DebateCited: An empirical experiment into the value of open-source research methods and peer collaboration to science journalism

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Abstract

DEBATE[CITED]: An empirical experiment into the value of open-source research methods and peer collaboration to science journalism

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This thesis studied the effects of science journalists opening their research to each other prior to producing an article. This was explored by examining the effects opening research has on the accuracy (the number of errors on verifiable information) and robustness (overall comprehension of different sides of a story) of science journalism stories. Due to critiques from scholars and the scientific domain on the accuracy and robustness of the science journalism found in newspapers, it is important to search for viable solutions to such problems. Theoretically, this problem was approached by using the gains of open-source journalism with the advantages provided by concept-mapping from the field of science education. Methodologically, this project used a mixed methods approach to examine the use of a web application (named DEBATE[CITED]), which was designed to allow science journalists to layout their research through a version of concept-mapping. This examination recruited both student journalists and professional journalists to write 'test' journalism on topics (biofuels and genomics) with and without the use of DEBATE[CITED]. This project gave three main results: (1) a qualitative analysis via an open questionnaire revealed that most of the journalists believed that DEBATE[CITED] helped them; (2) a quantitative analysis via a ranking test using a panelists of scientists revealed that DEBATE[CITED] had an effect on the accuracy and robustness of articles; and (3) a final test using a panel of scientists revealed that they preferred the articles produced by journalists when they were using DEBATE[CITED]. Overall, this thesis indicated that DEBATE[CITED]'s usefulness to journalists was statistically significant and created stronger articles. This study concludes that open-source journalism in combination with concept-mapping is a promising online tool to help science journalists counter some critiques of their journalism.

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Introduction

Science journalism is important for both science literacy and allowing lay publics to make scientific, personal and political decisions based on recent scientific developments (Bucchi 2007; Nelkin 1987; O'Hara 2010; Logan 2001; McIlwaine 2011; Dunwoody 2008). In recent years, it has been argued that the progress made in online science journalism may allow the public to better contribute to the advancement of science itself (Holliman 2011; Dunwoody 2008). These arguments, however, have yet to significantly address common critiques of science journalism (Gilbert and Ovadia 2011; Bubela 2009) that risk simply being transferred to the online environment — as opposed to being addressed by exploring how the advantages provided by the online environment can answer the critiques. Whether networking science journalists online will answer criticisms of science journalism should be explored (see Chapter 1).

This thesis explored the effects of science journalists networking with each other online prior to producing an article and whether it answered criticisms of science journalism. The examination focused on the potential for improvement networking has on the *accuracy* (the number of errors on verifiable information) and *robustness* (overall comprehension of different sides of a story) of science journalism stories. Accuracy and robustness are two classical critiques of science journalism, which also have a growing contemporary importance. For example, because many scientific developments involve a peer-review system that has now grown to people online judging, in part, how factually accurate a study is (Mandavilla 2011), an attention to accuracy should also be reflected in science journalism[1]. Furthermore, the accuracy of facts alone can be insufficient when a topic is dealing with issues that require the context of an overall scientific debate. Such topics, which are increasingly common (Bubela 2009), require making an article more robust by bringing in other sides of a scientific debate so as to better contextualize an issue for readers. Thus, by aiming for accuracy and robustness, the journalist can help ensure both a correct understanding of the facts and how these facts relate to other established facts.

Despite arguments for the importance of accuracy and robustness in science journalism, research

[1] There are many other critiques of science journalism (e.g. sensationalism, its lack of education value, lack of training of science

continuously criticizes science journalism for lacking either accuracy (Carsten and Illman, 2002), robustness (Dunwoody, 1980; McComas and Simone 2003), or both (McIlwaine 2011; Dunwoody 2008; Peters et al. 2008) (Nelkin 1987; Pellechia 1997), among other issues. The extent of this problem was initially realized by the author through observing current user actions with science journalism articles online. Accuracy (i.e. corrections made to an article) and robustness (i.e. the different and complementary sides of a scientific debate) can often be found within the comments sections of online journalism articles rather than in the actual article itself. The question is *can these important contributions to an article be made prior to the publication of the article?* Seeking an answer to this question guided this thesis and the approach to studying its overall problem.

Overall Problem

While it is not clear whether science journalists can still be considered as the most authoritative voice online and certain journalists have been found to use the comments section as a tool to expand on their articles' robustness later (Secko 2009), it seems worthwhile to consider whether it would be possible to extract the valuable-content of online user-contributions (i.e. the commentary after an online science journalism article that add more accuracy and robustness to a science story) and place them within the article pre-publication, rather than the post-publication comments section. Doing so will benefit both users who parse comment sections in an attempt to filter for relevant information (from the widely irrelevant information which is also produced (Secko 2009)), and will also benefit readers who avoid the comments section all together.

However, while much of the scholarly literature on science journalism criticizes its problems, few provide tested solutions (Bucchi 2007). The scholarly literature, in part, accuses science journalism of inaccuracy (Carsten and Illman, 2002; Nelkin 1987) and points to the limits of its robustness (Dunwoody, 1980; McComas and Simone 2003; Nelkin 1987). It is clear from these critiques that current practices in science journalism lack a representation of multiple perspectives (McComas and Simone 2003; Nelkin 1987) and multiple sources (Carsten and Illman, 2002; Dunwoody, 1980; Nelkin 1987; Winsten 1985; Eide and Ottosen 1994). Unfortunately, while some studies have suggested solutions, such as more scientific education of journalists (Casey, 2007), to my knowledge, there is little research that attempts to empirically study whether these suggested solutions work. Furthermore, neither current critiques nor proposed solutions take into account both (i) emerging discussions of how science journalism is becoming increasingly intertwined with science (Schafer 2011) and (ii) the emergence of the Internet as a dominant form of science communication (Brumfiel 2009; Secko 2009). We are therefore left with a gap between how science journalism (and thereby its criticisms) is created by journalists and how science is communicated via new media.

Recent scholarly debate on new media is beginning to point the way to how this gap may be addressed by empirically examining the merits and problems of practicing what has come to be known as "open-source journalism" via the Internet (Platon and Deuze 2003). In the context of this thesis, *open-source journalism* means opening journalistic information and processes that were otherwise kept private to a group of peers. Open-source is touted as beneficial for scientists due to its ability to allow more external members to participate, innovate, and augment data in scientific research (Tapscott and Williams 2010; David, 2009). Similarly, open-source has also been taken up by some journalists who argue it can increase expertise, broaden readership, and engage readers (Lewis et al. 2010). Open-source journalism can be thought of as a form of journalism where Internet users participate in the creation of an article (Deuze, 2003). To date, scholarly research on the topic of new media opening up journalism has largely focused on opening the final journalistic product (Platon and Deuze 2003; Schultz 2000), such as posting user generated content, comments or blogs, and not the research involved prior to producing an article. The latter, however, presents an intriguing, untapped area of study related to science journalism and its critiques, specifically due to the potential of open-source formats in combination with peer collaboration to help deal with the complexities of covering modern science debates in terms of accuracy and robustness.

This thesis explored the question: *Would a web application allow collaborating science journalists to open-source their articles to improve its accuracy and robustness?* The approach to studying this question sought to link two areas together, new media in science education and open-source journalism, to examine whether open-source formats used in a peer collaboration setting can help science journalism. To do this, an open-source web application was created by the author, titled DebateCited, and was tested as a way to help journalists in researching an article through making use of concept-maps. DebateCited allowed the author of an article to lay out the foundations of their articles' argument in a concept-map while other users contributed and/or debate points in the presented research. This thesis completed an empirical analysis of DebateCited using participant journalists who used the tool to support their storytelling on biofuels and energy-related scientific topics. The thesis discusses the benefits and challenges of open-sourcing research in combination with peer collaboration in science journalism, with particular emphasis given to how an article's foundations can be created in an easily traceable manner.

Research design and specific aims

The overall objective of this thesis was to investigate whether open-source concept-mapping through online multimedia will help collaborating science journalists to research scientific issues so that they have greater comprehension and thereby report on issues with both more accuracy and more robust scientific information. Theoretically, this problem was approached by using the gains of 'open-source journalism' with the advantages provided by concept-mapping from the field of science education [Chapter 1]. Methodologically, this project used a mixed methods approach [Chapter 2] to examine the use of DebateCited with the results addressing the following specific aims:

1. To develop and adapt software (DebateCited) for use as a web application in testing the usefulness of concept-mapping through online multimedia [Chapter 3, Section 3.1 and 3.2].

2. To recruit student and professional science journalists to use DebateCited to develop concept-maps and then create 'test' journalism on the complex and timely issue of genomics and biofuels [Chapter 2, Section 2.1-2.5].

3. To examine the created journalism for how DebateCited was used through geometrical analysis of the concept-maps built in aim 2 [Chapter 2, Section 2.6-2.9].

4. To examine the experiences of the science journalists in using DebateCited through a questionnaire and survey [Chapter 3, Section 3.7].

5. To examine how a scientist panel judged the accuracy and comprehension of the created journalism through ranking articles in order of accuracy and robustness [Chapter 3, Section 3.8-3.9].

Lastly, these results are discussed with regard to the promise and challenges of using an online tool to help counter some critiques of science journalism [Chapter 4].

Chapter 1: Literature Review

Section 1.1: How Open-Source Journalism Works

Open-source journalism's method of production is different from traditional journalism and online journalism. Traditional journalism that existed before online journalism is generally considered closed-source. Deuze (2003) distinguishes these two forms of journalism by defining journalism as more 'open-source' when it allows user interaction such as generating and sharing comments, posts, and files without moderation and 'closed-source' when readers do not have methods to participate and are limited to strict moderation (Deuze, 2003). Within this definition, print media may allow letters to the editors and many websites may allow comments, but if they are heavily moderated or filtered then they are considered more on the closed-source end of the spectrum. While this definition ignores that both of Deuze's open and closed-source journalism types are still mediated, it nevertheless serves as an important distinction for the focus of this project.

There is a range of views and a significant literature on the merits of open-source journalism and whether traditional journalism actually benefits from user input or whether open-source journalism just removes or shifts editorial control (Moon 1999; Platon and Deuze 2003; Tapscott and Williams 2010; Gillmor 2006; Witt 2006). Many of these debates are outside the scope of this project and not addressed here. However, regardless of the field, from open-source software to open-source journalism, these debates often focus on the Internet as a catalyst of the efficacy and popularity of the idea of open-source. For some, the Internet has enabled groups of individuals to collaborate together on projects as a community with less concern on the proximity of individuals (Moon 1999; Platon and Deuze 2003; Tapscott and Williams 2010). Prior to the Internet these communities existed but on much smaller scales. These communities share commonalities with Jurgen Habermas' idea of the "public sphere" (Habermas 1991) where the public would congregate to discuss matters "to reach a common judgment" (Hauser 1999). Scholars have argued that online communities have revitalized elements of Habermas' public sphere through interactive media that engages the public in discourse held online (Schultz 2000). Others have argued that while such arguments are important, as of yet online communities such as readers' forums often lack useful voices (Witschge 2007) or simply degenerate into insults (Cenite and Zhang 2010). Nevertheless, alongside online journalism, online communities do point to the potential of open-source journalism to be viable, at least in terms of allowing for an expansive public to easily contribute to the production of a document (Raymond 2010). Open-source journalism sprung from online science journalism that dates back to a bit over a decade ago (Moon 1999). One of the examples of media using open-source in science journalism includes an article by *Jane's Intelligence Review* on the science and technology behind computers and cyberterrorism (Moon 1999). The process involved contacting an online community, Slashdot.org, whose members were more technically savvy than the reporters of *Jane's Intelligence Review*. The community was first asked to preview the article to increase its comprehensiveness. However, the community's corrections were so critical that the magazine re-wrote the entire article and based it heavily on the users' edits. Thus, the research and information was gathered in an open public format and resulted in a "better, sharper feature" according to the former deputy editor Johan J. Ingles-le Nobel of *Jane's Intelligence Review* (Nobel 2010; Slashdot 2010).

Nobel chose to contact the community to increase the accuracy of their journalism: "the very nature and vocabulary of the subject precludes a thorough understanding unless you are a programmer in the first place. Buffer overflows, denial of service, CGI, 128 bit encryption - such words are all anathma[sic] to the layman, yet crucial to a good article on the issue" (Nobel 2010; Slashdot 2010). According to Nobel, the results accumulated from the process also increased the robustness of their journalism. It enabled Nobel to draw points from "250+ comments and 35 emails from psychologists to network analysts, and from Sun engineers to Cambridge Dons" (Nobel 2010; Slashdot 2010). Nobel strengthened the content of his article, built a relationship with readers interested in computer science, and paid a few of the commentators for their contributions (Nobel 2010; Slashdot 2010).

The author of this thesis also draws from his own experience in open-sourcing journalism. The *Capilano Courier* feature, "To Attack Piracy or to Share with Friends," was on the topic of open source software (Novin 2010). To open source the article, it was posted to an online Linux community at reddit.com/r/linux. Members were asked to help fact check the 2000 word article for any potential errors and in return an offer was made to donate half of the payment for the article to an open-source software organization. After 460 views and 108 comments on the unpublished article, roughly 80 edits were made by the community from minor revisions on more accurate terms to alternative perspectives which helped increase robustness. The final product was a successfully fact-checked article on open-source that, at least, the included community could agree with. No further changes were made when the article was published.

Although still a young form of journalism, open-sourcing is not limited to science journalism and is being experimented with by mainstream news such as Al-Jazeera who has made commitments to release 10 hours of footage under open-source licenses every year (Good 2010). Other news sources who have worked with open-source include: New York Times, Bloomberg News, The Economist, the New York Observer, Wikinews, OpinionRepublic.com, and ProPublica (Usher et al. 2013; Sill 2013).

These examples serve to highlight the potential of open-source journalism, which has yet to be significantly studied with regard to science journalism production or empirically tested in terms of usefulness. This thesis made use of the concept of open-source journalism from within the framework of combining open-source formats with peer-collaboration among science journalists. The Open-Source movement often discusses the concept of peer-production (Haythornthwaite 2009; Benkler 2006; Gillmor 2006; Benkler 2005; Benkler 2002). For example, it has two distinct models of peer-production which lie on polar ends of the types of open-source taking place: the heavyweight model ("based on strong connections among a committed set of connected members," for example virtual communities (Haythornthwaite 2009)) and the lightweight model ("based on microparticipation from many" individuals, the exemplar being crowd-sourcing (Haythornthwaite 2009)). Haythornthwaite also attributes the heavyweight model to the academic community that sprung from the "open science movement" (not to be confused with the 'open *source* movement') from the 17th century (Haythornthwaite 2009). She points out that the Internet has galvanized the open science movement in academia (i.e. open-access journals). Haythornthwaite also suggests that open-source projects may be "dual-weight enterprises" and contain elements of both models. She uses the example of Wikipedia, which is lightweight due to updates accumulated from minor changes made by many users and yet retains the heavyweight element of a smaller circle of editors who oversee the contributions. Similar examples can be found in scientific literature, such as the open-access scientific journal PLoS, which allows readers to add notes, corrections and comments to scientific journals. Their PLoS Hubs project allows members to interact with, reuse, and reorganize information found in the scientific literature while still being moderated by experts on the topics (Allen 2010).

The difference between these 'weight'-ends increases gradually, where a website may still be dual-weight but more heavyweight than other websites. For example, NewScienceJournalism.com, an online science news magazine for students, leans more towards a heavyweight model than PLoS because it does not allow microparticipation during the process of creating articles nor directly on the article after it is completed. Nevertheless, it still is dual-weight because it allows microparticipation from the public; in the form that they may contribute completed articles or add comments afterward to go along with the heavyweight model of the editorial staff (New Science Journalism 2013).

This thesis sought to work between both 'weight'-ends but leaned closer to the virtual community model (heavyweight model) in that it asked science journalists, like the Wikipedia and PLoS editors, to have a final say on the angle, content and structure of their articles after making use of open-source formats and peer collaboration[2].

Overall, open-sourcing a journalist's research with open-source formats and peer-collaboration highlights an important consideration: the potential of sharing the different sides to an otherwise complex science issue to generate a more complete story. In other words, whereas a political story may gain robustness by sharing different perspectives of a controversial story, a scientific story may gain robustness by sharing the educational burden required to understand a complex, jargon filled scientific issue. This consideration has so far been ignored in the journalism studies literature, despite its potential to meet selected criticism of science journalism.

Section 1.2: *Criticisms on the Accuracy and Robustness of Science Journalism*

During a time of new societal questions generated by the accelerating pace of scientific research, a

[2] However, due to the nature of how DEBATECITED is set-up, contributions can only be added incrementally, premise by premise, by the various users who may not share the same goals or seek to create similar final articles. Therefore, it also retains key elements of the lightweight model.

renewed urgency has emerged to more thoroughly consider the fields of science journalism (Secko and Smith 2010; Bubela 2009; Logan 2001), as some scholars have called for increased engagement among publics in the governance of emerging scientific technologies. This renewed interest is also partly linked to recurring and recalcitrant criticisms of science journalism (Dunwoody 2008; Dunwoody, 1982). In particular, both media scholars and scientists are often critical of science writing (Dunwoody 2008; Dunwoody, 1982). For example, some scholars have been critical of either a lack of accuracy (Carsten and Illman, 2002), robustness (Bubela 2009; McComas and Simone 2003; Dunwoody, 1980), or both (McIlwaine 2011; Dunwoody 2008; Peters et al. 2008; Pellechia 1997; Nelkin 1987). Scholars also highlight instances where journalists present varying scientific narratives on a topic when science communities may only see one prevailing issue (Jensen 2010) (Bubela 2009; Dunwoody 2008), such as the cases with climate change vs. deniers and evolutionists vs. creationists. Certain scholars argue that by balancing disagreements without dealing with the actual substance on either side, readers are left unable to focus on the respective validity of either side (Bubela 2009; Dunwoody 2008; Nelkin 1987). However, Dunwoody (2008) points out that when science journalists cannot determine the veracity between competing claims the best option available to journalists is to present a variety of perspectives. Dunwoody (2008) argues this will provide more "comprehensiveness" (what I equate to robustness)[3].

Research on science journalism, particularly the type appearing in mainstream newspaper journalism, also found that journalists can fail to use adequate skepticism on issues such as cloning, stem cells, and similar contentious issues (Jensen 2010; Pellechia 1997; Nelkin 1987). Scholars argue that many of the problems stem from outdated journalist frameworks, hype, and commercialism (Jensen 2010). Other problems include the lack of analysis on social aspects of science such as political interests (Pellechia 1997; Nelkin 1987). Due to time constraints and other pressures (Nelkin 1987) science journalists are limited to a fraction of the number of sources required for a comprehensive story, which scholars agree is a problem (Carsten and Illman, 2002; Eide and Ottosen 1994; Nelkin 1987; Winsten 1985). Other significant issues include whether science articles online reach audiences (since not all users may search for them), issues of overly positive or negative expectations

[3] I equate this argument to the need for more robustness in science journalism production, a term I choose over comprehensiveness. Robust implies strength and comprehensiveness implies completeness; news articles cannot always say everything but they can ensure that the information presented is not lacking support.

about a scientific issue, and which group of experts to trust if there is a lack of presented opposition (Gilbert and Ovadia 2011; Bubela 2009). Incomprehensiveness in science journalism is often attributed to such factors as: an overreliance on press releases, single-sourced articles, the depreciation of the role of science journalists, and now, governmental interference (see, for example, (McDonald 2011; O'Hara 2011; Jensen 2010; Bubela 2009; Carsten and Illman, 2002; Pellechia 1997; Eide and Ottosen 1994; Nelkin 1987; Saari 1985; Winsten 1985)). Critics argue that such factors are some of the inputs that lead to a form of science journalism that does not provide a complete scientific story. With the slashing of science journalists from news organizations – including the removal of all science journalists from CNN, for instance – some worry that the public is witnessing a decline in the quality of science journalism (Brainard 2012; Brainard and Russel 2012). Furthermore, researchers have long found that experience is a greater contributor to quality science journalism than being trained in the sciences (Saari 1985). And yet, the cutting of experienced staff combined with the time required to produce journalism can leave journalists seeking only primary authors as scientific sources for a story. This, in turn, leads to a style of journalism that some scholars have termed single-source journalism, where a researcher's study is taken at face-value and context is not provided. Some of the problems with this form of journalism are that scientists can provide fringe information, skewed information, or information heavily moderated by PR experts (Bubela 2009; Saari 1985). This is further amplified by the difficulties journalists can face in getting more comprehensive information, such as in the case of the government muzzling of Canadian scientists (McDonald 2011; O'Hara 2011).

These are not minor problems. Criticisms of science journalism have proved highly defiant (Secko and Smith 2010). The complexity of science as a topic of coverage is a significant challenge for many journalists who are currently lacking robust tools to help explain the significance of research to readers (Jensen 2010; Nelkin 1987). However, the Internet has been helping science journalism in recent years, with reference to journalists having access to a variety of sources (Dunwoody 2008) and some science journalists have been found to use the comment-sections of their online articles for leads on future stories (Amend and Secko 2012). Overall, this thesis is particularly interested in how open-source journalism may allow the advancement of online solutions to the identified issues of inaccuracy and robustness in current science journalism practice.

Section 1.3: *Possible Solutions: A focus on the potential of the Internet*

Some scholars have suggested education (Hewson and Laurent 2008; Casey 2007) and aid from other journalists or scientists as a solution to incomprehensive science journalism (Nelkin 1987). In addition, scholars write that, unlike regular journalism, science journalism may not require standards of balance but the empirical veracity of opposing views (Dunwoody 2008; McComas and Simone 2003; Nelkin 1987). Thus, possible solutions to some of the criticism of science journalism presented in the literature can be summarized to (1) greater **transparency** of influences on a story (i.e. influences from press-releases, advertisers, or companies funding the research) (Nelkin 1987), (2) **educating journalists** (Hewson and Laurent 2008), and (3) **more skepticism** from journalists to give proper contextualization of new or weakly-supported scientific information (Casey 2007).

Prior to the Internet boom of the late 90s, Nelkin (1987) wrote about the difficulty of implementing such solutions: "The use of computers has eased the time constraints of journalism. Reporters with access to data bands can gather information more rapidly, but the demands of daily story production still encourage the use of prepackaged information that has been organized specifically for the press. Reliance on such preconstituted accounts as press conferences, news releases, and computer-controlled information is, of course, no substitute for personal investigation, but it is a practical and therefore popular means of getting a job done under the pressure and routines of daily newswork" (Nelkin 1987). This thesis notes that Nelkin's statement does not account for the arrival of open-source communities deconstructing information from their limited "prepackaged" forms — which is part of the goal of DEBATECITED.

As such, while the hurdles to computer-network solutions are noted by Nelkin (1987), it is only recently that practical and inexpensive means in the form of web applications have become available to re-test this solution against its hurdles. It is precisely these means, namely facilitating scientific discourse by networking the public, that Walejko and Ksiazek (2010) suggest hold the potential to better inform readers on scientific issues due to their interactive nature. Online science journalism sometimes enable this by explicitly providing their sources of information (this may provide a solution for 1.transparency), through hyper-linking to academic sources (this may help provide a solution for 2.education), and providing a platform for many voices through a comment system (this may provide a solution for 3.skepticism) (Walejko and Ksiazek 2010). Open-source journalism uses these same advantages of networking computers via a web application, with an alternative format that is better suited for the purpose of this thesis.

Section 1.4: *Open-source formats: Bazaar style and Lakhani's concept*

Current trends in creating models for Internet communications are focusing on using critical thinking skills within a technological environment (Tapscott and Williams 2010). In 'mass collaborations' users join together to produce a collective voice on various topics (Shirky 2009; Salmons 2010) that is exemplified by the cathedral vs. the bazaar argument presented by Eric Stevens Raymond - former president of the Open Source Initiative and a leading figure among open-source advocates (Stewart and Gosain 2006). Raymond labels the closed-source model as the cathedral model while the open-source model is described as a bazaar model. He explains that he used to believe software should be built like cathedrals: an isolated process of building something to perfection until passing it along. However, Linus Torvalds, the creator of the open source Linux kernel, introduced him to what he saw as a bazaar style of production where code was taken from anyone and everyone in order to build programs. In the end, Raymond admits that he was shocked that his bazaar style projects strengthened software "at a speed barely imaginable to cathedral-builders" (Raymond 2010).

