students incorporated statements from the written outlines that had been authored by their partners.

From a usability perspective, the students were able to learn and efficiently use the software in a very short period of time, and expressed little or no dissatisfaction with how the software operated. Noted issues, including the need to move statements or reorganize them, could be implemented in future versions of *ArgueMint*.

Chapter 6

Discussion

In this thesis, the design and implementation that I undertook of a web-based software package, *ArgueMint*, has been described. The research design was intended to shed light on how *ArgueMint* would be used in practice. The research attempted to address the following questions:

1. How do students use ArgueMint in face-to-face argumentation on a socio-scientific issue?
2. What features of the system are the most useful and useable in mediating argumentation?

In this final chapter, these two questions are addressed through reference to the results of the study as described in the previous chapter. In addition, some directions for future research and development of *ArgueMint* are discussed, based on these findings.

6.1 How was *ArgueMint* Used?

In this section, several key findings from the research study are discussed, with respect to the way in which the students interacted with *ArgueMint* during the activity.

When given an issue to write about individually (without using *ArgueMint*), without working with other students, the students wrote reasonably well-argued positions, in the sense that they tended to make claims and support them with reasons either from their own thinking or from the information provided to them. However, the students in this study, in their individual essays, tended not to explicitly identify more than one perspective. In addition, they infrequently identified a need for more information or areas for further research. Only two of the students identified possible bias in the information presented to them. The counter-arguments that appeared in two of the individual essays were ones which appeared in the resource that they were given to read, so the students in their individual essays also failed to think of novel counter-arguments to their own reasoning.

During their activity with *ArgueMint*, the characteristics of the argumentation that occurred were somewhat different. While the *ArgueMint* outlines continued to show claims supported by numerous reasons, analysis of the conversation between the students while using *ArgueMint* and their outlines indicated that more counter-arguments were given than in the individual activity. In addition, with the help of the scaffolding, students identified and considered several different perspectives and identified several areas where further information or research would be useful.

In the final individual essays, however, some of the positive characteristics of the group activity were not reflected well. While claims continued to be supported adequately, the counter-arguments that appeared in the *ArgueMint* activity failed to appear in the students' final individual essays, with one exception. Only one of the students explicitly identified more than one perspective in the final essay, and none of the students pointed out potential bias or a need for more information. It is possible that these missing elements were a result of the nature of the activity; perhaps the students felt that counter-arguments or pointing out a need for information would weaken their position and were therefore inappropriate in an essay format. Another possibility is that the collaborative learning which took place in the activity simply didn't transfer well to the individual work.

It is interesting to note that, for most of the argumentation and SSI codes employed, the final essays actually showed fewer instances of the codes than the initial essays; the one notable exception was the increase (approximately two-fold) in the number of supporting reasons given for claims made in the essays. Due to the lack of a control group in the research design, it is impossible to make strong claims about the reasons for these differences. It seems likely that the *ArgueMint* activity and the resulting outlines that they produced with the software helped them to think of and recall more supporting reasons than when they were working individually. However, this could also simply indicate that they had had more practice at arguing socioscientific issues by the end of the data collection, or that they found the "Who Wants to Live Forever" article more engaging than the "Singing the Praises of Wind Energy" article. Overall, the increased frequency of counter-arguments and perspective-taking noted during the *ArgueMint* activity did not seem to transfer to the final individual essays, as these actually appeared less frequently than they did in the initial essays.

In the following sections, two aspects of socioscientific inquiry, *considering multiple perspectives* and *collaboration*, are considered. These aspects were two of the key elements that *ArgueMint* was explicitly designed to scaffold.

6.1.1 Considering Multiple Perspectives

Sadler, Barab and Scott (2007) identify the examination of socioscientific issues from multiple perspectives as one of the four key dimensions of SSI decision-making. One of the challenges that I encountered in the design of *ArgueMint* was to find a way to scaffold perspective-taking. In the first iteration of the study, the students were provided with four pre-defined perspectives and an "Other Perspectives" section; the students dutifully filled something in for each of the perspectives that were given to them, but left the "Other Perspectives" section blank. It seems unlikely that this type of scaffolding would encourage perspective-taking as a habit of mind that would transfer into other, unscaffolded problems.

In the second iteration, a different approach was taken. The students were give a list of named perspectives to choose from, which resulted in them choosing several different perspectives – in fact, the students seemed to wonder if they should perhaps try to do something for each of the perspectives. However, they again showed a tendency to only use the predefined list rather than think of perspectives on their own, which most likely means that transfer to other problems would be rather minimal.

6.1.2 Collaboration

In collaborative argumentation, ideally one would expect to find that working together with another student substantively changes or enhances the thinking of an individual. For example, one would expect that, by discussing a controversial point with another student, a student's position on that point might be further clarified, refined, or altered as a result of the conversation. In this study, codes such as *elaboration*, *negotiation*, and *rebuttal* were employed to label such interactions. In addition, one might expect to find that a student would incorporate many of the ideas or statements made by their partner into their own thinking on the issue (in this case, in the final individual essay).