Garzarelli et al. (2008) write that the central tenet to the bazaar style is that "the benefits of tapping from a virtually unlimited knowledge pool through a redundant division of labor outweigh all other costs, including coordination costs." Drawing on Lakhani (2003), Garzarelli et al. (2008) lay out the six steps that take place in the bazaar model [Figure 1.4.1.1]: 1) Community of volunteers develops code, 2) the code is distributed to users, 3) the users create the binary, 4) the users use the program, 5) if problems arise, users can fix/improve the program, and then 6) the users distribute the modifications back to volunteers. Hardey and Burrows (2008) further point out that the open source culture is not confined to software building and opens up different possibilities for researchers such as the collaboration between researchers in an open source manner through online social relations. The three aspects of research that can be most impacted are 1) "Communications — to gather, disseminate, and exchange information," 2) "Representation — the capacity to describe, model and visualise information" and 3) "Storage — the capacity to retain and retrieve information" (Fischer et al. 2008).

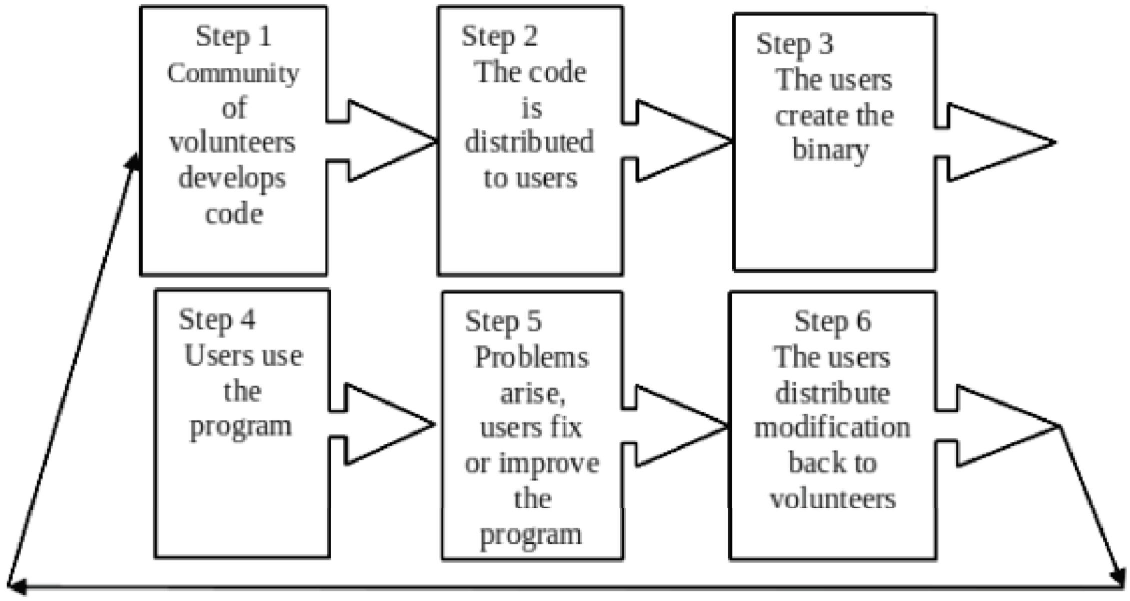

Figure 1.4.1.1: LAKHAMI AND GARZARELLI ET AL. MODEL FOR BAZAAR STYLE DEVELOPMENT

Theoretically, these ideas provide a general framework that could be used by media staffs to create articles (from the pitch to the publishing), where open-sourcing research could be implemented into the process used by journalists to create articles. This could involve open-sourcing any of these steps to a larger community (e.g. Al-Jazeera open-sources the use of their content (Good 2010), akin to Step 4, while PloS open-sources corrections (Allen 2010), akin to Step 5 and 6). Thus, a prediction for this project is that open-sourcing research should not disrupt the journalist's process in creating an article.

Section 1.5: *Science Education: Using the Web for Concept-Mapping*

While open-source formats can theoretically be used in the process of creating a journalistic article, for science journalism, the method of participation, who participates, and how contributions are implement, also needs to be addressed. Nelkin (1987) claims that accuracy of an article can be increased by participation among journalists who share their knowledge on a topic. Furthermore, in "Scientists Must Speak," a study guide in preparing scientists for communicating with the media, Walters and Walters (2002) suggest scientists map their research by breaking it down into branches to enable them to effectively communicate their key ideas.

Walters and Walters' (2002) work relates to scientists communicating their research, but it has been argued that journalists use the same process of mapping when preparing questions for an interview (Ritchie and

Lewis 2003). Here the suggestion is that when interviewers map questions it “help[s] the researcher identify relevant issues and generate multiple dimensions of the subject of inquiry” (Salmons 2010). In this context, a “tree and branch” style of mapping is useful for allowing many themes on an issue to emerge (Rubin and Rubin 2008). Thus, not only is the key topic outlined along with its respective branches, but so are any different *sides* to the topic.

These concepts provide a theoretical underpinning to the idea that it can be useful to represent abstract science theories in visual models where the relationships between variables and their respective causal relationships are diagrammed (Creswell 2009; Blalock 2007). For example, Figure 1.5.1.1 is suggested by Creswell to display a simplified causal sequence between different variables. It allows users to display path analysis to readers. The positive and negative symbols are used to postulate the strength of relationship between variables. The one-headed arrows indicate the increasing path of dependency between variables from left to right (Creswell 2009). Concept-mapping is also similar to arguments for how knowledge itself is created by the mind. Gerald Edelman points to knowledge being created by what is called ‘reentrant signaling’, where communication between maps allows us to organize concepts to create our thoughts (Ratey 2001; Edelman 1993). Edelman’s model of how the brain forms concepts is similar to mind mapping which is a “free-form method of outlining that is modeled on the image we have of neural networks in the brain” (Howard 2008). All of this serves to suggest that concept-maps may help science journalists to educate themselves on the robustness of a scientific topic by having the various points laid out in a simplified manner, along with their relation to each other. This help may be further enhanced by groups of science journalists working together. Scholarly work on groups using concept-mapping for science education often shows positive effects (Ryve 2004). Furthermore, concept-mapping has had some success when implemented into software. Liu and Wang (2010) found positive results when students learned to combine mapping with web based learning on a scientific topic. The method for the web based learning involved students going online to 1) find a theme, 2) focus on an interest within that theme, 3) find materials based on that theme, 4) integrate the shared knowledge with peers and finally, 5) publish and share that knowledge (for example in a web based document (Liu and Wang 2010)).

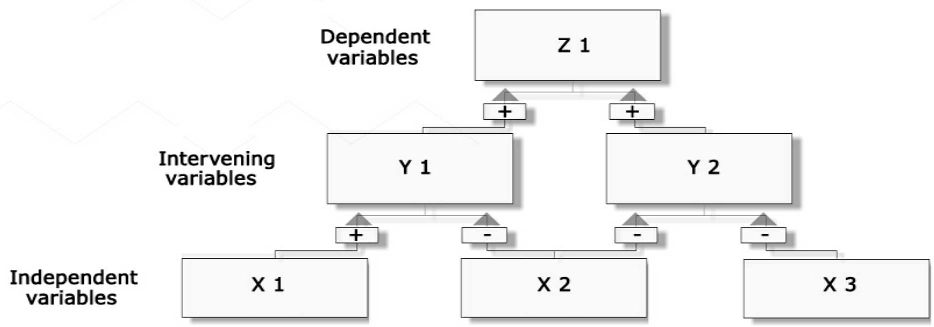

Figure 1.5.1.1: MODEL BASED ON CRESWELL'S MAP (CRESWELL 2009)

Section 1.6: Open-Source and Science Journalism

A hypothesis of this thesis is that an open-source method for journalistic research may allow for new media to contribute directly to a science journalism article prior to its production and thereby potentially raise its accuracy and robustness. This potential can be explored by linking two areas that have so far been disparate in the science journalism literature: science education and open-source journalism. Theoretically, this will be approached in this thesis by drawing on the notion of open-source formats in combination with work in science education on concept-mapping, followed by applying these concepts to open-source science journalism.

Chapter 2: METHODS

Section 2.1: Method Overview: Use of a Web Application and Challenging Scientific Topic

Given the suggestions by Dunwoody and Nelkin (Dunwoody 2008; Nelkin 1987; Dunwoody, 1982; Dunwoody, 1980) this thesis combines several fields of study to explore a methodological approach to the problem of incomprehensive reporting on scientific debates, with a focus on issues of accuracy (the number of errors on verifiable information) and robustness (overall comprehension of different sides of a story). To improve the practicality of this thesis, it focused on a contemporary issue that challenges comprehensive science journalism: the coverage of energy (Brainard 2012; Brainard and Russel 2012). To focus this topic on a complex scientific/social issue, the thesis used biofuels and genomics as its content topics (Wright and Reid 2011; McKone et al. 2011; Delshad et al. 2010). In developing a web-tool to aid science journalists, the project sought a unique yet theoretically informed (i.e. tied to scholarly suggestions in the literature; see Chapter 1) approach. A heuristic approach led to the development of an online-mapping technique for science journalists — one which maps debates against already established expertise (i.e. citations) and relates them by their validity through mapping software; thus, the term DEBATE^CITED.

The creation of DEBATE^CITED is more fully explained in Chapter 3 [Section 3.1 & 3.2]. But briefly, to utilize advantages provided by the Internet to help educate science journalists (Brainard 2012; Brainard and Russel 2012; Wright and Reid 2011; McKone et al. 2011) DEBATE^CITED was developed from previous code[4] by the author. The code resembles concept-maps that have been used for science education to allow for more robust understanding among children as young science learners (Liu and Wang 2010). The thesis advanced the software to be user-friendly, relatively bug-free, secure, and useful to journalists.

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[4] The code was initially created with my younger brother, Alish Novin, for a project we had previously worked on but it was never fully incorporated. The code sat dormant for a few years, until Dr. David Secko had asked me to come up with ideas for how his classroom of science journalists could interact with each other on the Internet that was different from regular networking systems (such as blogging, Twitter, and Facebook). I thereby modified the code to suit the purpose of opening up the research data into concept-maps. Dr. Secko also helped focus the idea so that we could create a category that focused specifically on how data was used to construct a story (rather than simply having journalists lay out the data they found in an educational manner regardless of how it fit their story).

Throughout the thesis, the analysis of the use of DEBATE[CITED] used a mixed methods approach involving (i) a comparative analysis of the stories produced and (ii) a quantitative and qualitative analysis on the experiences of student and professional science journalists from using the web application. Mixed methods were deemed necessary in this case due to the need to (1) explore the online and offline worlds of the participants (Lee et al. 2008; Hewson and Laurent 2008), thereby reducing the misapplication of data that "would be reasonably accurate in the right context" (Rasmussen 2008; Erp and Vuurpiil 2003); (2) reduce non-responsive participants in an otherwise complex research activity that is asking for a significant amount of effort (Rasmussen 2008); and (3) provide higher validity and explanatory power of collected data through a combination of web surveys and in-depth interviews. This use of mixed methods was sensitive to the allocation of resources to each method, to potentially differing results from each method, and to the potential problems of combining (sometimes contradictory) findings from each method (Vehovar and Manfreda 2008). Overall, mixed methods were used to identify "best predictors" for addressing the stated thesis question and objectives (Creswell 2009; Hauser 1999).

The project was first piloted with a group of science journalism students before professional science journalists were recruited to make use of DEBATE[CITED]. This was followed by asking a scientist panel to judge the accuracy and comprehension of the journalism created by the professional science journalists.

Section 2.2: *Pilot Project: Students Use the Software*

The thesis began as a qualitative pilot project to see how students interact with online concept-maps and to explore the potential of its open-source format to help meet some critiques of the field, and in particular, to help journalism students create more comprehensive science journalism (Novin and Secko 2012). Students came from the Department of Journalism at Concordia University (Montreal) and were instructed on how to use DEBATE[CITED]. Fourteen students participated over four months from January to April 2011.

During the pilot, participants were asked to input the angle (main point) or lead (most newsworthy information) of their work as an initial premise for a story on biofuels. This served as the root premise and allowed for the student to lay out the proceeding premises in their story as a skeleton for their articles. The last step occurred when other participants collaborated on filling out a concept-map by contributing information that agreed or disagreed with the root premise. Participants were not allowed to edit comments, unless they made a special request, so that all changes could be tracked. Students were informed that participation was not mandatory and that they may submit their opinions on the application's usefulness, ideas, and/or bug reports at any time.

Students were informed that DEBATE^CITED was to serve the purpose of helping them construct their articles, if they chose to use it, on the topic of biofuels. Students were allowed to approach the topic whichever way they preferred, as long as the end-result was a journalism article. Analysis of the pilot focused attention on the process students used to create a scientific story. The results were accumulated via: (i) a geometrical analysis of the concept-maps used by participants using a point-system comparable to Novak's concept-maps (Novak 1984) and (ii) a student questionnaire on the functionality of the system. Novak and Gowin's method to measure the geometry of a map uses a point-system (Novak and Cañas 2008; Novak 2000) that requires awarding one point to the first branching of a concept-map, followed by additional points to each successive branching (horizontal expansion of a map) and/or each addition to the hierarchy of a map (vertical expansion of a concept-map). The student questionnaire centered on whether peer collaboration via DEBATE^CITED helped improve their knowledge on the subject, whether DEBATE^CITED helped their stories overall, and whether the participant would consider using DEBATE^CITED again.

Section 2.3: Main Mixed Methods Study: Journalists Using the Software

Despite the success of the pilot project [Chapter 3], it was limited in its sampling (e.g. using students who were not strictly trained as science journalists), controls (e.g. student who did not use DEBATE^CITED were not surveyed) and outputs (e.g. there was no independent assessment of the accuracy of the final product). To address these limits and further explore the potential of DEBATE^CITED, a second study was undertaken with professional journalists.

This second study had three phases:

1st Phase*: Set Up*

Journalists used DEBATECITED and were surveyed.

2nd Phase*: Analysis of the Outputs of Phase 1*

Comparative and geometrical analysis of data collected from Phase1.

3rd Phase: *Third Party Evaluation of Phase 1*

A Science Panel evaluated the accuracy and robustness of articles.

These phases led to three forms of data:

1. Survey on the experiences of the science journalists in using DEBATECITED (qualitative).
2. Geometrical analysis of the concept-maps produced through the use of DEBATECITED (quantitative) and a comparison of the maps to the respective articles they produced (quantitative).
3. Comparative ranking of the articles by a panel of scientists, (quantitative) followed by an unstructured questionnaire on *why* and *how* the scientists compared the articles (qualitative).

Creswell suggests six ways of mixing data from such a study based on the criteria of timing, weighting, mixing, and theorizing (Rasmussen 2008). In this thesis, a sequential explanatory strategy was used as it satisfies the following criteria which Creswell lays out for such a method: 1) Timing: The data was sequentially collected from the journalists and then the scientists in different phases. 2) Weighting: The research put a heavier emphasis on quantitative data that served to guide the analysis of the qualitative data. Consequently, 3) mixing: The collected data was mixed during the final phase of research, during which the data analysis of the qualitative data was "embedded" in the quantitative data. Finally, theorizing was not utilized (Rasmussen 2008).

Section 2.4: *Participant Selection and Tasks*

Six professional science journalists with similar writing skills and experience levels were recruited to use DEBATECITED and write science stories for the main study. Although it is not possible for this project to gather identical science journalists, recruitment was purposeful and focused on recruiting journalists based on the following specific selection criteria.

A. Experience with science journalism: Participants had to have some experience with writing science journalism (i.e. they had to have published in a news medium more than 1 article in the field of science journalism).

B. Similar writing formats: Sample articles were provided by the participants to ensure they had experience writing for similar formats. Sample articles were required to match the format of the test-articles that would be assigned in this experiment. The criteria for this format included: 1) approximately 500 word articles, 2) on science topics, 3) written in laymen terms, 4) for the general public, and 5) for a news publication.

C. Similar experience with journalism in general: Freelance science journalists were sought for this project. The amount of experience from the freelancers was: 1) at least a year's worth of experience writing for publications and 2) not being a well-established science writer (e.g. having published a book or establishing a name for themselves in a field). The latter was deemed necessary to ensure comparable science journalists were recruited, since six well-established science journalists could not be found for the project.

D. Similar affinities towards new methods and technologies: Studies have shown that participants who are not open to learning new methods or technologies do not perform well when instructed to use them (Tseng et al. 2012). This dilemma of converging technologies lies outside the scope of the study and was seen as a separate issue. This study is only interested in making inferences on participants who are already open to learning new methods and technologies. Therefore, participants were asked directly whether they were open to learning and using new technology.

E. Similar affinities towards peer-collaboration and open-source journalism: Because the project aimed to test the efficacy of peer-collaboration, participants had to identify themselves as open to participating in peer-collaboration with other science journalists.

F. No personal agendas. Participants who were actively excluded were science writers whose body of work involved mostly public relations or who had an explicit agenda on either side of the debate surrounding energy use or biofuels (e.g. environmental-activists or writers for the oil-industry).

Two methods were used to recruit participants. The first involved recruitment from personal networks using a snowballing technique, where journalists learned about the recruitment via word of mouth. Requests for participants were made via personal online networks including: Email, LinkedIn, GoogleChat and Facebook. The second method used to recruit journalists was done via online websites that hosted science journalists as users. This method sought participants from non-personal external networks that already existed, so as to cast a wide call for participation [Figure 2.4.1.1]. These networks included: *Nature* Journal Network, Reddit.com, Craigslist.com, Canadian Science Writer's Association, and the Canadian University Press [Table 2.4.1.1.1]. These networks were chosen because of their size and popularity. *Nature* is the most highly referenced journal in the sciences, Reddit.com is a large social-network for anonymous users, and Craigslist.com is one of the largest networks for commercial exchanges (i.e. freelancers). Because Concordia University is located in Canada, two Canadian networks were also included, the Canadian Science Writer's Association because it is a large network of science journalists in Canada and the Canadian University Press because it is the largest network for working student journalists.

> I'm a Masters candidate who was also a science-journalist for almost 5 years. I'm wondering if there are any science-journalists interested in helping me out.
>
> For the last 2 years I've collected the problems scholars have listed with science-journalism in their research. I developed software to help science-writers tackle some of the basic problems in their writing. I created a pilot project, to test the software on a classroom of science journalists for a semester and received strong positive results. However, the pilot now needs to be tested with professional science-journalists (i.e. not just students) to see if the results remain positive – and that is where I need your help.
>
> I would like help from science-journalists who have at least 1 year

of writing experience. The task would require you to write two "test" articles: One using the software and the other without.

Figure 2.4.1.1: EMAIL SOLICITING PARTICIPANTS

In total, these recruitment methods gave 31 responses [Table 2.4.1.1.1].

Request	Total Responses	Interested-Responses	Responses which met criteria	Final Selection
Nature Journal	5	3	0	0
Reddit	15	10	7	2
Craigslist	1	1	0	0
Canadian Science Writer's Association	0	0	0	0
Canadian University Press	2	1	1	0
Facebook	8	6	4	4

Table 2.4.1.1.1: RESPONSES AND SELECTION PER SOCIAL NETWORK

Soliciting these responses proved challenging due to the social nature of the platforms themselves. Users on the websites who had an interest in science journalism wanted to discuss the concept of using software for science journalism without expressing any intention in participating in the study. There was difficulty in distinguishing users who were engaging in discussion due to an interest in participating from those who simply wanted to carry a discussion. Responses were therefore separated into *interested* and *disinterested*. Interested reactions involved users expressing their excitement over using the software or how it would be "fun" to participate in the experiment. Disinterested discussions ranged from simple inquiries on the project to statements on how it was depressing for science journalism to have fallen so low to require software in the first place. Of the interested results, 12 respondents met the criteria for inclusion [Table 2.4.1.1.1]. While external social-networks produced the highest number of results, personal networks through Email, Chat-messengers, and Facebook produced the most reliable responses. Reddit produced a high number of responses, but some of the participants did not meet the criteria due to a lack of journalism experience. Although seven of those participants met the criteria: two never returned emails by the deadline, two could not commit to the timeline, and one dropped out due to a family emergency. In the end, only two participants were recruited from Reddit and four participants from Facebook. The demographics of these participants are described in Table 2.4.1.1.2.

Participant	Group	Country	Age Group (5 year intervals)	Journalism Experience	Sex
1	1	Canada	25-30	6	Male

2	1	Canada	20-25	4	Female
3	1	USA	25-30	2	Male
4	2	Canada	20-25	3	Female
5	2	Canada	25-30	6	Male
6	2	Australia	25-30	7	Female

Table 2.4.1.1.2: DEMOGRAPHIC OF PARTICIPANTS

Once recruited, participants were introduced to the topics of biofuels and genomics as content foci of the study. Biofuels and genomics were chosen as the topics because they are very related and highlight many of the challenges under study. Biofuels, as a subset of energy coverage (Brainard and Russel 2012), is a topic of growing importance that has also reached an important crossroad (Brainard 2012; Delshad et al. 2010; Carriquiry et al. 2011). The coverage of energy issues draws on topics such as climate change, renewable energy, environmental law, energy policy, national security issues, investment banking, material science and genomics. It is a topic that sets traditional energy sectors (coal/oil/gas) against new "green" technologies and biofuels in a way that is global as well as local, environmental as well as economic, regulatory as well as scientific (Brainard 2012; Brainard and Russel 2012). Biofuels and genomics showcase a significant challenge for journalism: they are topics that require broad expertise to cover effectively (scientific, regulatory, legal, environmental, investment banking, etc.) and thereby a team effort. They are good topics with which to develop and test innovative approaches to journalism. Thus, this thesis focused on the specifics of how science journalists may deal with these debates when scientifically accepted positions are unclear.

The participants were asked to complete two trials, producing one 300-word article per trial. Recruited science journalists were split into two groups (three journalists per group; Table 2.4.1.1.3) with one using the DEBATE^CITED software to aid their research for their first trial article but not their second trial and the other group having access to the software for their second trial article but not the first. The point of the second trial was to help verify whether DEBATE^CITED can still help science journalists even after familiarizing themselves with a topic. The groups were asked to create their first trial articles on the topic of biofuels using the Concordia University Genozymes Project (http://www.fungalgenomics.ca/wiki/Main_Page) as their focal point but they were encouraged to look outside of this focal point for research as well. For the second trial, both groups again wrote on a topic related to the Genozymes Project but with a focus on explaining second-generation biofuels and genomics. The choice of the topic of biofuels and genomics was made due to access being granted to a research project studying these topics at Concordia University and to create a comparable focal point between the groups for the construction of the test stories.

	Group One	Group Two
Trial One	Uses DEBATECITED	Does not use DEBATECITED
Trial Two	Does not use DEBATECITED	Uses DEBATECITED

Table 2.4.1.1.3: GROUPS ARE DIVIDED BASED ON WHICH ARTICLE THEY WILL USE WITH DEBATECITED

Because the participants were separated into two groups, it was important to ensure that these groups were as equal as possible so that the peer-collaborations between members would theoretically not be unbalanced. These dynamics of peer-collaboration were predicted based on the writing samples provided by the participants. The writing samples were separated by how much context they provided and how many technical terms they introduced and explained for readers. Thus, the first two journalists who provided the most technicalities alongside relevant context were separated into two groups, as was the third and fourth, and the fifth and sixth. Two other factors were also taken into account: how responsive they were in replying to emails (for example how quickly they submitted their consent form) and their expressed engagement with the project. These factors were considered due to predictions that 1) journalists with a high level of responsiveness and engagement will make use of DEBATECITED more effectively and 2) should the differences in the writing styles not be apparent they will help distinguish participants further. Although journalists were already similar, due to the criteria used to select them, separating journalists on these factors was a further means used to create more similar groups.

Both groups of participants were given the topic of their articles simultaneously. Only afterward, was one of the groups introduced to the software. This meant that participants on DEBATECITED had to both learn the software and create their articles in the same amount of time as the group that created articles without it.

Participants were informed that DEBATECITED was to serve the purpose of helping them construct their articles on their respective topic. Participants were allowed to approach the topic whichever way they preferred, as long as the end-result was a journalism article.