There was little evidence that the collaborative aspects of the *ArgueMint* activity influenced the individual students' thinking in meaningful ways. There was little evidence of negotiation or rebuttal on controversial points, and even when some negotiation did happen verbally, the students then failed to incorporate that discussion into their own work on the individual essays. The students seemed to preferentially use their own ideas and statements from *ArgueMint* in their written work, rather than thoughtfully incorporating the ideas put forward by the other student.

Group dynamics undoubtedly play a large role in the quality of collaboration. In the first pair of students (Stephanie and Steven), one student, Steven, tended to dominate both the verbal discussion and the written work in *ArgueMint*. This is not to say that Stephanie had nothing worth saying; in fact, her individual written work was of high quality and incorporated more ideas from the collaborative work than Steven's did. However, whether due to personalities, gender stereotypes, or other factors, this pair showed a marked inequality in contributions. The second pair, by contrast, provided roughly equal contributions to both the verbal discussion and written outlines in *ArgueMint*, and also more frequently showed evidence of collaborative argumentation.

6.2 Usefulness and Usability

The students in this study demonstrated that the basic features of *ArgueMint* were quite useable. It took only a minute or two before each student demonstrating mastery of the interface in terms of adding new statements, choosing correctly between "supporting" and "opposing" positions, and editing or deleting existing statements. The rollover-based interface for editing or building on existing statements did not seem to cause any difficulty or frustration for the students.

As described in an earlier chapter, during the design process I decided to use a loosely-structured model for scaffolding argumentation. Rather than requiring students to classify statements as claims, warrants, backing, or qualifiers following Toulmin's (2003) model, a simplified structure of "supporting" and "opposing" statements organized within nested bullet lists was used. This resulted in students being able to work with the scaffolding competently with very little prior knowledge about the structure of arguments or definitions of argumentation terms, while still encouraging them to think about counter-arguments or rebuttals to their claims.

Some features of the interface were not utilized fully. For example, in the second pair, the added feature of being able to write a position statement for a given perspective went completely unused. The goal of this feature was to encourage students to collaboratively reach consensus on the issue from a particular perspective, and essentially scaffold individual students' use of the other students' ideas. However, this simply did not occur in the activity at all. A possible solution to this would be to make the position statement stage mandatory before the completion of the activity.

The other feature that went completely unused in the second iteration was the button to allow a statement to be changed from "supporting" to "opposing". In more than one case, the students simply retyped or copied and pasted an incorrectly labelled statement into a new statement. This likely represents confusion over the purpose of this button, perhaps due to an inadequate icon or confusion over the distinction between this button and the "support" or "oppose" buttons.

6.3 Future Directions

This study describes the initial design, implementation and testing of *ArgueMint*, but there is still a significant amount of work to be done to fully explore the possibilities of this software for synchronous collaborative argumentation. In this section, several suggestions for future development of the software are made. In addition, several remaining questions or directions for future research are proposed.

6.3.1 Directions for Further Design and Development

Several shortcomings and possibilities for future development arose in the analysis of the activities carried out in this research. The suggestions made in this section are intended to guide development of *ArgueMint* in preparation for its use in further research. Suggestions are organized into the following areas: *scaffolding*, *resource availability*, and *usability*.

Scaffolding

The scaffolding provided by the first two iterations of *ArgueMint* focussed on the structure of the argument being constructed, rather than the activity in which the argumentation would take place. In a future iteration, more attention should be paid to the activity in order to promote a more effective argumentation process.

In the first stages of the activity, students selected a perspective to start with from either a preset template containing a few perspectives or from a longer list of possible perspectives. While students did consider more than one perspective, this process seemed to limit their thinking to just the perspectives that were already given. Perhaps a more effective way to promote consideration of different perspectives would be to create a separate stage of the activity in which students are asked to brainstorm different perspectives before beginning to fill out details of the argument. Rather than using the term "perspective", which may be confusing to students, this stage of the activity could be framed with the question "Who are the possible stakeholders that may have an interest in this topic?". By personifying the perspectives, hopefully the students will have an easier time identifying several different perspectives and also identifying what arguments might belong to which perspective.

At the end of the activity, students were asked to write an essay describing their position on the topic that was discussed. One of the findings of the research was that the students tended to predominately use their own ideas in this essay, without much synthesis with the ideas of the other student, even when those ideas were written in the outline. In order to encourage more of this synthesis, *ArgueMint* could make the writing of a position statement for each perspective mandatory before completing the activity. For example, to complete the activity, students could click on a "Submit" or "Finish" button, triggering a review process which would then prompt them to complete any blank position statements before allowing them to print their outlines. This validation process could also be expanded to identify perspectives that seemed to lack counter-arguments or opposing statements, encouraging students to go back and think some more about perspectives which might have been under-discussed.