The topic of the first article was introduced with a shortened version of the press release [Figure 2.4.1.2] along with the contact information of the project manager for Concordia's Genozymes project.

Concordia University scientists make research advancements for biofuels

Dedicated scientists at Concordia University in Montreal are making advancements in biofuel research to convert plant materials into biofuels. Scientists will identify, analyze and develop potential enzymes in fungi to use as catalysts to produce biofuels and other plant-based products. This research will provide the cornerstones for the development of large-scale industrial biorefineries that process biomass into biofuels in Canada. The scientists aim to set new standards to measure the sustainability of biofuels. The need to move away from fossil-fuels has never been greater.

Figure 2.4.1.2: PRESS RELEASE PROVIDED TO JOURNALISTS FOR THEIR FIRST ARTICLE TOPIC.

The purpose of the second article was to go more in-depth on the subject of biofuels. Therefore, the journalists were instructed to use the information they gathered for their primary article and to write more in-depth on the subject of biofuels with the assumption that their readers had researched their primary article and are thus well informed [Figure 2.4.1.3]. This second article was intended for readers who would be more informed than most people and where a press release for an in-depth coverage would not exist. Instead of providing a press-release for this coverage, the journalists were simply directed with the ambiguous yet controversial term "Second Generation Biofuels" (Carriquiry et al. 2011). The meaning of the term is still being developed and not completely agreed upon among scientists (Carriquiry et al. 2011), but often denotes movement away from food sources as the feedstock for biofuel production. Still, some scientists may perceive that there is no such concept as 'second' generation and that the development of biofuels is a gradual continuum rather than a generational step or an upgrade.

This article is based off what you wrote in your first article and may be slightly more challenging in terms of depth (although it may not seem like it at first). We want you to assume your readers have read the first article you produced and are now more knowledgeable on the basics of what you have written in your first article. Now write one where you write more in depth on biofuels by focusing solely on what is known as ***'Second Generation Biofuels,'*** *(I'll leave defining the term up to your own research as there are several angles you can approach it by). You've all touched on the subject of Biofuels and this topic may seem similar to what you have already written on but to understand Second-Generation Biofuels you may want to look more in-depth into its practicality/potential/criticisms/controversy.*

Figure 2.4.1.3: INSTRUCTIONS TO JOURNALISTS ON SECOND ARTICLE TOPIC

Similar to the pilot, professional participants using DEBATE CITED were asked to input the angle (main point) or lead (most newsworthy information) of their work as an initial premise for a story. This served as the root premise and allowed for the journalist to lay out the proceeding premises in their story as a skeleton for their articles. The last step occurred when other participants collaborated on filling out a concept-map by contributing information that either agreed or disagreed with the root premise. Participants were not allowed to edit comments, unless they made a special request, so that all changes could be tracked. Participants were informed that they could withdraw from the study at any time. All participants gave informed consent to participate and the Research Ethics and Compliance Unit of Concordia University approved the project. Participants were paid $300.00 for participation.

Section 2.5: *Software Tutorial*

The instructions for participants on how to use the software were based off the instructions that were presented to students during the pilot project (Novin and Secko 2012). Because the purpose of the software was to connect science journalists through a virtual network and without the requirements of a physical space, the live presentation for the pilot project was made into a web video [Figure 2.5.1.2]. YouTube was chosen as the hosting platform due to it being widely familiar with users and its access being reliable.

Participants were allowed to contact the author for software support but not questions on actual article content (e.g. questions about the science research on biofuels or genomics). To control and evenly distribute the amount of interaction between the author and the participants, a list of answers to questions based on the pilot study was compiled. The list was distributed to all the participants after the initial video. The list of pointers is provided in Figure 2.5.1.1.

- It's okay if you're unfamiliar with the topic of Second Generation Biofuels, this software is meant to familiarize yourselves with unfamiliar topics through discussion. So don't worry about playing devil's advocate or making "weak" points you are mostly anonymous and the point is to engage.
- You may only have a rough idea of an angle, that is okay, you're allowed to make a simple point and see if others contribute to it or if it takes off. You're allowed to make several story attempts and are not restricted to one angle, so feel free to try different angles.
- If you are really lost on the topic, then that is the best reason to just throw out an angle or two and see if the other members contribute points to the topic.
- It is also important that you work with the rest of your group by contributing points to their respective story - that means add points which you may feel agree/disagree with their points (it's okay to play devil's advocate with each other. In fact, you should play devil's advocate).
- There are only three members per group so it's important for all of you to participate in order to help each other. The more activity you all generate on DEBATECITED the better it will be for everyone else in your group.

- If you are unsure of what angle to take or are considering several angles, feel free to construct several stories with the software - you are not restricted to only one story construct or debate.
- You should now begin working on constructing your articles using the DebateCited software today or this weekend - this is required. Participation is also a requirement. Consider different points and angles and construct your arguments now because you won't have much time to participate later.
- The reason it is important to discuss biofuels now is because the software may help you realize certain gaps in your knowledge on Biofuels. Therefore after you 'debate' these topics on DebateCited you may want to fill in the gaps by re-contacting Concordia.
- If you receive additional information after contacting Concordia (or through other means of research) then you should re-visit DebateCited and place those points in the maps for the benefit of all.
- Have fun with the software, don't stress out about it. You were all chosen because you stated that you were unafraid of new technology and there is no one-way/correct-way to use this software. There are no errors or mistakes that can be made - except for not using the software at all.

Figure 2.5.1.1: LIST OF TEN POINTERS TO ENCOURAGE PARTICIPANTS TO USE SOFTWARE

Figure 2.5.1.2: SCREENCAPS OF HOW-TO VIDEO SENT TO PARTICIPANTS

Section 2.6: Questionnaire for Journalists

Following the completion of the articles, the journalists were asked to answer a semi-open questionnaire on their experience with DebateCITED and the author completed an analysis of the concept-maps on DebateCITED. The online questionnaire and the method of analyzing the answers were based on the guidelines set by Salmons' "Online Interviews in Real Time" and Creswell's "Advanced Mixed Methods Research Designs" (i.e. question wording, formatting of the questions and ordering of the questions can all affect the answers given and thus their reliability (Salmons 2010; Creswell 2003)). Participants were allowed to answer on their own time in their homes. The answers were considered in full and read several times to ensure that I properly understood the context of their answers. As per Creswell's suggestion, I assessed whether 1) the qualitative and quantitative data when analyzed separately still yielded similar results, 2) the qualitative data on the demographics of users had no visible affect that would dispute the quantitative data and was easily incorporated, 3) the responses to the open-ended questions are included in this thesis, 4) the answers to open-ended questions were analyzed on whether they differ from precategorized questions, 5) whether they support the quantified responses, and 6) whether respondents were interpreting the questions in the same way (Creswell 2009). In the design of the questionnaire, Creswell's advice was also followed with reference to 1) questions were matched to the research objectives, 2) I, the researcher, used familiar language when speaking to the participants, 3) I aimed to be clear and precise while minimizing questions that were loaded, double barreled, or double negative, 4) the questionnaire asked closed or open questions based on what was needed, 5) close ended questions were exhaustive and I considered various response categories available for them, and finally that 6) the questionnaire was easy to use and I pilot-tested [Section 2.2 and Table 3.3.1.3.1] the questionnaire beforehand (Creswell 2009). Participants were also encouraged to expand their answers to reflect their experience with using DebateCITED and at the end they were also asked about their final thoughts on the whole experience. This qualitative aspect of the survey was a result of open-ended questions that were not testing for the frequency of variables from the sample, but looking for a diversity of responses instead (Jansen 2010).

The questions were based off similar questions posed to students during the pilot project that centered around whether peer collaboration on DEBATECITED helped improve their knowledge on the subject, whether DEBATECITED helped their stories overall and whether the participants would consider using DEBATECITED again. The questionnaire for journalist freelancers re-posed questions from the pilot survey (See Table 3.3.1.3.1) and added the following additional questions:

1. Assuming all participants were instructed to visit the website at the same time, checkmark which article-deadline(s) you feel would work with DEBATECITED? (Daily, 48-hour deadline, Weekly, Bi-Weekly, Monthly)

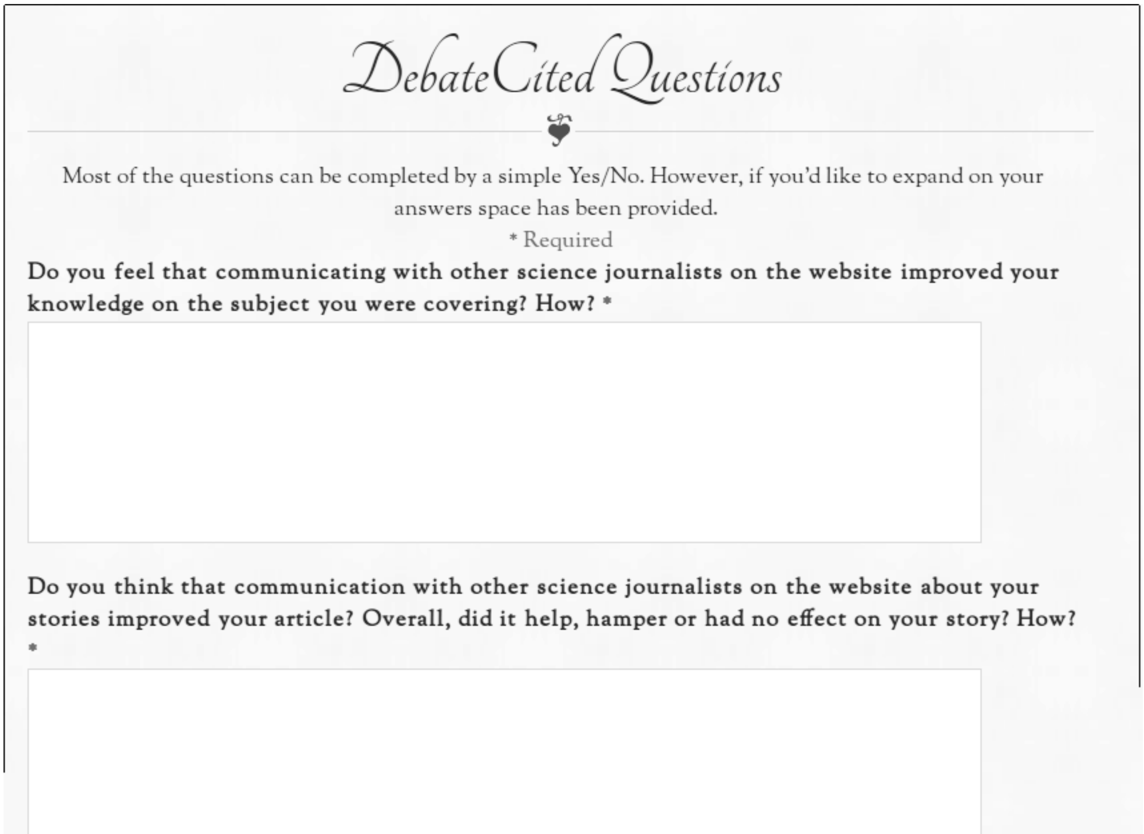
2. Aside from watching the video, do you think the software affected your time in researching various angles to your story? (i.e. did it waste your time, saved you time or had negligible effects).

3. Do you think the time spent on the site was an efficient use of your time? Or could it have been spent on something else?

4. Do you think that DEBATECITED added to the number of useful sources of information (or citations) in your article?

5. If you would like to see any changes in DEBATECITED or have additional comments on the website, please [make them].

If you would like to see any changes in how this study was run or you would like to make any additional comments, please [make them].



DebateCited Questions

Most of the questions can be completed by a simple Yes/No. However, if you'd like to expand on your answers space has been provided.

* Required

Do you feel that communicating with other science journalists on the website improved your knowledge on the subject you were covering? How? *

Do you think that communication with other science journalists on the website about your stories improved your article? Overall, did it help, hamper or had no effect on your story? How? *

Figure 2.6.1.1: SCREEN CAPTURE OF WEB-INTERFACE FOR SURVEY

Section 2.7: *Geometrical Analysis of Maps*

The geometrical analysis of the maps was based on work from the theorist, J.D Novak, who has created a measurable point-system to judge the success of a concept-map (Novak and Cañas 2008). The method requires awarding one point to the first branching of a concept-map, followed by additional points to each successive branching (horizontal expansion of a map) and/or each addition to the hierarchy of a map (vertical expansion of a concept-map). This thereby requires judging the number of links and content expansions in a map's links (Novak and Cañas 2008). Acknowledging that DEBATECITED is a unique software with its own differences, the point system used here included only some of Novak's basic criteria, but also included criteria from subsequent studies (Liu and Wang 2010; Markham et al. 1994).

Section 2.8: *Analysis by a Science Panel*

This step was designed to independently test whether changes in an article's accuracy and robustness due to the use of DebateCited were detectable. For this reason, the scientists who were most familiar with the scientific project, which was the topic of the journalists' articles, were chosen. As experts in their field, the scientists would understand the accuracy behind the scientific data and the robustness of information that contextualizes its meaning to the field better than either other scientists and the general public. The limits on restricting the panel to scientists will be addressed in the sub-section: Limitations.

The final phase of the project involved a scientist panel judging the accuracy and robustness of the articles produced. The scientist panel was recruited from the Genozymes project at Concordia University, which was the same project that formed the focus of the article production. The panel included the Genozymes Project Manager and two researchers who were working on the Genozymes project. All of the panelists worked on campus at Concordia University within the same building where the Genoyzme project lab was located. This was an initial test to see if an independent assessment of the articles can be made. However, this experiment is aware that this is a small sample that will need to be verified in future work. In consultation with the Genozyme Project Manager, the panelists were selected as scientists with sufficient background on biofuels and genomics to judge the scientific accuracy and robustness of the articles. Thus, the Science Panel consisted of qualified researchers who held prominent roles in the Genozyme Project: the Project Manager; the Platform Director, who was also the Research Specialist; and the Team Leader, who was also a Research Assistant and Lab Technician. None of the researchers were fully aware of what the DebateCited project itself entailed.

The panel was expected to rank and judge the quality of articles solely on accuracy and robustness. Once recruited, an email instructed the panel to rank the articles from best to worst based on the accuracy of the information. They were also asked to judge the articles on how comprehensive they were or whether any information was lacking from the articles. To ensure that the Science Panel ranked the articles with a focus on accuracy and robustness they were reminded of the task three times during the process. After defining accuracy and robustness, the email ended with the following breakdown of the instructions:

1. Read twelve 300-word articles on Biofuels and rank them from best to worst.
2. Rank them based on their 1) technical accuracy and 2) comprehensiveness (i.e. amount of important information).

Figure 2.8.1.1: **INSTRUCTIONS FOR THE SCIENCE PANEL**

The Science Panel was directed to a website which guided them through the process of ranking articles. When they arrived at the site they were greeted with Figure 2.8.1.2. The viewer saw the ranking list on the left with a comment-box for feedback. There was also a reminder about the "Instructions" at the top.

Figure 2.8.1.2: **SCREENCAP OF ARTICLES FOR SCIENCE PANEL TO RANK**

The articles were stripped of title and author and kept anonymous. They were placed randomly and could only be identified by letters. If Science Panel members inputted any information other than a number from 1-12 or if they did not provide a unique rank for each article they were warned with an alert.

Figure 2.8.1.3: EXAMPLE OF ALERT RECEIVED WHEN INSTRUCTIONS WERE NOT FOLLOWED.

When the final ranking was decided, participants were also warned: “Your results will be sent to me [the author]. Are you sure you want to submit these rankings now?” After being submitted, rankings were then collected into a private database.

Since the goal of this part of the project was to gain an independent assessment of whether DEBATECITED produced an increase in accuracy and robustness, the panel rankings were ordered from best to worst by taking the average of the three rankings. The Science Panel’s ranking informed whether a journalist’s article increased or decreased in ranking when DEBATECITED was used. To calculate the exact (hypergeometric) P-value to determine statistical significance in a 2x2 contingency table, the Fisher Exact Test, designed by Fisher (1922) and calculated by Daniel Soper’s (2012) software, was used. The Fisher Exact Test (Soper 2013) was used instead of a Chi-square Test due to the small sample size of six journalists. For the Fisher Exact Test to work, the 12 articles were randomly selected for the Science Panel. The selection was also non-replaceable (since articles can only be provided a unique ranking) as Fisher’s Exact Test requires (Soper 2013). The null hypothesis was that DEBATECITED’s method of article creation does not increase the accuracy and robustness of articles by an amount that is detectable by the Science Panel. The alternative hypothesis was that DEBATECITED’s method of article creation increases the accuracy and robustness of articles by an amount that is detectable by the Science Panel.

For the qualitative comments provided by the Science Panel the same methods of analysis that were used for the open-ended questionnaire portion [Chapter 2, Section 2.7] were used. Thus, the analysis again drew from Creswell's suggestions of including the open-ended questions; the answers to the open-ended questions were analyzed on whether they differ from pre-categorized questions, whether they support the quantified responses, and whether respondents were interpreting the questions in the same way (Creswell 2009).

Chapter 3: RESULTS AND ANALYSIS

Section 3.1: Theory: Mapping Debates

DEBATE CITED maps are a hybrid between concept-maps and logical truth-tree maps. The value of mapping debates by this method is that it combines the advantage of concept-maps visualizing the links between relative contextual information with the organization of argumentative-logic provided by truth-tree maps. The history of tree-maps can be traced back to the ancient Greek philosopher Porphyry. Porphyrian's Tree is the earliest example of a tree-map that exists [Figure 3.1.1.1](Gontier 2011). An important element in this map is how he divides categories into two premises that oppose each other (e.g. an object is "animate" or "inanimate" or an animal is "rational" or "irrational"). As will be demonstrated later on, DEBATE CITED's premises can be divided into proceeding premises that agree or disagree with them.

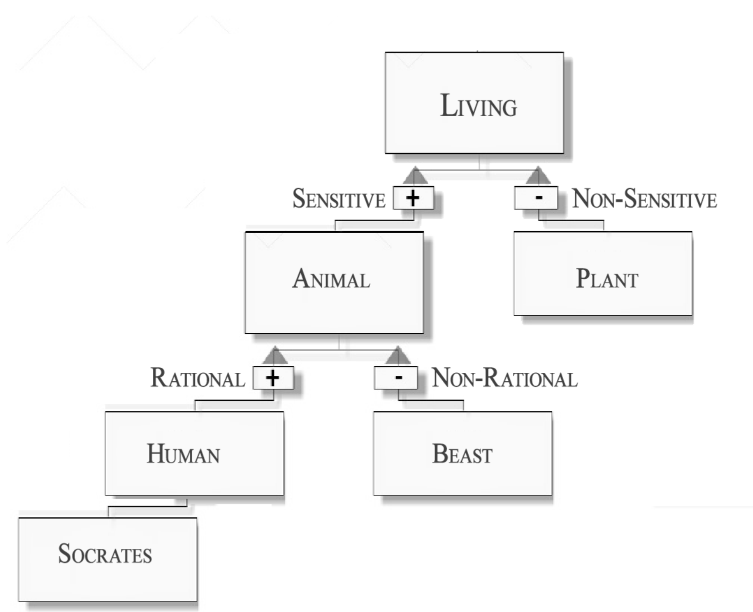


Figure 3.1.1.1: EXAMPLE OF PORPHYRIAN TREE

Novak and Gowin's (1984) "Learning How to Learn" is a seminal work that the majority of recent concept-map literature draws on. Novak's work on concept-maps, in particular, has shown positive results for students studying science. His work produced some of the most influential studies for today's scholars (Ryve 2004; Novak 2000; Sachsman 1976). Novak and Gowin's maps have four elements: propositions, hierarchies, cross links, and examples, all of which are shown in Figure 3.1.1.2.

Novak would label the six boxes with words in Figure 3.1.1.2 as **concepts,** while the lines that link them are **propositions**. For example, "Life" is a concept linked by the proposition "includes" to the node "Humans." The box with "Life" would be on a different **hierarchical** stage than the box with "Humans," which in turn, is on a different hierarchical stage level than the boxes with "Sensitive" and "Rational."

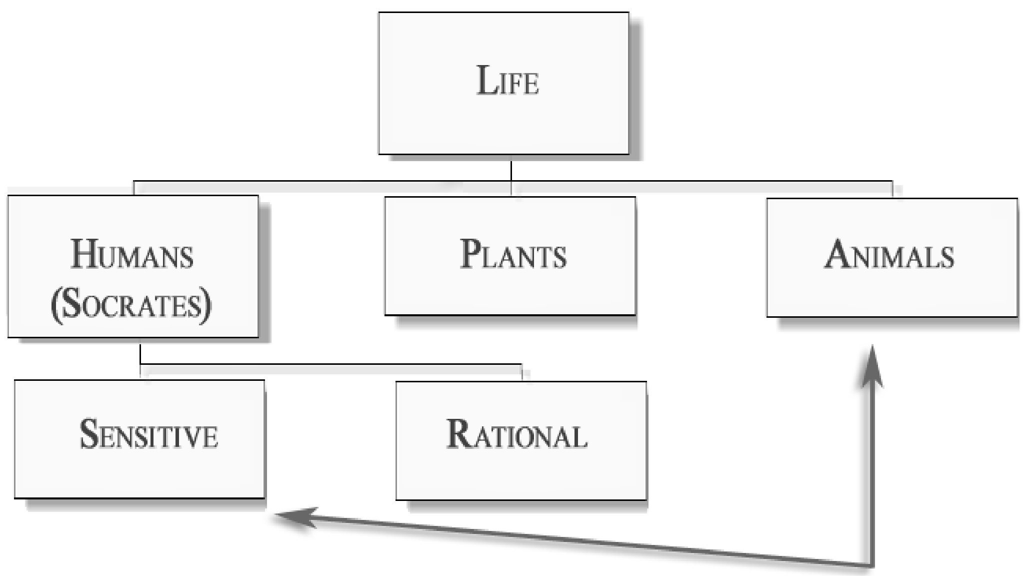


Figure 3.1.1.2: **EXAMPLE OF NOVAK CONCEPT-MAP**

The relationship between "Animals" and "Sensitive," indicated by the arrowed-line in Figure 3.1.1.2, would be labeled a cross-link. Lastly, Novak calls specific incidents of a concept an **example** (in Figure 3.1.1.2 that would be "Socrates"). Novak has also created a measurable point-system to judge the success of a concept-map (Novak 2000). It requires judging the number of links and content expansions in a map (Novak 2000).

For researchers, Creswell uses a map similar to concept-maps. A key distinction in Creswell's map is that he marks the positive or negative impact of variables that form propositions (by the use of

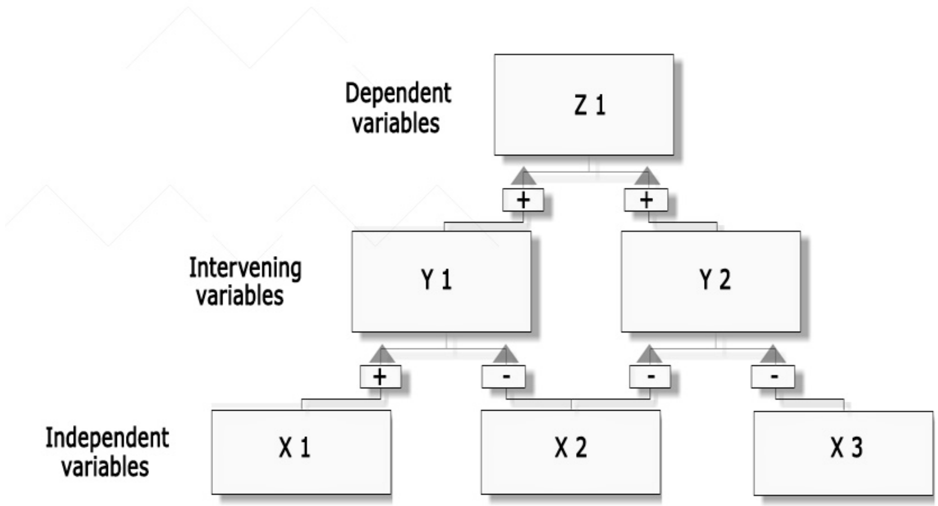


Figure 3.1.1.3: **EXAMPLE OF CRESWELL'S MAP**

the symbols + and - in Figure 3.1.1.3). By doing so, researchers can demonstrate how independent and dependent variables are organized in their research data (Creswell 2009).