By essentially staging the activity into three sections (brainstorm perspectives, discussion, and review), it may be possible to further enhance the quality of inquiry into the socioscientific issue provided.

Resource Availability

One of the constraints which was placed on the *ArgueMint* activity was that the students were only provided with the one-page article from *Science Times* about the issue being discussed.

Students made several comments throughout the activity that indicated they wished to have more information. For the purposes of this activity, given its short duration, the lack of additional information was acceptable; however, in many cases, it would be desirable to allow students access to additional resources. This does not come without challenges, however; in particular, providing access to resources on the screen clutters the user interface, making it harder for students to concentrate on the task at hand and increasing the amount of interaction that is required to navigate the interface. For example, if students were to open another window or tab in their web browser, they would then have to click back to the window or tab containing *ArgueMint* to add information, and go back and forth between the resource and the *ArgueMint* window. In addition, while looking at the other resource, the *ArgueMint* outline would not be visible, meaning that students would have to remember key points from the outline that they were researching further.

A better option would be to provide a one-screen interface showing both the outline and the resource. From a user interface perspective, there is a significant amount of wasted screen space in the present implementation of *ArgueMint*. The vertical arrangement of statements in an outline format means that there is often a significant amount of unused space towards the right-hand side of the screen. This space could be utilized as a "resource viewer", into which students could load web pages or other documents to provide additional information. In many pedagogical scenarios, it may be desirable to provide students with a pre-defined list of resources which could be loaded into this space. By synchronizing the resource viewer between all students working in the group, this would encourage students to continue discussing and arguing points while they examined additional sources.

The disadvantage to such an interface is additional complexity; the effects of the more complex interface in terms of cognitive load would need to be carefully studied and managed. The *split attention effect*, in which extraneous cognitive load is increased when students are required to integrate information from spatially-separate sources, would need to be considered. If one assumes that collaborative argumentation on a complex socioscientific issue would come with a high intrinsic cognitive load, the task of integrating information from the "resource viewer" with information from the *ArgueMint* outline may interfere somewhat with the learning and processing of the new information.

Usability

One of the key usability issues that surfaced in the analysis was the inability to move statements to a different part of the argument, or reorder statements within a perspective. The most straightforward approach to allowing a more flexible structure would be to implement drag-and-drop for statements within the page. This would allow users to "grab" a statement by clicking and holding the mouse button on it, and dragging it with the mouse to another position on the page. Given the outline or tree structure of statements within a perspective, it would be important to provide visual feedback to the user during the drag operation to show the level (e.g. child or sibling in the outline structure) at which the statement would be dropped. Due to the familiarity most students have with drag-and-drop in other software applications, it is anticipated that using this metaphor would be the most effective way to allow reordering of statements.

Another usability suggestion is the reimplementation of the "switch disposition" button, which was added for the second iteration of the study but went unused. The purpose of this button was to allow students to switch a statement from "support" to "oppose" or vice versa; however, the button's purpose may not have been clear enough as students instead retyped the statements they wanted to switch. An improved user interface for this task would be a pair of small radio buttons, tagged with the words "support" and "oppose". Another possibility would be to use a pop-up menu for the same purpose.

Accessibility is another area in which improvements should be made to *ArgueMint*. Because none of the four students involved in the study had disabilities that would affect accessibility, this was not a priority in the initial implementations. However, in a larger study, accessibility concerns would be more of a priority. *ArgueMint* already uses Cascading Style Sheets (CSS) to determine font sizes and colour schemes, which allow students with disabilities to easily adjust these settings using custom CSS in their web browser. Additional accessibility concerns include correctly tagging buttons and other links and ensuring that page layout is done in a semantically correct way, so that screen readers for visually impaired students can accurately read the page.

6.3.2 Distributed Applications

One possibility that was not explored in this study was the use of a tool like *ArgueMint* for collaboration in distributed learning settings rather than face-to-face group work. As web-based software, *ArgueMint* provides a tool for synchronous collaboration that only requires access to the internet and a web browser, making it ideal for students from different schools, even in remote locations, to work together.

In order to make *ArgueMint* an effective tool for synchronous distributed argumentation, a few important challenges would need to be overcome. First, *ArgueMint* provides a rather narrow form of communication. Much of the verbal discussion between the students involved in this study involved communicating about the process of the activity, such as determining who would type or edit a particular point. *ArgueMint* presently does not include audio or text chat functionality. Design decisions would need to be made to determine whether building in chat funcionality or simply allowing the use of a third-party chat tool would be preferable in allowing this sort of informal dialogue to occur. In addition, the face-to-face groups had the ability to physically point to paragraphs in the provided articles, to draw the other student's focus to a particular point that they wanted to discuss. For distributed use, a shared "document whiteboard" that would allow the group to look at the same resource and highlight discussion points could be implemented. This could also enable the use of additional resources, if, for example, they were able to access other documents or web sites in this shared space during the activity.

The tradeoff to adding chat and whiteboard tools to *ArgueMint* is one of complexity and cognitive load. Increasing the amount of information that the student has to deal with on the screen places a higher extraneous cognitive load on participants. As SSI inquiry is a complex activity that places a high germane cognitive load on the arguers, this may lead to a decrease in the quality of argumentation produced. The use of audio chat rather than text-based chat may offset this somewhat due to the modality effect (Mayer, 2001), which suggests that the use of multiple modalities (audio and visual) may decrease the extraneous cognitive load of trying to coordinate several visual elements (e.g. the *ArgueMint* outline, text-based chat, and paper document) at once.

6.3.3 Directions for Future Research

While there were some indications in this study that using the *ArgueMint* software helped students to engage in SSI inquiry, the design of the study does not allow us to draw generalizable conclusions about the effectiveness of the software, or even draw a strong comparison between the scaffolded and unscaffolded inquiry of the students in the study. In addition, the structure of design research is such that one never really feels the study is "done" - further iterations of design and data collection would undoubtedly provide important information and refinements to the software's design.

There are several important questions which warrant further study:

- **How does collaborative argumentation differ between unscaffolded groups and groups using *ArgueMint*?** In this study, no "control group" was used; an experimental research design could be used to demonstrate effectiveness of the scaffolding provided by *ArgueMint*.

- **What is the optimal scaffold for argumentation?** In this study, a simple "support or oppose" model was adopted, but other models such as Toulmin's argument structure (or a variation of it) might enhance argumentation further. Another possible approach would be to utilize sentence openers to help students classify the types of statements they are making.

- **How can *ArgueMint* effectively scaffold distributed collaboration?** In this study, the focus was on face-to-face group work; however, the synchronous nature of *ArgueMint* affords it the ability to scaffold argumentation between groups that cannot meet face-to-face. Research is needed to determine the types of additional features required to make it useful for this sort of scenario, and how these should best be implemented.

- **How can *ArgueMint's* user interface be optimized to reduce cognitive load?** As features such as the proposed resource viewer or audio chat are added to the interface, issues with cognitive load may become more important in limiting the quality of inquiry or the learning that takes place while using *ArgueMint*.

- **How can skills learned in *ArgueMint* successfully transfer to other situations?** There was little evidence that the students in this study transferred skills such as perspective-taking or considering counter-arguments to their individual work, even immediately following the *ArgueMint* activity. Research is needed to explain why that transfer did not occur, and how transfer can be realized more effectively.

6.4 Using *ArgueMint* in the Classroom

One of my goals in developing *ArgueMint* was to create a tool that could be put to use easily and effectively in a classroom setting. In my high school science classes, as I mentioned in the first chapter, I have employed several different techniques to incorporate socioscientific issues into my curriculum, including individual work, whole-class discussion, and small group work. I feel that *ArgueMint* provides a refinement in several ways to the small-group discussions that I had already found to be quite effective in the classroom.

In addition to the scaffolding for argumentation and SSI inquiry that has already been discussed, using *ArgueMint* to support small-group discussion may provide several other advantages. First, given the nature of the scaffolding provided and the easy-to-use interface, it allows students to begin discussing issues with a minimal amount of advance teaching time on how to use the tool or construct arguments. This is vitally important within my classroom setting, where instructional time is always a precious commodity. Second, *ArgueMint* may provide students who would otherwise be unengaged in small-group work an avenue to participate. For example, someone who is not dominating the verbal discussion may be able to work at editing statements, or organizing the structure of the argument, whereas in a verbal discussion without the scaffold, they may just sit silently and disengage. The focus on collaboration and problem-solving rather than "winning the argument" may also encourage engagement from students who may disengage in a debate setting. Finally, using *ArgueMint* provides a unique opportunity to monitor and assess students' work in the small-group setting. Generally, small-group discussion is difficult to assess and monitor, because the teacher can only be in one place at one time. *ArgueMint*, however, has been designed to support extensive logging of activity within the software. It would be straightforward to implement some statistical analysis of logs to indicate the level of participation of individual group members. In addition, having a collaboratively-written output provides the teacher the ability to see what went on in the discussion overall, rather than picking up on snippets of the conversation as the teacher walks by.

There are few barriers to using *ArgueMint* in a classroom setting, but they should nonetheless be articulated. The major concern is the availability of computers, as each member of each group would need access to a computer. However, the requirements for such a computer are minimal – the only required software is a web browser that can support JavaScript and allow text entry. As computers become less expensive and web-capable smartphones and other devices become more ubiquitous, this issue will become less of a barrier. Another issue is the need for a physical space for group members to work face-to-face while using their computers. In my experience, many high school computer labs are ideally designed for individual work, with computers arranged in rows and large monitors obscuring sight lines. In this study, laptop computers were used to allow a more flexible configuration in which face-to-face communication was easier. This is another area where web-capable phones or personal media devices would provide better flexibility and mobility than a traditional desktop computer lab.