Section 3.2: *Theory to Method: Creating the Software*

Seeing value in concept-maps and tree-maps as a way to potentially aid science journalists in doing their work, their structure, as described by Novak and others (Novak 2000; Novak 1984; Gontier 2011), were represented in a web application which used a concept-mapping technique termed DEBATE^CITED. Figure 3.2.1.5 represents DEBATE^CITED's structure.

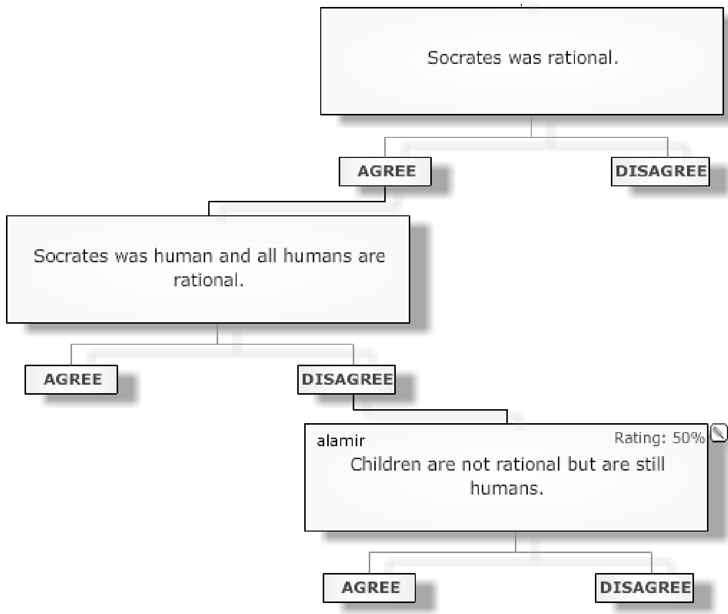


Figure 3.2.1.1: DEBATE^CITED's MAP-STRUCTURE.

DEBATE^CITED maps' focus on reconstructing debates into a logical format [Figure 3.2.1.1]. This focus has two requirements. It means the mapping structure has to incorporate elements that increase logical structure, while also saving elements in a debate that represent opposing views in an argument. Therefore, DEBATE^CITED sought to enable a dialogical structure of argument rather than a monological one. Monological arguments tend to be linear syllogisms and dialogical arguments incorporate the syllogisms of debating voices (vaguely similar to Socratic dialogue or Argumentation-Theory (Walton 2006)). DEBATE^CITED, it is hoped, allows debates to be deconstructed logically by dividing premises based on whether they agree or disagree with a preceding point. The bifurcation of premises allows concepts to either affirm or deny each other, which highlights their logical links.

In comparison, other messaging systems on the Internet (emails, forums, social-networks, etc.) are overwhelmingly linear in structure and work against the bifurcating lines of argument that come with debate. Their comment-systems are displayed in a top-down method where they are often ordered by chronology. Chronological hierarchy creates several problems, including (i) not knowing the strength of individual comments, (ii) not knowing which specific points are supported or opposed in relation to others, and (iii) being susceptible to tangential information such as memes, jokes, and spam (Secko 2009). Sometimes rating systems are implemented in commenting systems for other users to rate the value of a comment. The rating feature helps judge the value of a comment and DEBATE^CITED incorporates this feature. However, ratings can still be chronologically dependent where the first few comments can guide the discourse while subsequent comments become too low on the page to be rated on. Furthermore, should an early comment attract ratings then it will have more time to accumulate ratings than an equally valuable, yet late, comment. In an attempt to address this, DEBATE^CITED adopts a non-linear format where comments' placements are dependent on relevancy. This allows a user to view the relevancy of different points, comprehend the strength of certain points, the logic behind a topic, and opens up the possibility of reflecting on points of argument they may not have considered before.

One of the goals behind DEBATE^CITED was that the program had to be user-friendly for science journalists. This meant that it should be easy to access, understand, and use. Ease of access is enabled by the medium of the Internet itself. Participants did not need to install extra software and could access the application through most computers. Participants accessed DEBATE^CITED's online application by directing their browser to a short URL. Participants were greeted with a reminder on how DEBATE^CITED worked via a three-step reminder [Figure 3.2.1.2].

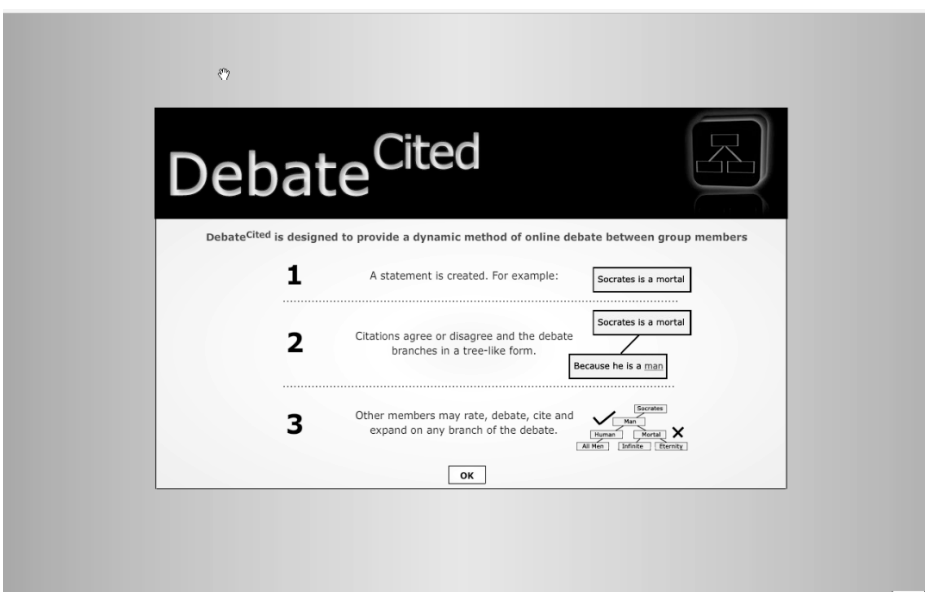


Figure 3.2.1.2: DEBATECITED'S FRONTPAGE. PARTICIPANTS WERE PROVIDED A BRIEF THREE STEP INSTRUCTION ON HOW TO USE THE SOFTWARE.

After the frontpage, users are presented with a blank canvas to create their maps and a box to login or register an account with DebateCited [Figure 3.2.1.3]. Alternatively, once maps have been created, users who wish to explore DebateCited maps belonging to other users could access them on the left side of their screen.

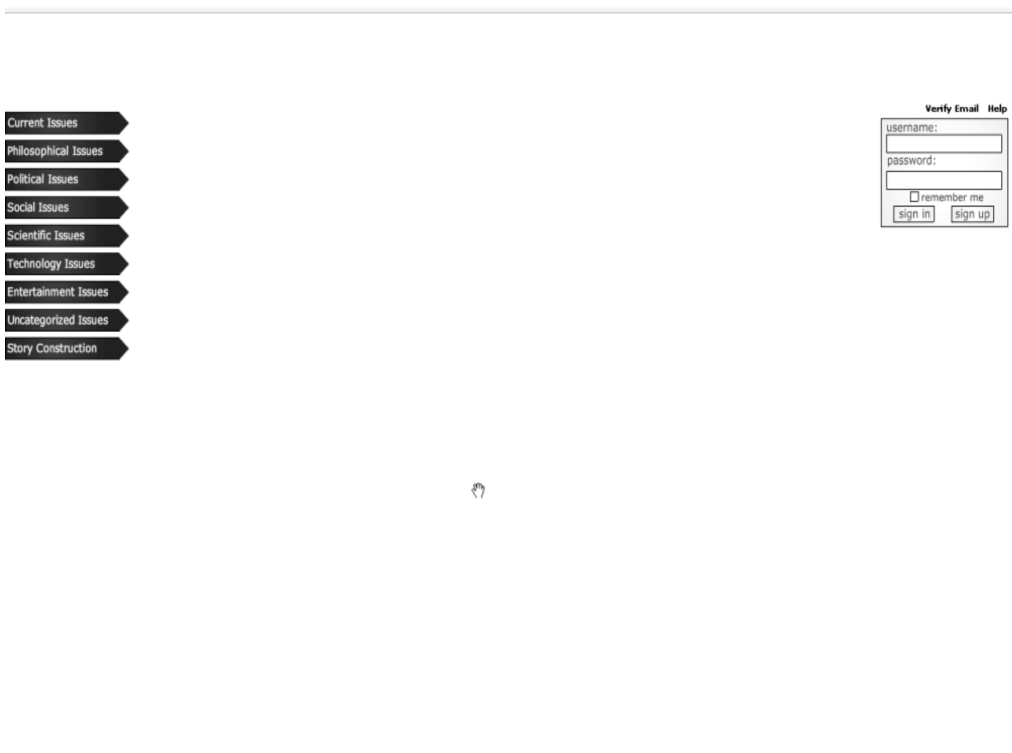


Figure 3.2.1.3: DEBATECITED'S BLANK CANVAS. PARTICIPANTS WERE PROVIDED A BLANK CANVAS TO BEGIN THEIR MAPS. A LIST OF TOPICS BY OTHER USERS IS PROVIDED ON THE LEFT.

When a topic is clicked in DebateCited [Figure 3.2.1.4] the corresponding map folds out [Figure 3.2.1.5] and displays the root premise of the selected topic, as well as the proceeding premises that agree or disagree with it. Because the maps grow both horizontally and vertically, navigation is simplified into two forms of action: The map may be navigated by clicking and dragging the mouse in the direction one reads, or one can click individually through each concept and be auto-focused to the next concept-box.

Figure 3.2.1.4: AN EXAMPLE OF COLUMNS OF MAPS ON DEBATECITED

On any of the premises, users may add related points, facts, citations (in the form of URLs) that agree or disagree with the preceding point. Users simply click the Agree/Disagree boxes and are prompted with a box to compose their message. This process allows both the reader and the author to visualize an in-depth argument based on its general syllogism rather than on the chronology of the message.

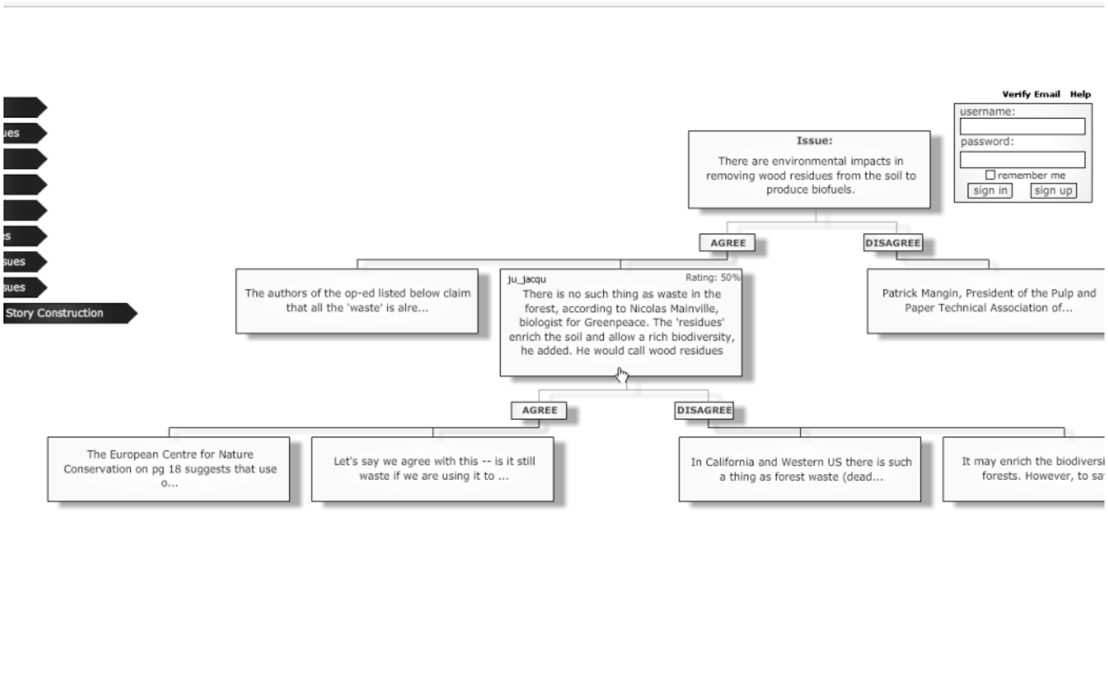


Figure 3.2.1.5: **AN EXAMPLE OF DEBATECITED'S MAPS. MAP EXPANDS BY HORIZONTAL AND VERTICAL NAVIGATION.**

Section 3.3: Pilot Use of DebateCited with Journalism Students

The pilot project was used to test the software, the questionnaire, and ultimately the overall approach of the thesis. The pilot allowed a heuristic examination of what elements of the software yielded positive results with the students so that those elements may be re-used and focused on in the main study with professionals. Similarly, Creswell suggests that for mixed method questionnaires, the questions are tested in a pilot prior to the actual experiment (Creswell 2003). The pilot was published in the online proceedings of the *Journalism Interest Group's of the Canadian Communication Association* (Novin and Secko 2012). The following is a summary of the results from the pilot project.

With DebateCited created, the thesis set out to explore the potential of its open-source format to help meet some critiques of the field, and in particular, to pilot whether it could help journalism students create more comprehensive science journalism in a classroom setting. Students came from the Department of Journalism at Concordia University and were instructed on how to use DebateCited. Fourteen students were enrolled in the class where the software was piloted from January to April, 2011, with the use of DEBATE CITED not being mandatory (see Chapter 2: Methods).

Of the fourteen participating students, seven used DEBATE CITED. In total, twelve story constructions were created. Story constructions are original posts, similar to new topic threads in forums, and are placed at the head of a blank map (see Figure 3.3.1.2 and 3.3.1.3) to set the theme for follow up posts. Although most students created only one topic, two of the students created more than one. Observing the maps, it was clear that the nature of the discourse allowed a DEBATE CITED map to grow vertically and/or horizontally. Table 3.3.1.1.1 lists the twelve topics created and how they grew.

Topic Number and Description	Max Vertical Spread	Max Horizontal Spread	Total Number of Boxes
1 Google's Clean Energy Plan	5	1	5
2 Biofuels and Wood Residues	5	5	11
3 Liquid Fluoride Thorium Reactors	4	4	11
$4 Comparison Between Electric Vehicles and Biofuel Cars	3	3	5
5 Benefits of Yeast	2	4	5
6 The Rise of Nuclear Power	2	4	5
7 Biofuels and the Entertainment Industry	1	1	1
8 Tobacco as a Biofuel	2	4	6
9 Corn Ethanol	3	5	4
10 Vegetarian Ethical Concerns with Biofuels	3	5	6
11 Whether Nuclear Power Lost the PR Battle	4	5	12
12 Science Journalism Standards	2	3	5
Total	**36**	**44**	**76**

Table 3.3.1.1.1: GROWTH STORY CONSTRUCTIONS BY STUDENTS

'Max vertical spread' refers to how many vertical levels of boxes appear in the associated map from top to bottom (or what Novak would call the hierarchies). 'Max horizontal spread' refers to how many boxes grew adjacently at a single stage. 'Total number of boxes' refers to the sum of the number of boxes that were created in the map (or what Novak calls propositions). The topics tackled varied from a comparison between electric vehicles and biofuel compatible cars, to the benefits of yeast for biofuel production, to tobacco as a biofuel and corn ethanol.

What was apparent in the discourse that took place in the twelve maps was that almost every point made was well thought out. Unlike comment threads or discussions on forums where certain comments may be superfluous, chatty, inconsequential or tangential (Secko 2009) the format of DebateCited restricted the discourse to relevant and meaningful points being made. The following is an example of a discourse that took place on Topic #11, "Whether Nuclear Power Lost the PR Battle" [Figure 3.3.1.2].

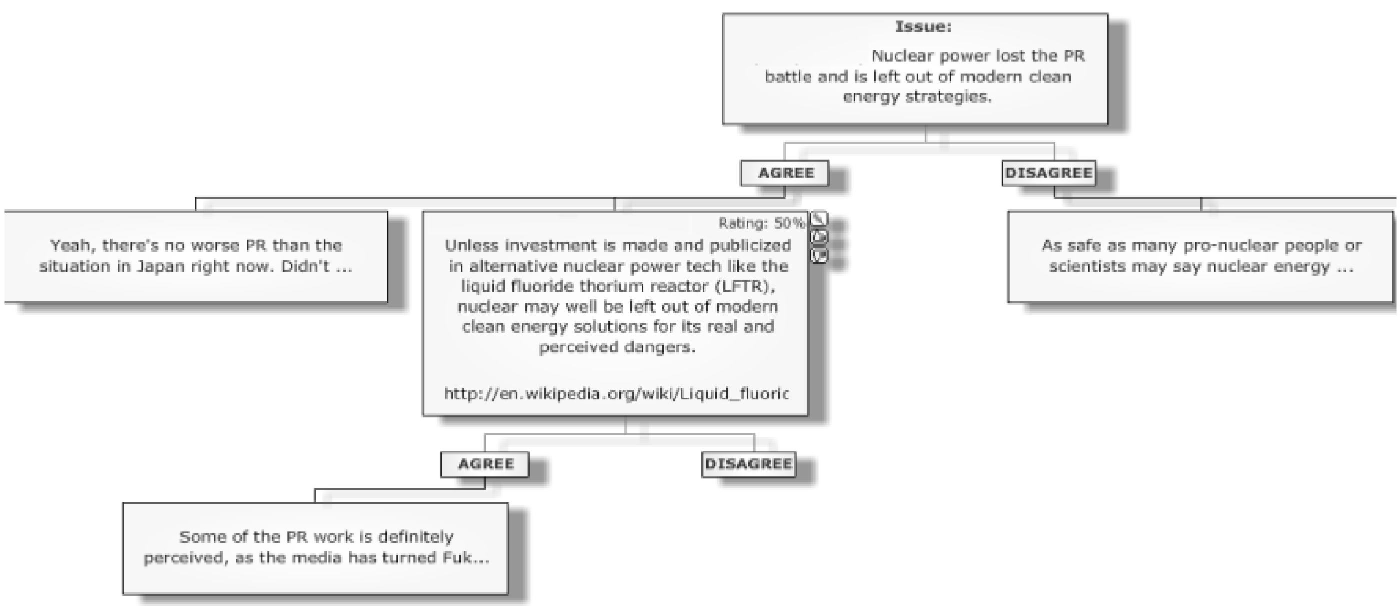


Figure 3.3.1.2: **EXCERPT FROM A DEBATECITED DISCOURSE ON FUKUSHIMA POWER PLANT**

The points that were added in these maps were not always listed chronologically. For example, in Figure 3.3.1.2, even though a point that disagrees with a premise was added later in the debate (i.e. "as safe as many pro-nuclear..."), the student felt it challenged the root premise and placed it horizontally adjacent to other points that disagreed in the hierarchy. On the other hand, a premise that already agrees with the root premise expanded the vertical line of discourse by providing a point with a citation from Wikipedia.

In Topic #2, "Biofuels and Wood Residues" [Figure 3.3.1.3] the line of discourse continuously expanded vertically and horizontally. Many of the premises carried their own set of controversies that were expanded on. Returning to comparisons to traditional commenting-systems, the branching of the argument into vertical and horizontal discourse observed in DEBATECITED could not be visually displayed in the traditional commenting system online due to their strict vertical-linearity. If linear commenting systems were sufficient, then one would expect such discourses to only grow vertically or horizontally on DEBATECITED as well. However, Figure 3.3.1.3 shows that the students made use of both vertical and horizontal posts, indicating a need and different purpose for each type. Furthermore, there is very little noise to signal in this system. Each of the premises that appear in this discussion provides the signal of agreement/disagreement with a corresponding justification and a frequent citation.

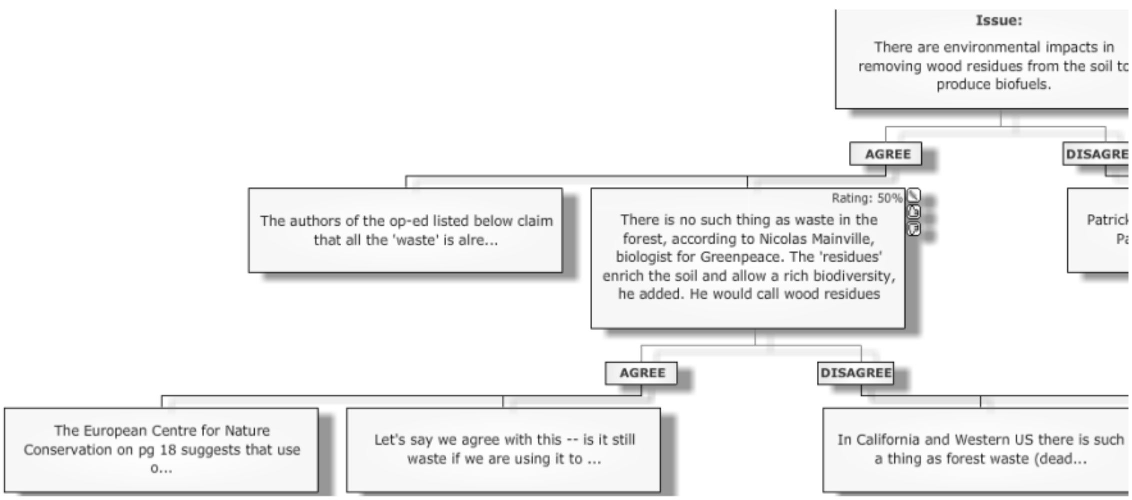


Figure 3.3.1.3: **EXCERPT FROM A DISCOURSE ON WOOD RESIDUES USED AS BIOFUELS**

Following the creation of the maps, an analysis of how the maps compared to the final stories was completed. Although the questionnaire provided stronger feedback from the students' experience, there were interesting correlations between the maps and articles. The students' final articles were on the same topics as their maps and students did not seem to change their mind on the topic. However, there were slight changes in how students approached the controversy behind their topic. For example, in Figure 3.3.1.3, one of the student's premises was " 'there is no such thing as waste in the forest,' according to Nicolas Mainville, biologist for Greenpeace." This statement was disagreed with by another study in California that had specified exactly what type of 'waste in the forest' exists. The premise was retracted and instead replaced in the article with a paragraph on both sides of the issue on what constitutes "waste in the forest." When controversial points on a DebateCited map appeared, students presented the information objectively in the article. One thing was certain: Mistaken statements in the maps that were pointed out were not repeated in the final articles. Whether DebateCited had caused the students to become more aware about an issue and how much students credited DebateCited's usefulness was explored in the questionnaire.

Do you feel that communicating with other science journalists on the website improved your knowledge on the subject you were covering? How?	Do you think that communication with other science journalists on the website about your stories improved your story? Overall, did it help or hamper your story? How?	Would you consider using DebateCited again? If so when?	Additional Comments
Yes. I was able to get immediate feedback on my ideas and was able to provide and be provided with helpful and interesting links.	It didn't help or hamper my story but it gave me confidence that my story idea was strong.	I would love to use DebateCited in a writing workshop scenario. Outside of the classroom getting together writing workshops where your peers evaluate and comment on your stories is hard but such a great thing to be able to do. I think Debate cited would be ideal for having a workshop without having to worry about getting people together in the same place, same time.	
yes. often there were remarks from other individuals that were quite insightful. the categorizations made it very easy to navigate. my follow up was lacking so i did not make the most of the program.	i did not use it for my stories particularly. the class did not seem so engaged with the program, but that is not to say that it does not have the potential to be very helpful. i don't see how it could hamper a story though.	yes. i am not sure of the circumstances. i am not sure of the best way to utilize debatecited. the diversity of online communication platforms is overwhelming and thus i seldom participate. this a personal issue, not one with debatecited.	debatecited has a lot of potential. thanks for letting us experiment with it. i hope the feedback is helpful.
Yes, because often the input of others would bring tangents that I wasn't necessarily considering. This would give me more depth to work with.	Yes, it helped improve the story. Anything that gives more depth will help, even if the points aren't directly addressed in the story, since you are always considering those extra dimensions when crafting your story. The comments help focus the story -- either positively or negatively -- that is, it helped me realize whether or not I had a specific focus that was achievable, and if not, focus my story.	Certainly. If I was trying to flesh out stories and needed insight, I think it would be great to forward a topic to friends and have them give their input. I think another good use for DebateCited would also be just as a fun communication tool between friends -- have friendly debates online, sort of like how people play chess games against each other online.	