From a pedagogical standpoint, I found myself wanting to continue the activity beyond the single class period that was used in this study. Some of the students who participated in the study were overheard enthusiastically discussing the "Who Wants to Live Forever" article with their friends at lunch. In my classroom, I would tend to use the Science Times articles and the *ArgueMint* activity as described in this research as a jumping-off point to a larger investigation of a socioscientific issue. In addition to having students conduct further research into the issue, I would be very interested to engage the students in a broader form of discourse. For example, groups working on an issue could invite other groups from the class or experts from the scientific community to help them refine their *ArgueMint* outlines. Another possibility would be to integrate the *ArgueMint* tool with the Science Times website, allowing students from different schools around the world to collaboratively construct arguments on the issues as they are posted online.

6.5 Conclusion

Science Times aims to give students "the opportunity to examine, develop opinions, and discuss pressing and authentic issues of the day, while engaging critically with the culture of science". In this research, a software tool, *ArgueMint*, was developed to assist students in this process of critical engagement in socioscientific issues. The students in the study used *ArgueMint* to create an outline of an argument from multiple perspectives in an effort to reach a reasoned position on a controversial topic.

ArgueMint is by no means a finished product. Suggestions have been made for potential new features, such as a resource viewer, audio chat to support distributed groups, and several usability enhancements. In addition, several areas for future research have been proposed, in order to better understand the role of this sort of software in scaffolding collaborative argumentation and SSI inquiry. Future development and study of *ArgueMint* for this purpose will, hopefully, lead to it being an effective and engaging tool that will help meet the goal of developing scientific literacy in our students.

Appendix A

Science Times Articles

The next two pages show the articles from the *Science Times* website (http://www.sciencetimes.ca) that were used in the student activities in this research.

The first article is "Singing the Praises of Wind Energy" (Science Times, 2008a), which was used by the students in their initial individual essay assignment. The second article, "Who Wants to Live Forever?" (Science Times, 2008b), was used in the *ArgueMint* activity. These articles are reprinted here with permission from the author.

Singing the Praises of Wind Energy?

Wind energy may be one of the fastest growing sectors of the energy industry as energy utilities try to minimize their reliance on fossil fuels. However, this “green-energy” industry is not without its own environmental consequences. Researchers say that nocturnally active birds and bats have increasingly become prey to these large wind turbines, yet little guidance can be found for assessing the impacts of wind energy on the birds until now.

Songbirds are by far the most abundant flying vertebrates in most terrestrial ecosystems and until recently have been the most frequently reported fatalities at large (utility-scale) wind facilities in the US and Canada. A previous study showed that 78 percent of carcasses found at wind-energy facilities outside of California were songbirds protected by the US Migratory Bird Treaty Act. Among these, approximately half were nocturnal birds.

Recent monitoring studies indicate that these utility-scale, wind-energy facilities have also killed considerably more bats than were expected based on the earlier studies. For example, large numbers of bats have been killed at wind-energy facilities constructed along the tops of forested ridges in the eastern United States.

Part of the problem is that ‘preconstruction monitoring’ prior to wind turbines going into service is far less consistent than ‘postconstruction monitoring’ which includes keeping track of bird fatalities. Some US states have no requirements for preconstruction surveys, whereas others have only minimum requirements for surveys on threatened or endangered species or species of concern.

Making meaningful, visual observations of nocturnal activity requires not only selecting the appropriate methods and equipment, but also including the time-based and spatial scales required to answer important questions, say the researchers. They recommend a variety of methods and equipment to study the full impact of wind-energy facilities.

Suggested equipment includes night vision (thermal infrared) cameras, Doppler (weather surveillance) radar, as well as audio and ultrasound microphones (for birds and bats respectively). With the proper monitoring and equipment, scientists suggest we may get a better measure of the effect that the wind turbines are having on nocturnally active birds and bats.

ST

Do wind turbines provide us with “green energy”?

Volume 66 – Version C
(ISSN 1202-3639)

Who Wants to Live Forever?

Biologists have now created baker's yeast capable of living to the age of 800 in yeast years without apparent side effects. The basic but important discovery, achieved through a combination of dietary and genetic changes, brings science closer to controlling the survival and health of the unit of all living systems: the cell. "We're setting the foundation for reprogramming healthy life," said one scientist.

The research group put baker's yeast on a calorie-restricted diet and knocked out two genes (RAS2 and SCH9) that promote aging in yeast. "We got a 10-fold life span extension that is, I think, the longest one that has ever been achieved in any organism," said the scientist. A few years ago, the same research group reported a five-fold life span extension. Normal yeast cells live about a week.

Baker's yeast is one of the most studied and best understood organisms at the molecular and genetic levels. Remarkably, yeast has led to the discovery of some of the most important genes and pathways regulating aging and disease in mice and other mammals. Another recent study reported that a mouse with a gene mutation (first identified by the same group) lived 30 percent longer than normal and was also protected against heart and bone diseases without apparent side effects.

Scientists plan to further investigate life span extensions in mice, and also study a human population in Ecuador with mutations analogous to those described in yeast. Finding drugs to extend the human life span without side effects will not be easy, he said. "Maybe it will do nothing, but having nothing else, I think it's certainly a good thing to try," said the scientist.

In the study, scientists identified a major overlap between the genes previously implicated in life span regulation for yeast and mammals and those involved in life span extension under calorie restriction. Calorie restriction, which in practice resembles controlled starvation, has been shown to reduce disease and extend life span in species from yeast to mice. Scientists believe that a nutrient shortage kicks organisms into a maintenance mode, enabling them to re-direct energy from growth and reproduction into anti-aging systems until the time they can feed and breed again.

Will we one day have a drug that can reverse aging?

ST

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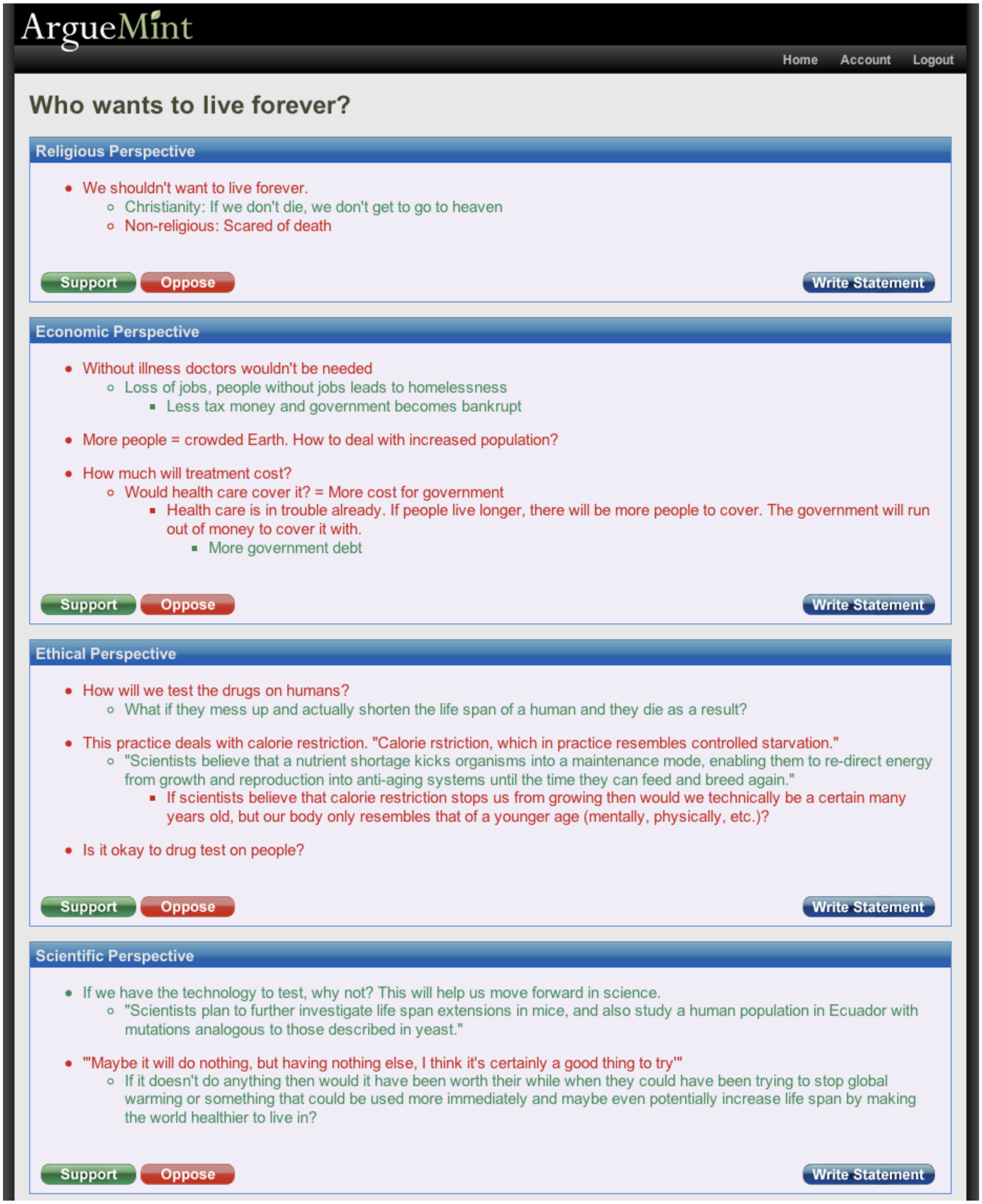
Appendix B