I could have if it had been thouroughly used by all students. It helped sharing ideas and increasing knowledge by raising different points vues.	I could have if it had been thouroughly used by all students. It helped sharing ideas and increasing knowledge by raising different points vues.	I would if it was really used by everyone. The issue with this was that the necessary back-and-forth was not used to its full potential. If everyone had been sharing and discussing ideas on it, it could have been a lot more useful.	Please make a function that allows you to review your posts (or delete it in case you do not put it in the good section)
Yes. It improved my knowledge by exposing me to new sources, different or reinforcing perspectives and new questions on my topic.	It moderately helped my story. As in the first question, DC opened me up to other avenues of thinking and forced me to develop a counter-argument that I already held but had not yet developed, not having been faced by the particular opposite argument before. Basically, it's like debate practice where you get time to think about your argument and research it.	Yes. Debate Cited is generally a good tool, not necessarily only for science journalism. It would be helpful for the development of any reasonably complex argument or story. It could be a good democratic participation tool, if applied as part of a decision-making process.	Usability features can improve. You know what I'm talking about.
A bit. it enabled me to browse through other peoples research, links an thoughts, which added depth to my own knowledge.	Yes i think it is an interesting tool and it did help my story in that others made comments and recommended links that were beneficial to my stories.	Yes. In any situation where I would like to collaborate on a story, debate etc. with other people. I see little use in the tool if there is not several people using it simultaneously to discuss the same subject.	

Table 3.3.1.3.1: QUESTIONNAIRE FEEDBACK FROM PARTICIPANTS

From the students who used DEBATECITED, six provided feedback. While there were suggestions for improvement, which were taken into consideration, most were satisfied with the results. When students were asked if they “feel that communicating with other science journalists on the website improved [their] knowledge on the subject [they] were covering” four of the six participants gave a clear “Yes,” while the remaining two gave positive results with slight reservations. On whether DEBATECITED helped or hindered results, two of the six students responded “Yes” and one reported that it “moderately helped.” Two others gave views that were still positive but slightly reserved [Table 3.3.1.3.1]. The least positive was one student who wished more students in the class participated with DEBATECITED as they believed it held potential to be “very helpful” to their story. When asked if the students would consider using DEBATECITED again, five of the six students responded positively. The remaining student said that he or she would consider using it again as long as there were enough participants to use DEBATECITED at its full potential. The most frequent complaint by students was that the sample of users should be higher. However, none of the students provided strongly negative feedback.

In summary, while DEBATECITED could have been used as a simple organizer or a discussion forum, students favoured using it to construct science journalism articles. This may be somewhat a function of the instructions given to students on its use, but it also indicted that DEBATECITED was not an overwhelming burden to use when creating an article. The effectiveness of DEBATECITED was also given positive feedback suggesting it may hold value for use by professional science journalists.

Section 3.4: Results of the Main Study, Description and Analysis of Maps

After observing the results yielded from the students' usage of the software and their questionnaire-responses during the pilot, this thesis took the next step of testing professional journalists to see if similar results would be reproduced. Specifically, the piloted software and questionnaire were used with six professional journalists in two trials [Chapter 2: Methods].

Sub-Section 3.4.1: DESCRIPTION AND ANALYSIS OF MAP CREATION IN TRIAL 1

In the first trial, all three participants using DEBATECITED created root premises based on the angle they chose for their stories for the topic of biofuels. Three maps were created. Their root issues were: (Article a) "Biofuels provide many benefits, but they are not the only option. As well as the positives, biofuels are accompanied by many negative side effects that may affect their overall sustainability" [Map 1], (Article b) "Biofuels will be a major part in solving the energy crisis. The primary use for Biofuels will be as an alternative fuel supply to fossil fuels. However, they have many down sides including CO2 emission and increased cost for foodstuffs that biofuels replace" [Map 2], and (Article c) "Some biofuels are better than others. Methods of acquisition and environmental footprints of some potential sources outweigh their benefits" [Map 3].

The journalists then proceeded to lay out the main points and citations to support or challenge their angle. During this process, the three journalists also contributed points to each other's maps and shared their citations (see Appendix II for the full maps). The number of contributions from participants to maps that they did not create themselves was 30 times. The participants connected the nodes of developing maps by relating them on DEBATECITED as concepts that agree/disagree with former concepts. In all three maps, this generated debates within the maps themselves. For example, in Map 2 the statement "Biofuels are the most tangible option because we know how to make them and because they can [sic] made from a variety of resources" prompted a back and forth of agreements and disagreement from the participants. Citations were often used to support points or inform other users on a related point. On average, participants received two extra citation-URLs per map from the other journalists to support or refute their map. The maps grew both vertically and horizontally by up to 5 and 4 nodes respectively (further analyzed in Section 3.5). A total of 37 premises on biofuels were made in all three maps. Participation by journalists in helping to support the growth of another user's map was relatively equal.

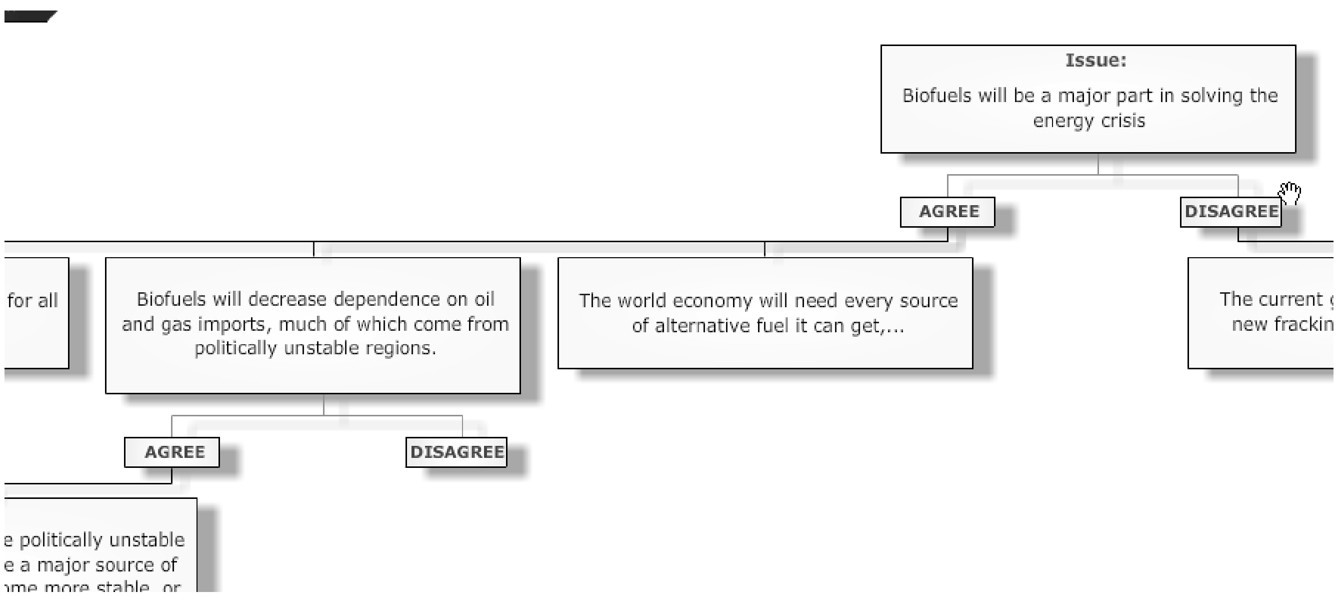


Figure 3.4.1.1: **EXAMPLE OF MAP CREATED IN FIRST TRIAL.**

Sub-Section 3.4.2: DESCRIPTION AND ANALYSIS OF MAP CREATION IN TRIAL 2

Although there were some noticeable differences in the second trial, they still held key features that were similar to both the pilot project and the first trial. The three participants using the program created root premises based on the various angles they chose for their stories. Two of the journalists created more than one map for their respective article. Their root issues were: (Article g) "Will 2nd-gen biofuels force rainforest destruction" [Map 4], (Article h) "Second-Generation Biofuels: a question of feasibility or sustainability?" [Map 5], "Adequate definitions of crop/forest residue" [Map 6], (Article i) "Residue based biofuel production should have minimal impact on food prices" [Map 7], "Investment in 2nd-gen biofuels at current production costs is a high risk venture" [Map 8], "2nd-gen biofuels not likely to make significant contribution before 2020" [Map 9], "Are 2nd-gen biofuels really less of a threat to food security" [Map 10], "Cost is a major barrier to increasing commercial production in the near to medium term" [Map 11].

The second trial produced different results due to external factors. Two of the participants began using DEBATE^CITED much later in the process than the third participant. Although all participants eventually contributed to DEBATE^CITED, it was far too late for maps to grow to the depth that the maps did during the pilot project and Trial 1 because most people would have begun working on their articles by that time. This meant that the participant who began the article earlier experienced less peer-collaboration than the other two members. These results are still included here due to the interesting and unexpected data produced on DEBATE^CITED. The one participant who began using DEBATE^CITED earlier took the liberty to create five separate maps based on various topic angles. It was only after the two participants joined that they got to interact with the maps normally through peer-collaboration [Appendix II].

There were 10 contributions from participants to maps that they did not create themselves. Once again, the participants connected the nodes of developing maps by relating them on DEBATE^CITED as concepts that agree/disagree with former concepts. This generated debates within three of the maps themselves. For example, in Map 10 the question "Are 2nd-gen biofuels really less of a threat to food security than 1st gen?" prompted a back and forth of agreements and disagreements between participants. Citations were again often used to support points or inform other users on a related point. On average, participants received one extra URL-citation per map from the other journalists to support or refute their map. The maps grew both vertically and horizontally by up to 4 and 3 nodes respectively (further analyzed in Section 3.5) and, eight root premises were made compared to the three in Trial 1. A total of 24 premises on biofuels were made in all eight maps.

Participation by journalists in helping to support the growth of another user's map was relatively equal. With the greater number of maps per article created in Trial 2, maps did not grow as vertically long or horizontally wide as the maps created in the pilot project maps or the maps from the first topic. Contributing to the smaller maps was also the fact that less peer-collaboration took place due to two participants using DEBATE^CITED much later than the other. The maps corroborate with the answers that were provided during the questionnaire where members felt that they would not be able to use DEBATE^CITED on very short deadlines, which is addressed in the Discussion section of this thesis. Furthermore, it also correlates with why the one member of the group who used DEBATE^CITED early-on responded several times that he/she wished there were more participants involved so that more collaboration could take place. As will be shown later on, this participant was also the only member of both groups in both trials that the Science Panel judged to produce an article with DEBATE^CITED that lowered in rank. Nevertheless, DEBATE^CITED was still used for smaller scaled collaborations between members.

Section 3.5: Description and Analysis of the Main Study Articles

Sub-Section 3.5.1: DESCRIPTION AND ANALYSIS OF ARTICLES IN FIRST TRIAL

In total, 12 articles of roughly 300-words were created by the participant journalists — six per trial [Appendix I]. The first trial articles approached the topic of biofuels from different angles but each of the three articles covered the contents of their respective maps. The articles created with DEBATE^CITED can be summarized as:

- Article A / Map 1 – The negative sides of biofuels that counterweigh the benefits in terms of overall sustainability.
- Article B / Map 2 - Whether Biofuels will be a major or minor player in solving the energy crisis.
- Article C / Map 3 - The various forms of biofuels and how factors such as methods of acquisition differentiate their benefits.

In comparison, the articles not using DEBATE^CITED were less focused on the different sides of the debate surrounding biofuels and focused on the research itself. However, a more in-depth analysis of these articles (e.g. a textual analysis) is not the focus of this thesis, which instead sought to examine the effect of DEBATE^CITED on article rankings (see Chapter 2: Methods). Nevertheless, a few additional points can be made on all twelve of the articles. The word lengths all met the 300-word requirement. The voice, or writing style, of the journalists was representative of the samples they had submitted during recruitment. For example, the two journalists who aimed to simplify the science as much as possible also approached the topic of biofuels in a similar manner. This meant that despite being familiar with the voice and approach of the official PR Release that was provided, the voice and approach of the articles was more representative of their original writing samples. In addition, this supports the importance of comparing the first trial rankings to the second trials because while the voice and approach of the journalist remained unchanged, the accuracy and robustness of the individual journalist did increase. These articles can be reviewed in Appendix 1.

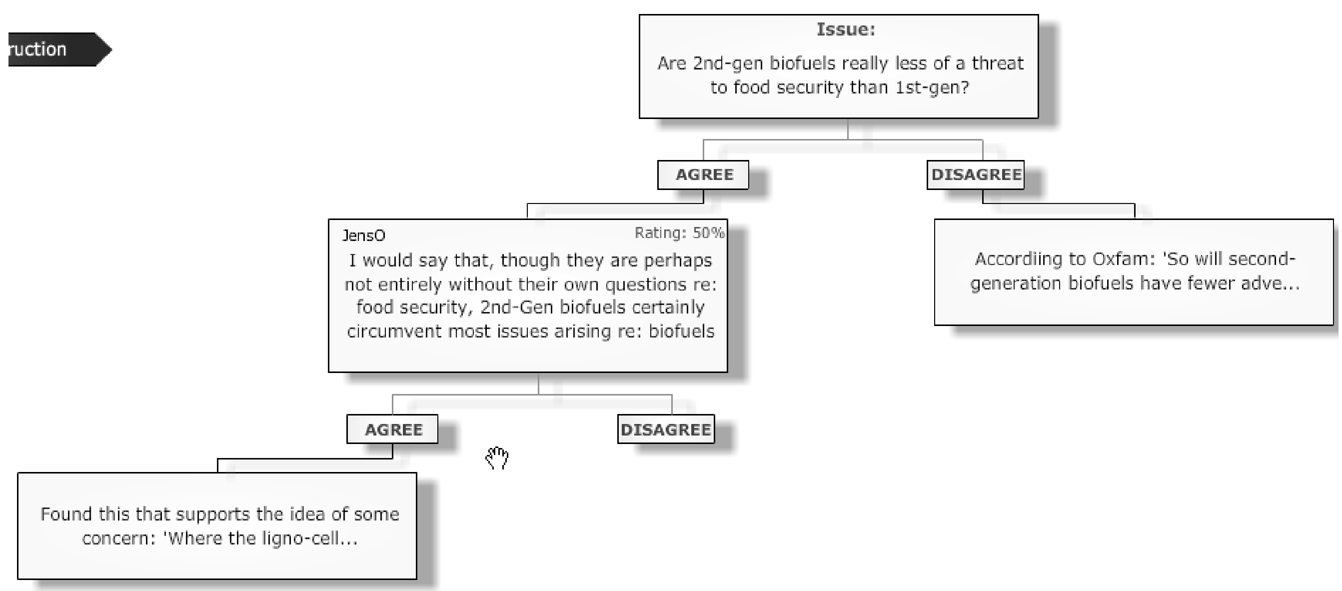


Figure 3.5.1.1: EXAMPLE OF MAP CREATED IN SECOND TRIAL.

Sub-Section 3.5.2: ANALYSIS OF THE ARTICLES CREATED IN SECOND TRIAL

Once again, six articles of roughly 300-words were created by the journalists [Appendix I]. The second trial articles approached the topic of Second-Generation biofuels from different angles again. Although the journalists using DEBATECITED created more than one map this round, each of the three articles covered the contents of their respective maps. The articles created with DEBATECITED can be summarized as:

- Article g / Map 4 – What Second-Generation biofuels consume in terms of resources (e.g. rainforest destruction).
- Article h / Maps 5-6 - The feasibility and sustainability of second-generation biofuels in terms of crop/forest residue.
- Article i / Maps 7-11 - The barriers that face second-generation biofuels in terms of production cost, development time, and unforeseen agricultural threats.

In comparison, the articles not using DEBATECITED were less focused on the topic of Second-Generation biofuels and less concerned with possible controversies. All twelve of the article met the 300-word requirement. In all twelve of the articles, the voice of the journalists was similar to the articles they had produced in the first trial.

Section 3.6: *Overall Observed Interactions with Concept-Maps*

Overall, participant journalists engaged with DEBATECITED in ways similar to the pilot project. All participants created a root premise based on the angle they were planning to use when approaching the topics of biofuels and genomics. From there they laid out the main points which supported or challenged their topic by relating them on DEBATECITED as concepts which agree/disagree with the root premise. All users contributed to each other's maps with proceeding points in agreement/disagreement. This allowed for debates to take place between members on certain points that, in turn, generated greater activity. Users also shared citations to support their points and inform other users. This resulted in maps growing both vertically and horizontally — in similar fashion to the growth of the maps in the pilot project (See Table 3.6.1.2.3, Figure 3.4.1.1, and Figure 3.5.1.1).

Based on observations made in the pilot project between the maps and articles created by students, the following interactions were analyzed for the two trials (these interactions are summarized in Table 3.6.1.2.3): 1. Map Vertical and Horizontal Growth, 2. Mapping Concepts Relate to Article Concepts 3. Laying Out Main

Points in Articles, 4. Journalists Make use of Organizing their Citations, 5. Journalists Contribute Concepts to Each Other's Maps 6. Journalists Contribute Citations to the Maps of Other Journalists 7. Journalists Incorporate Elements from Other Journalists from the Map into their Article, 8. Journalists Adjust Main Points that are Countered by Other Journalists. These interactions are described below.

1. Map Vertical and Horizontal Growth

In both trials, maps grew both vertically (premises were expanded on with agreements or disagreements) and horizontally (several premises were placed side-by-side to support a premise in agreement/disagreement). Maps grew a total of 15 concept boxes horizontally and 15 concept boxes vertically in Trial 1 and 12 concept boxes horizontally and 17 boxes horizontally in Trial 2 [Table 3.6.1.2.1 and Table 3.6.1.2.2; Appendix II].

2. Mapping Concepts Relate to Article Concepts

For both trials, the participants were introduced to the topic they were to write on at the same moment that they were introduced to DEBATE^CITED. This meant that there was no time built into the experiment for journalists to come up with their respective angles or skeletons prior to using DEBATE^CITED. Similar to the pilot project, the topics of the maps related to the articles for both trials. In contrast to the pilot, while the final articles listed the pertinent data of the Concordia University Genozymes Project, such as where it is taking place and who is involved in it, the maps focused on contextualizing the overall debate of biofuels itself. In fact, terms such as Concordia University, the Genozymes Project, and the various names of researchers involved were rarely if ever mentioned in the maps — as opposed to the articles. The facts and terms mentioned were based on the details surrounding the topic of biofuels itself that were not provided by the Genozymes Project researchers or their PR release. Lastly, Table 3.6.1.2.1 shows the three topics that the journalists chose to focus on respectively in the first trial: Solving the energy crisis, biofuels in comparison to other alternative energies, and the complexities behind the acquisition and use of biofuels. These three topics were all different from each other despite the fact that the Trial 1 group members were all primed with the same project information at Concordia University.

3. Laying Out Main Points in Articles

All participants created a root premise based on the angle they were planning to use when approaching the topic of biofuels. From there they laid out the main points which supported or challenged their angle, by relating them on DEBATECITED as concepts which agree/disagree with the root premise. The layout of the maps also related to how the article topics were ultimately structured. In Trial 1, the journalists used a total of 3 maps and in Trial 2 they used a total of 8 maps.

4. Journalists Make use of Organizing their Citations.

Journalists included citations to support their points. They did not use citations for every single premise. Rather, participants set up their argument and used the citations to only support premises that required external factual backing. A total of 15 citations were made in Trial 1 and 8 citations in Trial 2.

5. Journalists Contribute Concepts to Each Other's Maps.

All journalists contributed concepts to the maps of other journalists. Thus, many maps included concepts from several journalists. The rate of concept contributions was 30 of the 37 in trial 1 and 10 of the 24 in Trial 2.

6. Journalists Contribute Citations to the Maps of Other Journalists.

Along with concepts, journalists included citations to either help support their own maps or the concepts that they placed in other journalists' maps. The rate of citation contributions was 2 citations per map in trial 1 and 1 citation per map in Trial 2.

7. **Journalists Incorporate Elements from Other Journalists' Maps into their Article**

Another element that was observed was journalists incorporating concepts from the maps of other journalists into their articles. These concepts that were incorporated were unique because they were part of the maps belonging to other journalists and did not appear in the journalist's own map. An example of this dual use of peer-collaboration by participants was in Map 10/Article B. The participant raised the issue in their own map [Map 10] that second-generation biofuels may risk being a threat to agriculture through certain means. A second journalist wrote an **Agreement-node** that it was a point of concern but also questioned whether 2nd-generation should circumvent it [Figure 3.6.1.1]. The first journalist countered the point and provided support for the argument with a link that cited a scholarly article. Although, this map [Map 10] belonged to the first journalist, the second journalist saw it as fit to mention in their article [Appendix 1, Article F]. They also found a secondary citation on the topic in the map through a **Disagreement-node** that was related to their discussion but *not* one they participated in [Figure 3.6.1.1]. The second journalist used both points as a counter-view to their article's main argument [Appendix 1, Article F]. Neither of these points were made in the second journalist's original map and he/she confirmed that the citation they found in the first journalist's map was a new "great find."

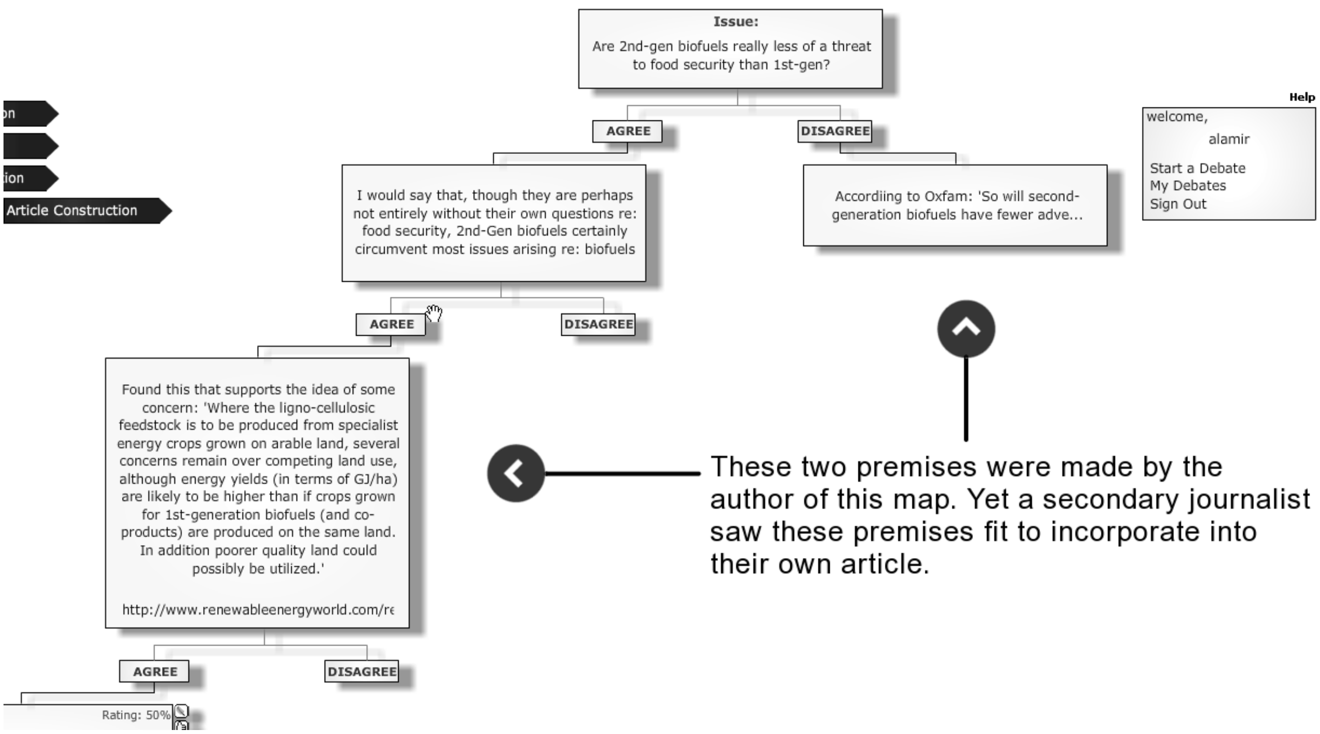


Figure 3.6.1.1: EXAMPLE OF DUAL USE OF PEER-COLLABORATION WHERE ONE JOURNALIST USES A SECOND JOURNALIST'S MAP

8. Journalists Adjusted Main Points that were Countered by Other Journalists.

When journalists placed the main-points made in their maps into their articles, they adjusted them to address the counter-points that were made in the map. This observation was also made in the pilot (see Section 3.3). For example, in one map, Map 1, a journalist created the concept that "biofuels are the most tangible option" to solve the energy crisis [Fig 3.6.1.2]. This point was 'Disagreed' with on the map with a concept created by a second journalist who pointed out that biofuels can be criticized because they "still emit greenhouse gases." In their article [Appendix 1, Article C], the first journalist used the second journalist's point and wrote: "Because biofuels presently cause environmental concerns and still emit greenhouse gases, as they are produced from carbon, they have received significant criticism suggesting they are not the best way forward."

Although this characteristic was observable in the Pilot Project and Trial 1, it was not observable in the Trial 2 — perhaps due to low participation.

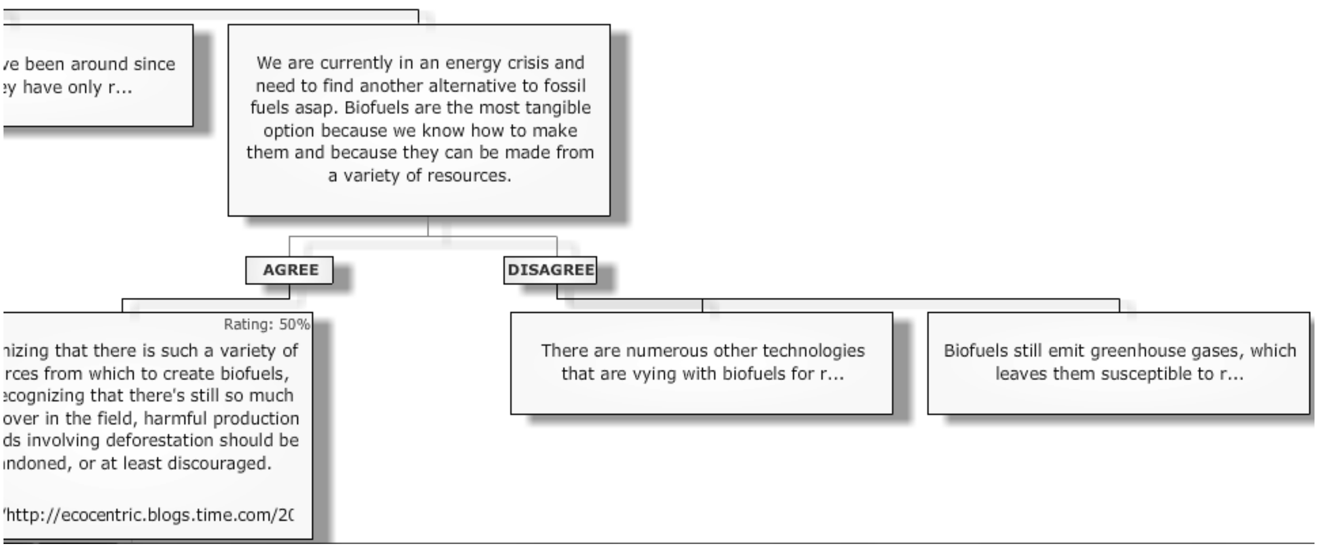


Figure 3.6.1.2: EXAMPLE OF A JOURNALIST INCORPORATING A SECOND JOURNALIST'S DISAGREEMENT FROM THE MAP

Topic Number and Description	Max Vertical Spread	Max Hoizontal Spread	Total Number of Boxes
1 Biofuels will be a major part in solving the energy crisis. The primary use for Biofuels will be as an alternative fuel supply to fossil fuels. However, they have many down sides including CO2 emission and increased cost for foodstuffs that biofuels replace.	5	4	11
2 Biofuels provide many benefits, but they are not the only option. As well as the positives, biofuels are accompanied by may negative side effects that may affect their overall sustainability.	5	7	18
3 Some biofuels are better than others. Methods of acquisition and environmental footprints of some potential sources outweigh their benefits.	5	4	18
Total	15	15	37

Table 3.6.1.2.1: MAP TOPICS CREATED IN FIRST TRIAL

Topic Number and Description	Max	Max	Total

	Vertical Spread	Horizontal Spread	Number of Boxes
1 Adequate definitions of crop/forest residue	2	1	3
2 Will 2nd-gen biofuels force rainforest destruction	2	3	5
3 Second-Generation Biofuels: a question of feasibility or sustainability?	2	2	3
4 Residue based biofuel production should have minimal impact on food prices	2	1	2
5 Cost is a major barrier to increasing commercial production in the near to medium term	1	1	1
6 Investment in 2nd-gen biofuels at current production costs is a high risk venture	2	1	2
7 2nd-gen biofuels not likely to make significant contribution before 2020	2	1	3
8 Are 2nd-gen biofuels really less of a threat to food security	4	2	5
Total	17	12	24

Table 3.6.1.2.2: MAP TOPICS CREATED IN SECOND TRIAL

Observed Interactions with Concept-Maps from Pilot Project	Trial 1	Trial 2
1. Map Vertical and Horizontal Growth	Yes (3 of 3 maps)	Yes (5 of 8 maps)
2. Mapping Concepts Relate to Article Concepts	Yes (3 of 3 journalists)	Yes (3 of 3 journalists)
3. Laying Out Main Points in Articles	Yes (3 of 3 journalists)	Yes (1 of 3 journalists)
4. Journalists Make use of Organizing their Citations	Yes (3 of 3 journalists)	Yes (1 of 3 journalists)
5. Journalists Contribute Concepts to Each Other's Maps	Yes (3 of 3 journalists)	Yes (3 of 3 journalists)
6. Journalists Contribute Citations to the Maps of Other Journalists	Yes (3 of 3 journalists)	Yes (2 of 3 journalists)
7.Journalists Incorporate Elements from Other Journalists from the Map into their Article	Yes (3 of 3 journalists)	Yes (1 of 3 journalists)
8. Journalists Adjust Main Points that are Countered by Other Journalists.	Yes (2 of 3 journalists)	Yes (1 of 3 journalists)

Table 3.6.1.2.3: OBSERVED INTERACTIONS WITH CONCEPT-MAPS

Section 3.7: *Questionnaire Results*

The impact of DEBATECITED on the participants in the main study was assessed with a questionnaire. The responses to the questionnaire are summarized in Table 3.6.1.1.1 and the full participant answers are provided in Table 3.7.1.1.3. Overall, the responses show a positive result in terms of the usefulness of DEBATECITED to the production of science journalism. For example, when asked "Do you feel that communicating with other science journalists on the website improved your knowledge on the subject you were covering? How?" Five of the six respondents replied that they did. The sixth respondent gave a slightly positive response but wanted other members in the group to participate more.

Questions on the effects of DebateCited	Improved knowledge on the subject.	Improved articles	Would consider using DebateCited again	Saved Time Researching Various Angles	Used Time Efficiently	Increased number of useful sources of information (or citations).
Number of respondents who agreed (out of 6 participants)	6	5	6	4	6	5

Table 3.7.1.1.1: Summary of Participant Responses

Reasons for how DebateCited improved knowledge included "exploring aspects of the topic I was unfamiliar with," "opened up my way of thinking to other perspectives that I hadn't considered before," "it was useful to be able to consider a wider variety of angles," "each of the participants brought their own unique skill set, or expertise to the discussion," "it was interesting to see what angles they took," and "I was able to draw from how the others were using it in order to form an angle for my story." One participant added a point about confidence: "Even if not everything considered made it into the short, 300-word article, it was easier to focus on an angle and feel confident that I was addressing what I believed to be the most relevant, important, and factually supported issues."

When asked "Do you think that communication with other science journalists on the website about your stories improved your article? Overall, did it help, hamper or have no effect on your story? How?" Four of the journalists responded that it helped, one reported it had some effect, and the last responded that it had little to no effect. This latter point about "no effect" was linked to the comment: "but that had more to do with the lack of participation on the other journo's[sic] part than anything else." For those it helped, the reasons provided were "broader knowledge," "more back and forth," "helped direct me to sources, provide a way to confirm facts or suspicions, and provided a good visual web of ideas that was useful during the writing process," "streamlining the process," and, "reinforce that the research and basic scientific principles I had used in forming my article were solid."

All six participant journalists said they would consider using DebateCited again. This result is similar to the Pilot where all the participants had said the same thing.

Five of the six journalists felt DebateCited added to the number of useful sources of information (or citations) in theirs articles. Reasons for this included: "I looked at sources that I wouldn't have otherwise without the software" and "the site's encouragement of citation-per-comment was very useful." The one participant who said it did not add to the number of useful sources explained that it was because the other participants did not include extra citations to their map, suggesting the importance of peer citations for DebateCited on this aspect of article production.

Of course, time usage is a potential issue in adding an online debate mapping software to the toolkit of a working science journalist. When asked how DebateCited affected the time needed to research an article, four participants said it saved them time. Of the remaining two participants, one responded "I think it took longer, but it was worth the extra time because the end result was of much higher quality" and the second responded "I spent about the same amount of time researching, but it was easier to refer back to bits I found salient when I had it saved in DebateCited than just in a word document." All six participants felt DebateCited was an efficient use of their time when asked "Do you think the time spent on the site was an efficient use of your time? Or could it have been spent on something else?" Some of the reasons for explaining its efficacy were that it solved "writers block," " to bookmark pieces of information [and] a way to structure a draft outline," as well as "other journalists found sources I might have otherwise spent time seeking out."

Lastly, in terms of production timelines, five of the six participants felt that DebateCited worked under the weekly deadline while one felt that more time was needed. All the participants felt that DebateCited could work on monthly and newspaper bi-weekly deadline. However, only four of the six participants felt that

DebateCited would work on 48-hour deadline and only half of the participants felt it would work with a 24-hour deadline [Figure 3.7.1.1.2].

Journalism Timelines	# of Participants	Total%
DebateCited could work on a 24-hour Deadline	3	50%
DebateCited could work on a 48-hour Deadline	4	67%
DebateCited could work on a Weekly Deadline	5	83%
DebateCited could work on a Bi-weekly Deadlin	6	100%
DebateCited could work on a Monthly Deadline	6	100%

Table 3.7.1.1.2: JOURNALISM PRODUCTION TIMELINES THAT DEBATECITED COULD WORK ON. (PARTICIPANTS WERE ALLOWED TO PICK MORE THAN ONE ANSWER.)

Do you feel that communicating with other science journalists on the website improved your knowledge on the subject you were covering? How?	*Do you think that communication with other science journalists on the website about your stories improved your article? Overall, did it help, hamper or had no effect on your story? How?*	*Would you consider using DebateCited again for another article?*
Yes - I feel that communicating with other journalists helped me to explore aspects of the topic I was unfamiliar with because I did not know they existed.	Yes	Yes.
Yes, it opened up my way of thinking to other perspectives that I hadn't considered before (which is exactly what I think it was intended to do).	Yes, it helped the article overall. It gave it more back and forth argument, which helped to build tension, though the article itself was somewhat constrained by length. I don't think it'd be as useful for new stories which are more straight facts and not opinion pieces, but it is useful for other types of writing.	Sure, assuming there are other people to use it with (that's sort of key to the process).
I think it probably would have helped a lot ... if the others in my group were more participatory. It was interesting to see what angles they took and what information they used to support the few things they did post.	In the end, i'd say it had little to no effect - but that had more to do with the lack of participation on the other journo's part than anything else.	yes

Yes. It was useful to be able to consider a wider variety of angles. Even if not everything considered made it into the short, 300-word article, it was easier to focus on an angle and feel confidant [sic] that I was addressing what I believed to be the most relevant, important, and factually supported issues.	It certainly helped direct me to sources, provide a way to confirm facts or suspicions, and provided a good visual web of ideas that was useful during the writing process to help keep my thoughts in order.	Yes.
Absolutely. While my contribution to the discussion was initially limited, I was able to draw from how the others were using it in order to form an angle for my story. I knew nothing about the subject before starting, but through discussion on the site, I found out where to start looking and, finally, what to write about.	My communication with the other authors improved the article immensely, as they helped me determine a unique angle for the piece. Interaction with other authors is obviously going to improve any story, but as the site is geared towards science journalism (a field that utterly depends on peer review and fact), the entire "peer-review" process (for lack of a better term) was streamlined.	I would gladly welcome another chance to use the website. Since the whole process was a sort of learning experience regarding the software, I'd love to try using it for something else, as a DebateCited veteran.
Yes, I do. It did seem that each of the participants brought their own unique skill set, or expertise to the discussion, which worked out very well.	It did have some effect on my article. I think the effect it had was helpful - though not exactly revolutionary. The effect it had was more in helping to reinforce that the research and basic scientific principles I had used in forming my article were solid. (Or, in the event that I had based my article on incorrect scientific principles it would have been very valuable to identify the errors.)	Yes - though I think the effectiveness of the discussion/debate could be improved by increasing the number of participants in each discussion group/debate.

Aside from watching the video, do you think the software affected your time in researching various angles to your story? (i.e did it waste your time, saved you time or had negligible effects)	*Do you think the time spent on the site was an efficient use of your time? Or could it have been spent on something else?*	*Do you think that DebateCited added to the number of useful sources of information (or citations) in your article?*
I think it took longer, but it was worth the extra time because the end result was of much higher quality.	It was efficient.	Yes.
I think it saved some time, especially since other authors were providing stories that they had gotten their information from. It saved me some time trying to dig up that same information.	I think it was efficient, especially for helping to frame the story correctly. I can also imagine that it would be extremely helpful for getting around writer's block (which wasn't a problem for me on the article we were working	Yes, I looked at sources that I wouldn't have otherwise without the software.

	on).	
I spent about the same amount of time researching, but it was easier to refer back to bits I found salient when I had it saved in DEBATECITED than just in a word document.	I found it helpful. There are two ways I could see it being really useful in the future: 1. as a way to bookmark relevant pieces of information, and 2. as a way to structure a draft outline for a story.	No, but that's because no one but me included sources
Yes, likely saved me time.	Overall it was not a time-consuming site to use, and sometimes it saved time since other journalists found sources I might have otherwise spent time seeking out.	Yes.
It ultimately saved a great deal time on article construction - as online research was a key aspect of the process for me, it was refreshing to have help finding somewhere to begin. Only once during the project did I begin to explore a fruitless angle - but another feature of the site is that it allows someone to potentially try multiple angles before deciding on the "best" one.	Once each contributor stared using the site and helping each other, it was clear that we would each end up saving time on article construction. There's no question that the site enhanced efficiency - as long as everyone involved was using it.	Certainly. The site's encouragement of citation-per-comment was very useful, and many of the sourcesCITED in those discussions were used for reference during the actual writing process.
I do feel that, aside from the time spent familiarizing myself with the software, use of the software was time-efficient. I think that once one has utilized the software a few times, and, perhaps more importantly, contingent upon active participation of others in the 'debate', the software/concept has great potential to increase the efficiency of science journalists conducting research.	Knowing that there was a group of qualified journalists working on the exact same question, and being able to go to DEBATECITED to ask a question, was considerably more efficient than other methods of researching would have been. Aside from some fairly minor technical/ease-of-use issues, I did feel that this was an efficient use of time.	Yes, absolutely. Unfortunately, I did think the timeline was a little tight to be able to fully investigate all of the sourcesCITED by the other participants. However, the quality of the sources uncovered by the other participants was clearly very high.

Table 3.7.1.1.3: PARTICIPANT ANSWERS TO QUESTIONNAIRE

Section 3.8: Science Panel Analysis

To further assess the usefulness of DEBATECITED an independent panel of selected scientists (referred to as the Science Panel) read the 12 articles. The articles were randomly ordered and the selection was non-replaceable (since articles could only be provided a unique ranking). All three members of the Science Panel provided results. Two members provided some additional comments on how they ranked the articles' accuracy and robustness. The following paragraphs analyze the results of their rankings in conjunction with their feedback.

To analyze the rankings, Jean-Charles de Borda's count method (1781) was used for several reasons. Most notably, it is a popular method of ranking, dating back to 1781, and is argued to be one of the most optimal methods (Erp and Vuurpiil 2003). It is also an accurate form of ranking when there are 12 or more items to rank (such as the 12 articles in this experiment) (Saari 1985). The use of this ranking system ensures that an ordinal and complete ranking system (i.e. where voters voted on each article) is used (Saari 1985).

Briefly, in the Borda system, the voter gives a '1' to their first preference, a '2' to their second preference, and so on. Afterward, each article gets 0 points for each last place vote received, 1 point for each next-to-last point vote, 2 points for the next, etc., up until the total number of points for the first place vote (where *n* is the number of options). The option with the largest point total wins the election. Thus, for the purpose of this thesis, $n = 12$ because there are 12 total articles to be ranked. An article in first place will receive 11 points (n - 1=11) while the one in second place will receive 10 points (n - 2 = 10) and so on until the last place, number 12, will receive 0 points (n – 12). The total is calculated by summing all points awarded, therefore the maximum points that may be received by an article is 33 (3 panelists x 11 awarded points = 33 total points) while the minimum is 0 (3 panelists x 0 awarded points = 0 total points).

According to the Borda Rankings in the first trial, the group who used DEBATE^CITED to produce their first articles and then stopped using DEBATE^CITED for their second article was ranked by the Science Panel as producing better articles while using DEBATE^CITED than when they didn't [Table 3.8.1.1.1]. In the second trial, the Science Panel also ranked that the group that used DEBATE^CITED resulted in two of the three participants had an improvement in accuracy and robustness [Table 3.8.1.1.1].

Journalist	Journalist A	Journalist B	Journalist C	Journalist D	Journalist E	Journalist F
Ranking by Scientist #1	2	3	7	9	11	1
Ranking by Scientist #2	9	3	10	8	6	4
Ranking by Scientist #3	10	3	7	2	4	8
Borda Sum of Rankings for using DEBATE^CITED	15	27	12	17	15	23

(Higher is Better)						

Table 3.8.1.1.1: **EACH SCIENTIST'S RANKINGS (FROM 1-12) FOR ARTICLES USING** DEBATECITED

Journalist	Journalist A	Journalist B	Journalist C	Journalist D	Journalist E	Journalist F
Ranking by Scientist#1	12	10	6	8	5	4
Ranking by Scientist#2	12	1	11	7	5	2
Ranking by Scientist#3	12	1	11	5	6	9
Borda Rankings for not using DEBATECITED **(Higher is Better)**	0	24	8	16	20	21

Table 3.8.1.1.2: **EACH SCIENTIST'S RANKINGS (FROM 1-12) PER JOURNALISTS NOT USING DEBATECITED**

Journalist	Journalist A	Journalist B	Journalist C	Journalist D	Journalist E	Journalist F
Ranking Improvements Due to Using DEBATECITED **(Higher is better)**	+15	+3	+4	+1	-5	+2

Table 3.8.1.1.3: **JOURNALIST'S RANKING IMPROVEMENTS MADE FROM USING DEBATECITED (TABLE 3.8.1.1.1) COMPARED TO NOT USING DEBATECITED (TABLE 3.8.1.1.2)**

To provide a test of the statistical significance of the results in Table 3.8.1.1.1, a Fisher Exact Test (Fisher 1945; Soper 2013) was performed on the ranking data to calculate a (hypergeometric) P-value in a 2x2 contingency table (see Chapter 2: Methods).

The following table represents the Fisher Exact Table:

	Increase	Decline
Used DEBATECITED	5	1
Without DEBATECITED	1	5

Table 3.8.1.1.4: **FISHER EXACT TABLE OF JOURNALIST'S OPINION ON WHETHER THEIR ARTICLE IMPROVED OR DECLINED.**

The Fisher Exact Test provided an exact (hypergeometric) P-value of 0.03896104, meeting our alpha set by the pilot project and providing a confidence interval higher than 95% and rejecting the null hypothesis that DEBATECITED's method of article creation cannot increase the accuracy and robustness of articles by an amount which is detectable by the Science Panel.

The Science Panel's rankings on the articles paralleled the results of the journalist's opinions on whether DEBATECITED improved their articles [Table 3.8.1.1.4]. Just as 5 of the 6 journalists felt like DEBATECITED improved their article, the scientist's rankings also confirmed that 5 of the 6 journalists had produced better articles by using DEBATECITED.

	Increase	Decline
Used DEBATECITED	5	1
Without DEBATECITED	1	5

Table 3.8.1.1.5: FISHER EXACT TABLE OF SCIENCE PANEL'S JUDGMENT ON WHETHER THE ARTICLES IMPROVED OR DECLINED.

Scientists observed that the articles which improved while using DEBATECITED shifted a total of 25 rank placements higher, while the article that did not improve while using DEBATECITED shifted lower by 5 placements.

	Total Rank Numbers Raised By	Total Rank Numbers Declined By
Using DEBATECITED	25	5
Not Using DEBATECITED	5	25

Table 3.8.1.1.6: FISHER EXACT TEST ON NUMBER OF RANKS SHIFTED.

In this context, the Fisher Exact Test gives an exact (hypergeometric) P-value of less than 0.0001, which is statistically significant with a 99% confidence interval. It is important to note that the one participant whose article declined while using DEBATECITED was the member who reported that they had a less than satisfactory experience (see Table 3.7.1.1.3). This was self-reported by the journalist as a result of the other two participants in the group not being active on DEBATECITED early on when he/she began the article — suggesting that without peer-collaboration DEBATECITED is not as effective. However, because both the journalist and the Science Panel recorded the ineffectiveness, it suggests some correlation between the participant feedback and independent article ranking by the Science Panel.

In total, two comments were made in reference to four of the twelve articles [Table 3.8.1.1.7]. One noted that the quality of the writing of two of the articles that did not use DEBATECITED was low — the scientists were not aware of which articles used DEBATECITED. One science-panelist mentioned that one of the articles, Article J, that was not produced on DEBATECITED, “didn’t seem to understand the distinction between second-generation biofuels and syngas.” Finally, one panelist commented that he was “surprised by the range of outcomes given that I provided the writers with basically the same raw material.” This point is addressed in the discussion as it alludes to a response to one of the possible criticisms of DEBATECITED, which is that articles may risk becoming homogenous if they all drew from the same source.

Scientist Panel	Comments
Panelist 1	A and C were particularly pporly[sic] written; B was overwritten or I would have ranked it first instead of second (for example, way too many needless transitional words); J doesn’t seem to understand the distinction between second-generation biofuels and syngas.
Panelist 2	I’m surprised by the range of outcomes given that I provided the writers with basically the same raw material.
Panelist 3	N/A

Table 3.8.1.1.7: SCIENCE PANELISTS COMMENTS ON ARTICLES

Section 3.9: *Summary of Results and Comparison of Pilot Project, Trials and Science Panel*

Slack and Draugalis (2001) recommend outlining inclusion and exclusion criteria and associating subjects with their relevant variables to achieve a generalization of research results. Thus, to help point to the external validity between the cause and effect of DEBATE^CITED and the participants' final articles, the three runs with DEBATE^CITED (i.e. the Pilot and the two Trials) can be compared where external variables were increasingly altered. In the Pilot it was asked whether DEBATE^CITED improved the students' knowledge on the subject they were writing on and whether they would consider using DEBATE^CITED again. All the participants responded positively to both questions. Finally, it was asked whether they felt it improved their final article and only 4 of the 6 reported that it did. When these questions were re-asked in the Trials with professional journalists, all the participants said it improved their knowledge and they would consider using DEBATE^CITED again (similar to the Pilot). Furthermore, a slightly higher number of participants reported that it improved their final article (5 of the 6). While the data here was limited, it provided a first sampling that perhaps neither the variables in student/professional status nor the classroom/office settings played a major role in how DEBATE^CITED was interacted with. When the Science Panel rated the journalists' articles they also reported similar results to the Trials. This suggests that a difference in the journalists' articles was detectable by a limited set of expert readers. With the Pilot and two Trials narrowing the effects of various variables, the internal validity of this experiment indicates that DEBATE^CITED can improve the accuracy and robustness of a science article under controlled settings.