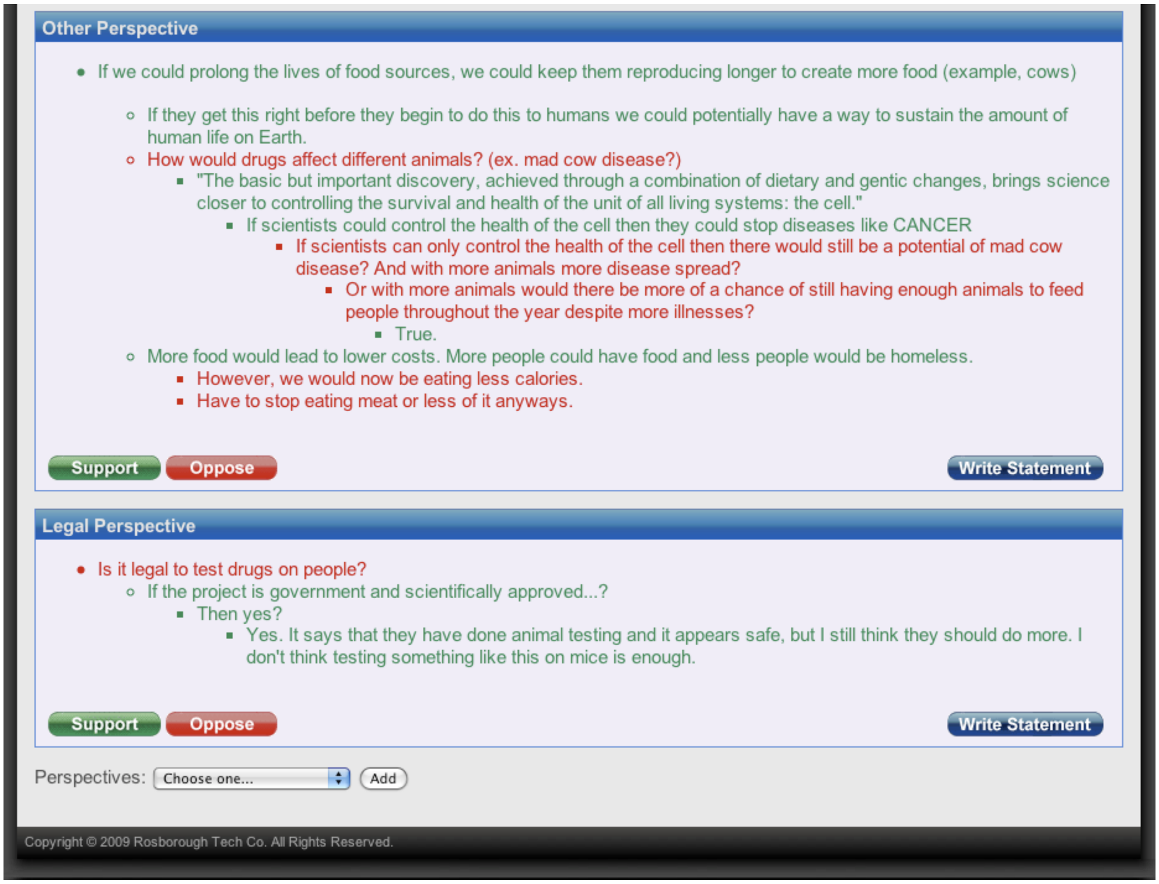
ArgueMint Output

In the following pages, screenshots of the two pairs' work in *ArgueMint* is provided. The first pair, Stephanie and Steven, worked with the first version of the software, while Angela and Adrianne worked with a later version. Both students were discussing the same article, "Who Wants to Live Forever?", from *Science Times*.

Pair 1: Stephanie and Steven

Pair 2: Angela and Adrianne




Other Perspective
If we could prolong the lives of food sources, we could keep them reproducing longer to create more food (example, cows)
If they get this right before they begin to do this to humans we could potentially have a way to sustain the amount of human life on Earth.
How would drugs affect different animals? (ex. mad cow disease?)
"The basic but important discovery, achieved through a combination of dietary and gentic changes, brings science closer to controlling the survival and health of the unit of all living systems: the cell."
If scientists could control the health of the cell then they could stop diseases like CANCER
If scientists can only control the health of the cell then there would still be a potential of mad cow disease? And with more animals more disease spread?
Or with more animals would there be more of a chance of still having enough animals to feed people throughout the year despite more illnesses?
True.
More food would lead to lower costs. More people could have food and less people would be homeless.
However, we would now be eating less calories.
Have to stop eating meat or less of it anyways.
Support
Oppose
Write Statement
Legal Perspective
Is it legal to test drugs on people?
If the project is government and scientifically approved...?
Then yes?
Yes. It says that they have done animal testing and it appears safe, but I still think they should do more. I don't think testing something like this on mice is enough.
Support
Oppose
Write Statement
Perspectives:
Choose one...
Add
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Appendix C

Research Consent Form

Dear Parents,

As a part of my Master of Arts degree program in Educational Technology and Learning Design at Simon Fraser University, I am carrying out some research looking at students' reasoning and communication about scientific and environmental current events. I am hoping to conduct a small study involving your child, and would like your consent for your child to participate in this research. My goal in this research is to develop some computer software that will help students to visualize and compose better arguments about key scientific controversies. This study will help us to understand the ways in which students construct arguments about controversial topics, and will help to inform the way in which scientific controversies are taught in our classrooms.