Group	Number of Participants who claimed DEBATE^CITED Improved Knowledge on Subject	Number of Participants who would Consider Using DEBATE^CITED Again	Number of Participants who Improved Their Final Article
Pilot Project	6 out of 6 (100%)	6 out of 6 (100%)	4 out of 6 (67%)
Combination of Trials1+2	6 out of 6 (100%)	6 out 6 (100%)	5 out of 6 (83%)
Science Panel	N/A	N/A	5 out of 6 (83%)

Table 3.9.1.1.1: COMPARISON OF PILOT PROJECT, THE COMBINATION OF TRIALS 1 AND 2, AND THE SCIENCE PANEL

Chapter 4: DISCUSSION

Section 4.1: *Analysis of Using a Mixed Methods Approach*

A journalist's science article is a mixture of qualitative and quantitative writing. They take scientific research and couple it with an interest in storytelling in search of the deeper implications for readers. In a similar light, the mixed methods approach taken by this project wanted to study both whether there is a measureable difference in improvement with DEBATECITED alongside why and how any difference exists. Because a project like this has rarely been performed with a group of science journalists, the author wanted to know both the journalists' qualitative experience with DEBATECITED and whether it paralleled the quantitative results. This thesis was not simply about performing qualitative and quantitative research as two distinct methods, it also deemed their intertwinement as an important area for exploration. For example, one of the most telling parts of this thesis was when a journalist commented that although he/she was not sure how DEBATECITED would affect his/her writing, the fact that his/her peer-journalists were reviewing his/her approach made him/her *feel more confident* about the statements in the article. This was an example of the intertwinement between qualitative and quantitative data. The journalist's confidence level may not be easily quantified by a reader, but it could affect how the journalist chooses to word a statement which, in turn, may affect how accurate the statement is — and scientific accuracy is a quantifiable measure. This thesis therefore ends with a discussion analyzing the intertwinement of the qualitative and quantitative data produced, theoretical considerations suggested from the data, and the limits and strengths of the methods used.

Section 4.2: *Interpretation of Data*

The research problem of this thesis was whether DEBATECITED could improve the accuracy and robustness of the articles produced by journalists. Indeed, controversial scientific topics require comprehensive journalism. Yet, current science journalism has drawn criticism for being incomprehensive (Bubela 2009; Peters et al. 2008). To counter this, this project began an exploration into how to combine the preliminary work produced by science journalists (e.g. from interviews, researched facts, and counter-factuals) so that the different sides of a scientific debate have a greater chance of being represented alongside the context of their scientific validity. The project built on software developed from previous code created by the author, which was advanced here to be more user-friendly, relatively bug-free, secure, and useful to journalists. This initial work found that DEBATECITED was responded to favourably by science journalism students and that they felt it helped their overall articles [Table 3.3.1.3.1].

The students involved in this study indicated that DEBATECITED helped improve their level of knowledge. This echoes the past scholarly work on group concept-mapping schemes in science education, which found it to be an effective learning tool (Ryve 2004). It has also been recently shown that the combination of concept-mapping and web-based learning can help students understand scientific topics (Liu and Wang 2010; Ryve 2004). However, these studies are often aimed at educating children about elementary science. The purpose here was to represent newsworthy scientific debates where the science is not always clear and other fields may need to be drawn from to provide a comprehensive view of the issue. In science journalism, many forms of information need to be shared, and thus DEBATECITED's challenge was to fit them all into a visual diagram. Students in this study were able to fit a maximum of 11 propositions into a concept-map that was used to produce a science journalism story [Table 3.3.1.1.1]. After observing the results from the pilot project on student-journalists, the main question was whether the positive-outcome from the data could be reproduced with a sample of professional science journalists (Table 3.6.1.2.3 shows the parallel of the pilot vs. the trials). The results from the two trials with the professional journalists paralleled the pilot with the student-journalists by maintaining the positive results and keeping them statistically significant. The majority (5 of 6) of the professional journalists confirmed that DEBATECITED increased the number of useful sources of information to draw from for their articles, improved their knowledge on their article's subject, and improved their articles overall. Importantly, the majority said it saved them time. The majority also said that they felt DEBATECITED worked on the weekly deadline this project provided. Finally, one of the most positive feedbacks was when all the participants said they would consider using DEBATECITED again. Together, these results were not only parallel but also highly positive (see Table 3.9.1.1.1); confirming that both the included student journalists and professional journalists felt DEBATECITED was effective.

Furthermore, if we accept that the Science Panel is an independent judge of the accuracy and robustness of articles produced for this particular project, then they were important judges of whether there was a noticeable increase in the accuracy and robustness of stories that used DEBATECITED. There was a correlation between journalists claiming DEBATECITED increased the accuracy and robustness of their stories and the Science Panelists noticing this increase (see Table 3.9.1.1.1). Therefore, it follows that, the Science Panel's results are in internal agreement with the journalist's own judgment that DEBATECITED helped their stories' accuracy and robustness. While the trials conducted here are artificial in comparison to the normal work of a science journalist, the results nevertheless suggest that online concept-mapping in combination with peer-collaboration is a useful line of scholarly inquiry to pursue further.

One possible criticism of DEBATECITED is whether articles may become homogenous if all the journalists are drawing from the same map. However, it was clear in both trials that journalists had produced topics coming from a variety of angles. It may also have been the case that journalists purposely distinguished their articles after observing what other journalists were covering. As one member of the Science Panel mentioned, the diversity in writing was surprising given that they were all provided the same raw information materials. Perhaps, homogeneity is a criticism that is more characteristic of the wire-services and PR releases that journalists currently rely heavily on. Future studies may be interested in comparing whether DEBATECITED can increase diversity due to its incorporation of multiple journalism voices. By not relying on a single PR piece as the guiding voice, DEBATECITED may allow many voices of discourse to be observed, considered, and taken.

The imposed structure of DEBATECITED forced the journalists to input data by laying out the main points to their future articles and by using the maps to organize their citations. The journalists collaborated with each other on top of this structure by helping each other's maps grow both horizontally and vertically [Figure 3.6.1.1 and Table 3.6.1.2.3]. They did so by contributing concepts and citations to each other's maps. These contributed concepts proved to be useful because they reappeared as concepts in the final articles produced (see Appendix 1 in comparison to Appendix 2). In other words, the journalists incorporated concepts into their articles that were contributed to them by other journalists [Table 3.6.1.2.3]. Had these journalists not collaborated by sharing maps, these same concepts may not have been placed in their articles.

One element provided by DebateCited deserves more focus: concepts that were in disagreement (i.e negation). When one journalist would mark one concept as a "disagreement" with a concept made by the original author of the article, it was found that the original author would adjust their main point so that it would be more *accurate* or provide more *context* (thereby expanding on its robustness) [Figure 3.6.1.2, Table 3.6.1.2.3]. While some may argue that this element is redundant since editors should be serving part of this function (Bubela 2009), it is clear that the increasing complexity of modern scientific debates (Bubela 2009; Dunwoody 2008; Dunwoody, 1982; Dunwoody, 1980) and the recalcitrant nature of various criticisms of the quality of science journalism (Bubela 2009) require fresh solutions to these challenges.

DebateCited forms one of the few tested solutions for these issues. With this in mind, I now turn to a 1) final consideration of some of the wider theoretical points surrounding the use of DebateCited in this thesis, 2) with reference to building future studies, 3) before discussing the strengths and limits, and 4) then providing a final conclusion.

Section 4.3: *Analysis of Opening Journalism's System of Production*

This project drew on different methods for opening up the process of creating journalism. Thereby, to the author's mind, the reported potential of DebateCited opens up various areas to consider in terms of systems of production that are worthy of note for future work.

First, alternative systems of production that affect the current shifts occurring in the balance between quality-journalism vs. time and cost (Witschge et al. 2009) should be explored to see whether better outcomes could be reached. The current structural strategy being adopted in journalism is the increasing trend towards outsourcing steps in journalism production and relying on wired services (Witschge et al. 2009). Two main criticisms against outsourcing and wired-services are 1) alienation from the product and 2) a declined quality in journalism (Witschge et al. 2009). An alternative to outsourcing provided by DebateCited is open-sourcing certain steps in journalism production. It is a rational consideration in terms of exploring alternative structures to the current structures being adopted because it addresses the two criticisms of outsourcing. The first criticism may be addressed by open-source journalism because, in lieu of the type of alienation associated with outsourcing, this thesis found open-source journalism is more likely to invoke a sense of community — as was mentioned by participants on DEBATECITED (see Table 3.7.1.1.3). The second criticism of outsourcing was addressed by open-sourcing because using the DEBATECITED method was found to help strengthen an article's accuracy and robustness, thereby the newspaper's quality.

While the appeal of outsourcing is that it is low cost, it comes with the risk of low quality journalism. This problem is an old one. In the 1920s when Walter Lippmann criticized the wired-services, he argued the traditional solution, good *investigative* journalism, is quite costly (Lippmann 1922) — this applies to good science journalism. However, today we have an alternative solution to consider where part of the *investigation* in journalism is magnified: open-source journalism. At its optimum, open-source implies peer-review by a larger intelligent mass of *volunteers*. Most of the participants felt DEBATECITED saved them time (4 of the 6 participants), all of them (6 of the 6 participants) felt it was an efficient use of time, and, as the Science Panel agreed, most felt it improved the quality of their articles (5 of 6 participants) [Table 3.7.1.1.1]. Therefore, DEBATECITED can 1) combat the journalist's alienation brought from outsourcing and 2) rebuild the quality of journalism — without increasing the production cost since much of it is voluntary. In this context, DEBATECITED holds potential as a new structural strategy, through open-sourcing, that can compete against the increasing trend of structuring journalism to be outsourced and the faults associated with it. Future work would have to compare the quality of the two structures (open-source journalism vs. outsourcing journalism) and weigh it against the time and cost saved in both systems.

Second, new models of participation between journalists themselves and their readers should be explored. Currently, many news organizations allow participation in articles through a commenting system. The comments are often unconstructive due to spam or tangential information (Secko 2009). Nevertheless, within the comment-systems they can still produce 1) useful pieces of information that an article could have used or 2) information that contradicts certain statements made in the article. Furthermore, science journalists are *already* reading and sometimes using relevant information found in the comment sections of their respective articles. It would be in the newspaper's interest to filter better for the thoughtful comments that increase a newspaper's quality from the spam which decrease it. DebateCited was designed to enable the strong points from a comment system to appear prior to the creation of the article and those points have a higher chance of being read by the author due to the high signal-to-noise ratio. Future work could measure how well the mapping-system provided by DebateCited lays out information for a group of journalists and readers. They can do so by comparing it to a second group who shares the information through a traditional commenting system or a forum. In such a scenario, factors such as ease of use and comprehensiveness would be measured and compared between the two groups.

Third, similar to the argument for the second point, new models of participation between journalists and scientists themselves should be explored. There may be valuable input from scientists that can be derived through their review of scientific information and their collaborations. Future studies would investigate whether the scientists add valuable scientific data to a concept-map or whether they confuse non-scientists by adding too much technical detail on information unfit for an article. Furthermore, it should investigate whether the scientists use their knowledge of a topic to educate journalists or simply provide data to support their own biases while withholding contributing data for opposing views.

Fourth, the production-cycle for articles may pose a limitation for DebateCited. Some news stories are expected to be produced daily or even within hours. The Internet's constant real-time access for readers has accelerated this cycle (Deuze 2004). Whether a tool like DebateCited would aid or hinder the production time was only partly investigated in the study and based off the opinions of users rather than being tested. On one hand, a website like DebateCited may decrease the amount of time required to produce an article because it allows for science journalists to access information and sources instantly (i.e. without the need of physical relocation). On the other hand, the requirement to access extra information may be seen as superfluous work. Furthermore, if neither a science journalist nor an editor feels as though an article will lack in robustness there is no inclination to access such a tool. This problematic scenario is parallel to news sources that merely rehash press releases despite the ongoing criticism scholars make against single-sourced forms of journalism. What is important to note is that a variety of forms of production cycles exist — not just with different news sources but also with different sections and types of stories. While certain science stories may require a day to be produced, others could require a week or longer. Because this study allowed the science journalists to produce their articles in a week, it was addressing this particular news-cycle length. Four of the six journalists believed DebateCited could work within a 48-hour deadline. Half of the participants thought DebateCited would work if the publication deadline was within 24-hours. However, the experiment was taken in an artificial setting, and participants were only tested on a weekly news cycle. Future work could alter the time of the cycle to see the effect.

Section 4.4: *Unification of Concept-Maps*

Concept-maps were originally created on paper (Novak and Cañas 2008; Novak 2000; Novak 1984). However, recent research has found that web-based concept-maps are more advantageous than their non-web counterpart (Novak and Cañas 2008). Two of the advantages DebateCited aimed to utilize were that 1) it can be accessed by participants from any computer connected to the Internet (due to its cloud-based system) and 2) participation on the web site is not intended to be performed at a specific time of day (like many traditional experiments with concept-maps) but is more flexible to a user's schedule.

DebateCited retained many of the criteria from Novak's notion of a concept-map (Novak and Cañas 2008; Novak 2000; Novak 1984) except for what Novak called "cross links." Cross links were abandoned for this particular study to provide a more straightforward map for users that would be easier to navigate. User friendliness is important to DebateCited since the concept-map was to be used at an individual's own leisure without aid (i.e. as oppose to concept-map research conducted in classrooms where teachers can provide hands-on support). Furthermore, a straightforward flowchart would be easier to transform into a news article than one with excessive relationships (as is the case with online concept-maps based on theories from Bruno Latour's Actor-Network Theory (Latour 1992)). Propositions, hierarchies, and examples correspond tightly with a common form of making an argument in a newspaper article. A point is made (proposition), a hierarchy of rational statements provides information, and real-world examples are curated to provide context. This project also reintroduces a feature in the concept-map that dates back to Porphyrian's original concept-map: disagreements (or negation). Negation is a significant function. It is a function that makes logical statements more accurate, keeps scientific claims falsifiable, and articles contextualized.

Section 4.5: Why Post-Publication Commenting Systems Alone Will Not Work

To return to the start, this thesis began with the author observing current user actions with science journalism articles online, where further accuracy (i.e. corrections made to an article) and robustness (i.e. the different and complementary sides of a scientific debate) can be found within the comments sections of online journalism articles rather than in the actual article itself. One of the goals of this study was to probe how, on a practical but theoretically informed level, these important contributions could be made prior to the publication of the article.

Currently commenting systems only *list* user input from top to bottom [Figure 4.5.1.1.1]. DEBATECITED required information to be *mapped* out using two means that the majority of current commenting systems do not: 1) it allowed information to be subsumed into a hierarchy of premises based on their value and 2) it bifurcated premises into agreements and disagreements. Part of the problem with current commenting systems is that the technology behind them does not have journalists in mind but are built simply for any type of information to be communicated between various parties regardless of the users' expertise; thus, for journalism production, journalists risk adapting to a system of linear communication that may not be optimal for their line of work.

For example, consider the standard and popular forms of communication taken place on the Internet: Twitter, Facebook, emails, and forums. Their structure can be visualized if we picture a table for data entry, where we have a single column for comments and each row is prepared for a different comment.

User 1	Comment 1
User 2	Comment 2
User 3	Comment 3

Table 4.5.1.1.1: ARRAY OF LINEAR COMMENTING SYSTEM

One repercussion of inputting/outputting and reading/writing in linear chronological formats is that it does not link information based on the *value* of that information. By not organizing information based on the *value* of information, users who are exploring an unknown subject anchor themselves to the first few answers and relate them to the answers that follow, simply because they were chronologically ordered that way. Some systems do allow comments to be given value by having users rate their quality, however a rating is still affected by chronology where a point that was made early may receive more views, and thereby more ratings by other users — as oppose to points which may be equally valid but made much later in the discussion and read less often. The second problem is that current formats do not put significant value on what DEBATE CITED called a "Disagreement." Disagreeing concepts lead to what Karl Popper categorizes as a falsifiable statement that *disagrees* with scientific statements (i.e. that a "statement (a theory, a conjecture) has the status of belonging to the empirical sciences if and only if it is falsifiable" (Popper 1983)). For science journalists this is the contrapositive study that *disagrees* with the validity of other studies and helps to provide context on the validity or value of information being reported.

In the end, the issues with linear commenting systems are also issues that we may risk adapting to (or internalizing) in terms of how journalists think through the complex scientific information needed for accurate and robust science journalism. Thus, if journalists should break from the linear presentation of information, then future studies should find ways to bifurcate the linear information created during journalism production. In DEBATE CITED, bifurcation means that any statement can be forked into two lines where one line leads to a premise which "Agrees" (or possibly affirmation) and a second line would lead to a premise which "Disagrees" (or possibly negation).

Section 4.6: Strengths, Limitations and Future Studies

Sub-Section 4.6.1: STRENGTHS

There were several strengths to this thesis. The first is that it is one of the few studies to empirically test the use of peer collaboration and open-sourcing science journalism to address issues of robustness and accuracy. Second, it also integrated literature on concept-mapping in science education to provide a novel method of producing stories on science journalism. Third, it was designed to use the advancements of Internet technology to streamline the tasks needed for journalists to collaborate together. It adapted existing code to create an online program that journalists could quickly use — and it did so without reported difficulty. Fourth, the study used a mixed-methods approach of accumulating data to gain insight on how the software worked from both a qualitative and quantitative perspective, and involved professional journalists as research participants. The inclusion of professional journalists allowed the testing of DEBATE^CITED in a more realistic fashion, providing initial data on how the program may work in the field. Finally, it was innovative because the thesis included a panel of scientists to rank various journalism articles on their own project. It allowed experts on the details of a science project to judge and rank the accuracy and robustness of the scientific details appearing in articles.

Sub-Section 4.6.2: LIMITATIONS

Despite its success in testing the use of DEBATE^CITED, this thesis has some limitations. First, while the journalists said they would use DEBATE^CITED again, this study was limited to student-journalists and journalists who were 1) enthusiastic about new technology and 2) open to working with others. There is an ongoing scholarly debate on the merits of introducing journalists to new technologies and the benefits of multi-skilling (equipping journalists with multiple tools) as a result of the Internet's potential at converging mediums (Bromley 1998; Deuze 2004; Frith and Meech 2007). The ability of multi-skilling has emerged especially among journalists who wish to compete in the online media (Frith and Meech 2007). Training journalists in multimedia has become increasingly important since the popularization of the Internet (Bromley 1998). Furthermore, Deuze (2003) has found a 'professional identity' is emerging among multimedia journalists. He finds that most journalism schools are developing their students' peer-collaboration and social-networking skills in different mediums to meet current industry demands (Deuze 2004). With this current trend in web training, the author believes this limit, in terms of a learning-curve for working with DEBATE^CITED, could be overcome in future work.

Second, most of the people interested in participating in the study were not highly experienced. Although they all had more than a year of experience in professional journalism, the interest I received from highly experienced science journalists was minimal. Thus, even though the study held positive results for professional journalists, this may not translate directly to highly experienced professional science journalists who have curated their own method of investigation. That stated, many of the problems listed with science journalism seem to be targeted towards lesser-experienced journalists. In *Selling Science* Dorothy Nelkin singles out this experience as the greatest factor influencing article quality (1987). In addition, one should keep in mind that major news outlets, such as CNN, have cut their entire science journalism staff (Amend and Secko 2012); this suggests that journalists with less experience covering science are an important target of investigation for future studies.

Third, the sample sizes of this study were small and therefore only present an initial exploration of how DEBATECITED may function. Further work is needed to expand the sample sizes in terms of numbers and diversity. The most common criticism during the pilot project and both trials was that the participants wish there were more people to interact with. Due to a small budget, the word length for each article was limited to a short 300-500 words. In addition, the results from the Science Panel, numbering only three participants, should be tempered —in terms of how the results may be uniquely tied to their experience and perspectives. Nevertheless, the small sample size did allow for this project to study the journalists' personal work more in depth.

Fourth, although DEBATECITED is an original concept design, this project wanted to adopt point-systems which have already been used for prior concept-map research. This was problematic for a number of reasons: 1) Similar to how a number of different concept-map theories exist, many point systems already exist; 2) there is still an ongoing-debate on the value of point-systems; 3) and as a result, point-systems are still continuously being developed (West 2002). While a point-system may provide some indication that a certain map may be more robust than relative maps created by similar participants, it does not logically follow that this will always be the case. Several point systems were considered and the majority of them based the point system on a 1-point per element system (i.e. 1 point per links, concepts, and hierarchies). Therefore, the point system used only served as an indication of how useful maps were between groups in *this* study.

Fifth, by limiting the panel to scientists only, valuable input from the general public was excluded. This input is valuable because the general public represents the average readers that the articles are intended for. The public's concept of robust information may include data that is not as pressing to the Science Panel, such as where the research funding is being distributed and the political implications of the results. While it is first and foremost important that the *scientific data from the actual scientists* is being reported correctly — since they are the producers of the data — it is equally important to make sure the receivers (i.e. the readers) agree upon the information. If budget and time constraints permitted, a second panel would have been used to represent the general public instead of exclusively scientists. However, having to choose between the two panels, ensuring that the initial scientific data itself was accurately representing the scientists' message was the greater priority.

Conclusion

This thesis aimed to provide a practical solution with empirically verifiable evidence on the potential of open-source formats addressing the criticisms of science journalism. The results support theories on concept-maps as educational tools (Novak and Cañas 2008; Ryve 2004; Markham et al. 1994), the concept of whether science education aids science journalists (Bubela 2009; Bromley 1998), and finally the theories of whether science journalism can be improved systematically (Brainard 2012; Bubela 2009; Brumfiel 2009).

Because there is little scholarly literature on viable solutions to problems faced by science journalism, there is little literature on whether proposed solutions are internally valid at all. To my knowledge, this is one of the few studies to layout a clear causal relationship between what occurs in a journalist's research and the scientific accuracy of the article produced. The students in the pilot project reported that DEBATE^CITED improved their knowledge on the topic of their articles and these results were repeated with the selected professional journalists. Furthermore, the Science Panel reported that most of the articles created with DEBATE^CITED were perceived to be more scientifically accurate and robust. Thus, on a practical level, this project provides a viable alternative research tool for science journalism.

Finally, a value of DEBATE^CITED is the rhetorical concept of providing two or more sides to a story. There is debate on when and how journalists should provide the 'other side' of a story (Tannen 2012). One of the intentions of DEBATE^CITED was to provide an interface that allows journalists to evaluate the different sides of a science topic more efficiently. To measure whether propositions are receiving more than one side of a story, the horizontal growth that occurs within a hierarchical stage can be observed. If a proposition receives several responses (agreements or disagreements) on DEBATE^CITED, then it is more likely to be receiving more than one side to the proposition — especially, if the proposition contains both responses that agree and responses that disagree. The maps produced in this study (see Appendix 2) demonstrated horizontal and vertical growth, and indeed, the hierarchies on DEBATE^CITED are more apparent than on a linear structure such as a comment system.

More importantly, the maps allowed participants to relate direct negations and counterpoints, which in turn, allowed the journalists to read and judge the different sides to each proposition.

DEBATECITED is a work in progress. It forms part of a research direction that is situated at the pinpoint between journalism, education, and online communities. DEBATECITED aims to add to the ongoing scholarly debate on how to help improve accuracy and robustness in science journalism production. However, it does this not by describing or listing a problem, but by seeking to develop a method to address current limitations. DEBATECITED is one attempt that evolved heuristically through testing and is based on how scientific debates can be mapped prior to science journalism production. Signs of improvement presented here are based on whether the participants themselves reported satisfaction with the use of DEBATECITED. The participants found it to be a useful tool in improving their articles. The improvements were also detected by a Science Panel. Overall, the promise of an approach such as DEBATECITED has been demonstrated in this work.