If you agree to have your son or daughter participate in this research, they will participate in the following:

- A written assignment in which they will read about a scientific issue and write their opinions on the issue. (approximately 30 minutes)

- A group activity in which they will read about a scientific issue, discuss their opinions with their partner, formulate an argument about the issue using computer software designed for this purpose, and create a written "position paper" containing their conclusions. This activity will be video-taped. (approximately 60 minutes)

- A brief written survey about their experience of the activity and the computer software they used. (approximately 15 minutes)

This study is part of my studies at SFU and as such, it has received research ethics approval. In addition, the study has been reviewed and approved by <*Name*> (Head of School) at <*School Name*>. This study poses no anticipated risks to students. The possible benefits include a deeper understanding of a particular socioscientific issue, and practice in developing their argumentation skills. The following steps will be taken to guarantee your rights as a participant in this study:

- We will videotape the group activity to document the process. You have the right to review this data at any point.

- The video recordings will be safeguarded until the conclusion of the research, and will then be erased.

- Names will not appear in the computer software or the data produced from it. All participants will be assigned aliases. The results will be reported without reference to participants' names.

- If data from this study is used in future studies, we will seek consent from you.

- You or your child will always have the right to withdraw at any time without any penalty or prejudice. This study is not a part of the courses they are taking, and there are no consequences for refusal to participate in this project.

If you would like to receive a copy of the results of this study, you are welcome to request a copy from me at the conclusion of my research. The results of this study will also be published as my Master's thesis and placed in the library at Simon Fraser University.

Thank you for considering this request.

Sincerely,

Dave Rosborough

Consent Form

Please make sure you understand and agree to the following statements before giving consent to participate.

- I understand the purpose of this study and know about the benefits and inconveniences that this research project entails. I understand that there are no anticipated risks associated with my child's participation in this study.

- I understand that my child is free to withdraw at anytime from the study without any penalty or prejudice.

- I understand that this research will not affect the evaluation of my child's progress in the program.

- I understand how confidentiality will be maintained during this research project. I understand that data collection involving use of the internet will be done using a secure, encrypted server, and that other data (including video recordings) will be safeguarded and kept confidential.

- I understand the anticipated uses of data, especially with respect to publication, communication and dissemination of results.

- I understand that permission has been obtained from <*School Name*> to carry out this research study.

I have read the above and I understand all of the above conditions. I freely give consent and voluntarily agree to allow my child to participate in this study. I understand that my child's identity will be protected and that all records will be coded to guarantee anonymity; video recordings will be used only for research purposes.

Student Name:	______________________________
Parent or Guardian Name:	______________________________
Signature:	______________________________
Date:	______________________________

SFU maintains an Ethics Review Board for studies using human subjects. Any complaints or problems may be reported to <*Name*>, Director, SFU Office of Research Ethics (<*Email Address*>, <*Phone Number*>).

My contact information, as the principal investigator of this study, is as follows:

Dave Rosborough

<*School Name*>

<*School Address*

<*School Phone Number*>

<*Email Address*>

Appendix D

Research Consent Script

As part of my Master's degree at Simon Fraser University, I am carrying out some research for which I would like a few volunteers.

The research is on how students construct arguments about controversial topics in science. If you choose to participate, you will be asked to write a few paragraphs each on two different controversies in science, as well as have a discussion with a partner about one of the issues. During this discussion, you will use some computer software to record your thoughts and structure your argument. While you are doing this, I will be videotaping your discussion and recording what you are doing on the computer. You will also be asked to complete a brief survey after your discussion with your partner.

Your identity will be kept completely confidential. Your real names will not be attached to what you are writing, and will not be used in the report that I will be writing afterwards. I do not anticipate any risks involved in participating in this research.

It is completely up to you whether or not you choose to participate in this study. It will not affect your course mark in any way. If, for some reason, you want to stop participating after you have begun, that is fine too.

SFU maintains an Ethics Review Board for studies using human subjects. Any complaints or problems may be reported to <*Name*>, Director, SFU Office of Research Ethics (<*Phone Number*>).

If you would like a copy of the results of this research, I am happy to provide them to you. Simply ask at any point, and I will make sure you get a copy when the research is complete. I am the principal investigator of this study, and my contact information is as follows:

Dave Rosborough

<*School Name*>

<*School Address*

<*School Phone Number*>

<*Email Address*>

Please consider volunteering for this - it will help us to better understand how students think about controversial issues, and how to help you to formulate better arguments in the future.

Are there any questions?

If you would like to participate in this study, you will need to take home this consent form for your parents to sign. You should read it as well - it describes in more detail what you would be doing if you chose to participate. Thank you.

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