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Appendix 1

Twelve Articles Created by Science Journalists.

Article A

In the battle against climate change and the ever increasing energy demands placed on society, technology has so far risen to the challenge of maintaining the modern way of life through advancements, innovation and ingenuity. That might not always be true however and scientists and engineers are going to need all the help they can get if they are going to continue the fight in the coming decades. That help comes from many sources, one of the more controversial of which is biofuels. Biofuels are both loved and despised due to their combination of noticeable benefits and worrying side effects.

Their benefits are twofold. First, they are renewable, meaning the Earth has a theoretically unlimited supply of them, which trumps the limited supplies of "fossil fuels" civilization currently relies on for most of its energy. Secondly, the crops they are derived from can be grown anywhere there is a suitable climate, making fuel-importing nations less beholden to the countries that happen to sit on top of seas of oil.

However biofuels also have their darker sides. Environmentalists are not particularly keen to the technology, as burning the fuel still emits greenhouse gases which contribute to global warming. Growing the plants that are used to derive biofuels also takes up valuable farm land and exacerbate existing problems caused by modern-day agriculture such as fertilizer runoff, deforestation and water conservation issues.

A new technology developed at Concordia University hopes to alleviate the later of these problems. Scientists there have derived an enzyme that can be used as a catalyst in biofuel creation. This technology could lead to large industrial facilities that can create biofuels without the need for additional farmland or the environmental costs associated with it. Another benefit is where the catalyst comes from. It is derived from mushrooms, which are also a renewable resource with unlimited quantities. Assuming that the research conducted at Concordia continues to improve biofuel production, this alternative fuel source might take its fossil fuel cousin's place at the top of the world's energy markets.

Article B

New studies conducted at Montreal's Concordia University may lead to the development of truly clean biofuels.

Renowned project manager Denis Legault and his team of researchers believe that they are on the cusp of a breakthrough. By analyzing fungal enzymes and their processes, they hope to discover new, genuinely environmentally friendly biofuels with industrial applications.

Biofuels have become the source of controversy among the scientific community in recent years, as it's been suggested that the detrimental environmental effects of the methods typically used to harvest and create them may outweigh the more obvious benefits.

In the process of planting crops for palm oil, for example, large quantities of rainforest have been cleared in Indonesia. This is a key step in producing the world's most prominent biofuel, biodiesel. While the process of clear cutting is environmentally detrimental in itself, removing such large quantities of rainforest increases atmospheric CO_2 levels to a hazardous degree.

Thus, while the general consensus has long been that alternatives to fossil fuels must be found in order to maintain a worldwide environmental balance, ensuring that these alternatives are less environmentally damaging has become a primary focus amongst researchers – Legault in particular.

Earlier this year, a study published in Science magazine determined that examining fungal enzymes may hold an important key in solving these problems. The study, conducted by researchers from 12 different country, concluded that a particular form of fungi known as white rot may have once caused the end of the Earth's 60-million year coal deposition period – in a process very similar to biomass conversion. Harnessing the enzymatic processes behind this development, then, may lead to new methods of biofuel creation. Legault and his team are in the midst of using practices involving molecular biology, genomics, and bioinformatics to approach this challenge.

Relative to other forms of life on Earth, there's still much about fungi that science has yet to examine – the evolutionary relationships between many different species of fungi, for example. The revelation that fungi may hold the key to solving the world's non-financial fuel crises comes at a time when the need for alternative fuel sources is more prominent than ever.

Article C

Canadians consume a lot of energy - nearly three times as much of energy as Italy, who in 2002 ranked last in energy consumption amongst G-8 countries (Canada ranked almost equal with first-place "winner", the U.S.). Energy consumption in Canada is on the rise, and we've seen huge jumps in usage over the last two decades – between 1990 and 2003, Canada's energy consumption increased by 23%. Of the energy consumed in 2010, 41.4% of it came from refined petroleum products, which was up 4.1% from 2009.

With these statistics, it is evident that Canada has a vested interest in finding a new, renewable energy source – which is precisely why a group of committed scientists at Concordia University in Quebec have been researching the production of biofuels.

"Biofuels have two main qualities," says Denis Legault, the Genozymes Project Manager. "First, they are produced with renewable resources, and in theory the raw material can be any biological material containing long sugars, and the current processes [of biofuel production] using grain, should be replaced in the long run. Their second quality is that if we do the chemistry right, the biofuel produced can have a lower overall impact on the environment."

"Wood-decay fungi have been known to be very efficient at transforming biomass," he says, which is how the project began. The scientists would identify, analyze and develop potential enzymes in fungi to use as catalysts to produce biofuels and other plant-based products. Proposed by Adrian Tsang, director of the Centre for Structural and Functional Genomics at Concordia University, the project Genozymes is a coordinated effort of teams across Canada working on fungi culture, including subjects like the extraction of genetic material, cloning and characterizing of potentially interesting enzymes.

The project is currently about halfway finished, and so far the team has adapted or developed the techniques needed by the species the scientists were working on, which until now had very little information available about them. They have found new enzymes, and will be researching in greater detail the more interesting ones.

Legault explains that producing energy from biomass is basically eliminating the material you don't want to use, and then breaking down the remaining cellulose/hemicellulose into smaller chunks, mainly sugar. "The key to success is to do it with the least amount of energy, in the shortest possible time," he says, "and that's what the right enzyme will do for you…[and] the fungi we study are world-class athletes at producing those enzymes."

Presently, biofuels are primarily produced from corn, but if the fungi tests are successful, it will be able to produce enzymes capable of breaking down a diverse range of materials, increasing the capacity of the energy source to be mass-produced.

They are not a new discovery, having been around since the development of the first car. However it is only recently that they have begun to garner attention as a worthy alternative to fossil fuels, and as a result there has been a surge in efforts to improve their development. Five years ago, the Canadian government pledged $1.5 billion between 2007 and 2017 to boost Canada's production.

"With the transportation sector accounting for more than a quarter of Canada's greenhouse gas output, increasing the renewable content in our fuel is going to put a real dent in emissions," said Prime Minister Harper. "Good for the environment and good for farmers, our government's investment in biofuels is a double win."

Although biofuels have a lot of potential, some studies suggest they cause much more environmental degradation than they reduce (including water depletion, land conversion, nitrogen runoff and habitat loss), and aren't the best direction for alternative energy.

Legault notes that the biggest problems with the energy source at this time are limiting the impact of biomass harvesting on the environment, and producing biofuels in a cost-efficient manner with a price low enough to be competitive with fossil fuels.

Because biofuels presently cause environmental concerns and still emit greenhouse gases, as they are produced from carbon, they have received significant criticism suggesting they are not the best way forward. Research is also being done into other sources of alternative energy, like hydrogen or nuclear energy, both of which do not produce greenhouse gases – excluding them from restrictions placed as a result of the Kyoto protocol or carbon taxes.

In order for biofuels to be the way of the future, scientists like the group at Concordia will have to continue researching new ways to make them more attractive – increasing sustainability, decreasing cost and ensuring there will be easy access to supply.

The ideal form of energy will be when it is "produced with renewable material, yet not produced at the expense of more noble purposes (food production, for example)," says Legault, "while having no harmful impact on the environment."

Article D

Scientists at Concordia are playing a key role in the 18 million dollar national Genozymes Project. The research and discoveries made at the university will contribute significantly to the knowledge base of fungal genomics, and could potentially have sustainability-focussed industrial applications, including making biofuel a more viable commodity in the future.

At present, petroleum dominates the fuel market in part due to the lower cost of extracting it compared to biofuels. By finding the most efficient fungal enzymes, scientists may be able greatly lower the cost of biofuel production. From his office at Concordia, Project Manager Denis Legault explains that the project is focussed on the genetic makeup of 30 different fungi species. After testing and reproducing the "most promising enzymes," scientists begin application testing.

As well as pure knowledge building, there are three possible applications for the enzyme research. All applications are based on enhancing sustainability in different industries. Researchers investigating pulp and paper are exploring enzyme-based ways to bleach paper, which could result in eliminating some of the harmful chemicals that are currently used. The other two applications deal directly with corn and grain. In Lethbridge, fungal enzymes could be used to improve cattle feed, and lessen dependence on grain to raise cattle. The enzymes can also be used as catalysts in the transformation of biomass into biofuels.

Currently, corn is overwhelmingly used to create ethanol fuel as an alternative or additive to fossil fuel. According to Legault, “other things of more value can be done with corn ... we are pushing towards using less noble biological materials such as what we call biomass.” Biomass, he explains, “has little value right now and it could be used to give extra value to pulp and paper, and would allow us to not use grain.” Biomass includes things like byproducts of wood cutting. According to Legault, this research will certainly result in concrete scientific knowledge contributions for Canada. The four-year project is currently at its halfway point.

Article E

Scientists at Concordia University in Montreal have embarked upon a project identifying fungi enzymes it hopes will help make biofuel production more competitive and sustainable.

The project, being carried out at the Centre for Structural and Functional Genomics, is focused on identifying enzymes in 30 species of fungus and the ways they work in breaking down natural matter, such as wood and plant materials, into components that may have industrial uses in biofuel production, among other applications.

Project lead Denis Legault says the project will attempt to reproduce the enzymes, and determine their benefits in industry, such as in cattle feed improvement, the pulp and paper industry, and the “holy grail”, improved efficiency in biofuel production.

Biofuels are derived from biological matter, often plants, wood and corn. They’re also a potentially lucrative replacement for fossil fuels. In 2010, biofuel production reached its highest ever levels of 105 billion litres, up 17 percent from the previous year, according to sustainability think tank Worldwatch Institute.

“Our long term goal,” says Legault, “if we’re really successful, is to find the tools that make producing biofuels more competitive.” He says we already know how to produce biofuels, but the big issue is price – at the moment it’s simply cheaper to use petroleum. “It’s like the choice between making your own jam or buying it off the shelf. We buy it off the shelf now, but it’s better in the long run to produce our own.”

The Concordia team is also looking to develop benchmarks of sustainability for biofuels production. “The footprint should be non-existent. That’s the benchmark,” says Legault. “But the realistic approach is to compare with what we are doing now. Our goal is really to come up with measurable improvements [over fossil fuel production’].”

The production of biofuels has come in for criticism from environmental NGOs like Oxfam, which calculated in 2008 that biofuels policies have pushed people into poverty by contributing to food price spikes. The organization said the rising price of fuel pushes farmers to change crops from food production to fuel production, thereby reducing the food supply.

Legault says the project tests on presently unused material and that in theory anything containing cellulose could be used for conversion. “We are working on transforming material that is right now not used for anything. Unless we move to a much larger scale, for the short term, the impact is very close to zero.

Article F

A considerable North American biorefining industry has blossomed in recent years – albeit somewhat outside of the public lens. Thanks in part to the security provided by government-mandated minimum requirements for both ethanol and biodiesel components blended within conventional, fossil fuel-derived transportation fuels, Canada has become a player in this industry. This should not come as any great surprise, as Canada produces an abundance of the raw materials that ethanol and biodiesel are derived from – primarily corn, canola, wheat, 'yellow grease' from the fast food industry, and by-products of livestock production, known as tallow.

While there are currently over thirty biorefineries operating in Canada – with nearly equal numbers producing ethanol and biodiesel, neither of these processes is considered the necessary silver bullet in catalyzing the shift away from fossil fuel-powered transportation. Ethanol production is intertwined within an ethical debate that touches on nearly every aspect of both social & environmental sustainability. Biodiesel, on the other hand, relies on the by-products of industrial livestock production, canola, and perhaps the least sustainable practice as far as human health is concerned – conventional fast-food production. The continued success and proliferation of industrial scale livestock production – and thus biodiesel from its by-products - is widely accepted as presenting significant long-term sustainability challenges on its own.

It is within this framework that Montreal's Concordia University conducts the Genozymes, or 'fungal genomics' research project. Despite the proliferation of biorefineries in Canada, according to information from Genozymes itself, "no commercial-scale cellulose-based operation yet exists in Canada." Cellulose-based fuels, derived from materials such as grass and wood chips, are estimated as having potential to replace one-third of the United States' transportation fuels.

In essence, the work of the Genozymes project seeks to be a catalyst itself – by researching the potential of fungal catalysts for the development of next-generation commercial biofuel-producing facilities, with a focus on cellulose-based inputs. Such processes would circumvent many of the most pressing environmental and social hurdles that burden ethanol and biodiesel production. Indeed, the project includes a considerable team of researchers, the GE3LS, devoted to evaluating the "related environmental, ethical, economic, legal, and social issues" involved in this process.

Key amongst the questions that must be answered for this industry that exists only conceptually, on any large scale is the economic question. As explained by Purdue University's Wallace E. Tyner, "we do not know by how much the cost of producing cellulose based biofuels can be reduced nor over what time period that can happen."

Article G

Scientists at Concordia are playing a key role in the 18-million dollar national Genozymes Project, which could lead to advancements in the field of biofuels. The research and discoveries made at the university will contribute significantly to the knowledge base of fungal genomics. Scientists will test enzymes that could help solve the food versus fuel debate that plagues first-generation biofuel production.

Second-generation biofuels have been touted by scientists and the media to address some of the problems with first-generation biofuels, especially their potential to raise food prices due to competition for crop land. These new biofuels are instead manufactured from biomass, or agricultural residue. The enzymes that Concordia scientists are testing would act as a catalyst in breaking down biomass.

From his office at Concordia, Genozymes Project Manager Denis Legault explains that biomass is comprised of "less noble biological materials ... you can define biomass as anything that contains cellulose, for example byproducts of wood cutting." Unlike materials used for first-generation biofuels, Legault explains that we could use "stuff that has little value right now ... [which] would allow us to not use grain."

According to the International Energy Agency, there are still concerns over land use for biofuels, but use of biomass and agricultural residue should lead to higher energy yields than if land is used solely for food-to-fuel crops. Biomass can also be produced from poorer quality land.

Another concern with second-generation biofuel viability is price, says Legault. Finding what Legault calls the "gold nuggets," or most efficient enzymes that can quickly break down biomass, is Concordia's role at present.

The IEA predicts that second-gen biofuels will be a long-term investment, not fully realized for another decade or two. According to Legault, "in order to justify switching from what is done now to something else, we have to be much better [in terms of enzyme efficiency], and that's the last step for us to be a complete success."

Article G

A considerable North American biorefining industry has blossomed in recent years – albeit somewhat under-the-radar. Thanks in part to the security provided by government-mandated requirements for both ethanol and biodiesel components blended within conventional, fossil fuel-derived transportation fuels, Canada has become a player in this industry. This should not come as any great surprise, as Canada produces an abundance of the raw materials that ethanol and biodiesel are derived from – primarily corn, canola, wheat, 'yellow grease' from the fast food industry, and by-products of livestock production, known as tallow.

While there are currently over thirty biorefineries operating in Canada - nearly equal numbers produce ethanol and biodiesel - neither of these processes is considered the necessary silver bullet in catalyzing the shift away from fossil fuel-powered transportation. Ethanol production is intertwined within an ethical debate that touches on nearly every aspect of both social & environmental sustainability, while biodiesel relies on by-products of industrial livestock production, canola, and perhaps the least sustainable practice as far as human health is concerned – conventional fast-food production. The continued proliferation of industrial scale livestock production – and thus biodiesel from its by-products - is widely accepted as presenting significant long-term sustainability challenges.

It is within this framework that Montreal's Concordia University conducts the Genozymes, or 'fungal genomics' research project, pursuing what is considered by many to be an antidote to the fossil-fuel based transportation quagmire our infrastructure currently locks us into. Despite the proliferation of biorefineries in Canada, according to information from Genozymes itself, "no commercial-scale cellulose-based operation yet exists in Canada." Cellulose-based fuels, derived from materials such as grass, and residuals of both the agricultural and forestry industries, are estimated as having potential to replace one-third of the United States' transportation fuels – but at what cost is still very much to be determined.

The work of the Genozymes project seeks to be a catalyst – by researching the potential of fungal catalysts, themselves, for the development of next-generation commercial biofuel-producing facilities, with a focus on cellulose-based inputs. Such processes have potential to circumvent many of the environmental and social justice hurdles that burden ethanol and biodiesel production – in particular the competition of first-generation energy crops with food crops. Indeed, the Genozymes project includes a considerable team of researchers devoted to evaluating the "related environmental, ethical, economic, legal, and social issues" involved in this process. However, there are still myriad concerns to be addressed before these third-generation biofuels can be deemed sustainable. Will the large-scale collection and refining of agricultural residues lead to diminished soil quality? Will demand for forest residue endanger biomass-loaded rainforests?

Among the many questions that must be answered for this industry that exists only conceptually, on any large scale, is the economic feasibility question. Oxfam, the UN's FAO, and the World Bank have each expressed doubt that this industry will not be financially sustainable, or make any significant contribution before 2018-20. As explained by Purdue University's Wallace E. Tyner, "we do not know by how much the cost of producing cellulose based biofuels can be reduced nor over what time period that can happen."

Article D

Biofuels have come under fire from all quarters recently, with charges that, despite large governmental subsidies in the US and EU, instead of promised reductions in greenhouse gases, unforeseen consequences have seen deforestation in the Amazon quickened, failed promises of greenhouse gas reductions, and poverty in the developing world increased. The so-called second-generation of biofuels, relying more on the by-products of existing processes rather than the establishment of specialist crops to produce them, have been widely hailed as a cure-all for the problems raised by the first generation.

Where first-generation biofuels are produced largely from crops, like corn, that double as food and are fairly energy intensive to produce, second-generation biofuels are those that rely on "residual" matter from forestry and farming. Ralph Sims is a Professor of Sustainable Energy at Massey University, and a lead author for Working Group III of the Intergovernmental Panel on Climate Change (IPCC) – the lead international scientific body on climate change. Professor Sims says residual material is that "left on the ground" after the primary product, timber or grain for example, has been extracted. In this sense, second-gen biofuels need not compete with existing food crops and, due to a lack of necessary cultivation, has the potential to deliver true reductions in greenhouse gas emissions.

However, environmental organizations, like Oxfam, are still cautious. In a 2008 briefing paper entitled "Another inconvenient truth", the NGO cautioned that, "just because a second-generation biofuel does not use food as a feedstock, it does not necessarily mean that it does not threaten food security: it may still compete with food for land, water, and other agricultural inputs."

Sims is similarly cautious. He maintains policy-makers need to carefully develop policies to promote second-generation biofuels, taking into account myriad unforeseen circumstances. The US' biofuels mandate saw farmers switch from soya bean production to corn, and Sims says, in a roundabout way, these policies helped contribute to Amazon rainforest deforestation. "It's not the US causing the deforestation, but the policy to encourage ethanol production from corn resulted in an indirect land use change in Brazil" – where most of the soya production moved to – he says. Even with biofuel produced with farming and forestry residuals, he points out that removing such biomass results in a removal of nutrients from the soil – which requires a nutrient replacement programme to be implemented, and potentially driving up greenhouse gas emissions.

Despite the obvious advantages of second-generation biofuels, estimates put large-scale production out 20-30 years. Research underway at Concordia University in Montreal aims to identify and isolate fungal enzymes at play in conversion of biomass to fuel, but there's no word as to whether the research could be commercially applied in the near future.

Article J

A dedicated group of scientists out of Concordia University have been working hard to research effective methods of harnessing biofuels. The Genozymes Project is about halfway complete, and has the researchers identifying, analyzing and developing potential enzymes in fungi that will potentially be used as catalysts to produce this alternative energy source.

Although biofuels have been heralded has the future for sustainable energy, critics have raised concerns about the benefits received over the environmental costs. They have been known to cause water depletion, land conversion, nitrogen runoff and habitat loss. Perhaps one of the greatest arguments against the use of biofuels is land conversion, because, as biofuels are currently primarily produced from corn, fields previously used for food production are converted into fields for biofuel production.

One of the aims of the study at Concordia is to "limit the impact of biomass harvesting on the environment," says Denis Legault, manager for the Genozymes Project.

However, the Concordia study might enable us to move away from what are referred to as first generation biofuels, or biofuels produced directly from food crops. With the assistance of a fungal enzyme, second generation biiofuels could become more commonplace. These second generation products come from the inedible parts of a plant – the leaves and husks for example – but so far it has been difficult to use them as an energy source because there hasn't been a commonplace ability to break down the more complex compounds, like lignin.

"Producing sugar from biomass boils down to getting rid of the material you don't want to use, most likely lignin," says Legault, "and breaking the remaining cellulose/hemicellulose into similar chunks, namely sugar. The key to success is to do it with the least amount of energy, in the shortest possible amount of time. And that's what the right enzyme will do for you."

Using inedible parts of plants as energy not only makes the process more environmentally sustainable but also assists in reducing the cost of biofuels, making them more competitive to fossil fuels. However, second generation biofuels have faced their own controversy, as concerns have been raised about land competition, their feasibility and the economic and technological barriers that would be incurred as a result of using an energy source that the infrastructure does not currently exist for.

The International Energy Agency, a subsidiary of the OECD, released a report in 2008 that stated, "Many of the problems associated with first generation biofuels can be addressed by the production of biofuels manufactured from agricultural and forest residues and from non-food crop feedstocks."

It pointed out that even if there was land competition between fields for biofuel production and food, second generation biofuels would likely be able to use poorer quality land, alleviating the problem.

"These second generation biofuels are relatively immature so they have should have good potential for cost reductions and increased production efficiency levels as more experience is gained…" said the report. "However, major technical and economic hurdles are still to be faced before they can be widely deployed."

The goal of the Genozyme Project is to enable efficient usage of less-valuable materials like mulch, instead of crops like corn. If the team is successful, we will be able to use fungi to produce energy, and it will be a huge step for the usage of second generation biofuels. For although they have significant problems attached to them presently, with the right technological advancements they will become the viable alternative energy source for the future.

Article K

Researchers are on the cusp of creating new practical, "second generation" biofuels, but the wait until these technologies can be actively implemented may be longer than expected.
First-generation biofuels (to the public: simply "biofuels") have seen minor success in the energy market in the past decade. Traditionally, these thermo-chemical fuels have been seen is beneficial to the environment long-term, but have sometimes come at the cost of the sustainability of the respective eco-systems that they are harvested from.

Second-generation biofuels (or "advanced" biofuels) would theoretically be harvested from biomass, which could mean anything from decay resulting from other harvesting processes or crop residue – the product left on the ground after the extraction of other, unrelated crops. The key difference between first and second-generation biofuels, viewed under this light, is that the first comes at the cost of eco-damaging processes, and the other uses pre-existing processes to its advantage.

The second-generation process would hypothetically eliminate the controversy concerning biofuels as a whole, but research is a naturally slow procedure. Denis Legault and his team of researchers at Montreal's Concordia are among Canada's premier scientists leading the charge towards practical biofuels – using fungal enzymes as a jumping point. Legault believes that fungal decay, which is incidentally a result of the harvest of grains and timbers worldwide, may hold the key to unlocking a long-term biofuel solution that is genuinely sustainable.

The approach is somewhat unique in the field, as a focus on the fungal aspect of existing (man-made) decay processes is a relatively recent idea. Should Legault's initial findings prove infeasible, both fungal study and the notion of second-generation biofuels are wide enough avenues that his team will have a great deal of unexplored options to consider. However, the clear hurdle to reaching these goals is finding financial support from a sector that may have already given up on the idea.

Article L

Biofuels are becoming an increasingly important element in the mix of rich-world fuel sources. However, they, like all sources of fuel, have disadvantages. One major concern in using biofuels is the replacement of staple food crops. If farmland is used to grow corn for ethanol production rather than for livestock feed, the supply of food will drop and prices will rise. To counteract this economic inevitability, researchers are developing a set of "Second Generation" biofuels that don't directly use potential food as a source. These technologies could lead to a long-term future for biofuels alongside other alternative energy resources without a drastic increase in food prices.

The technologies center around the creation alternative energy fuels such as what is commonly known as "syngas", or synthesis gas, which can then be run through a procedure, such as the "Fischer-Tropsch" process to produce liquid fuels for use in transportation and power generation. Currently, there are two main methods used to create these alternative fuels. These are known as gasification and pyrolysis. Importantly, both of these techniques can use bio-waste, such as agricultural residues and used cooking oil, instead of crops that could otherwise be used as food.

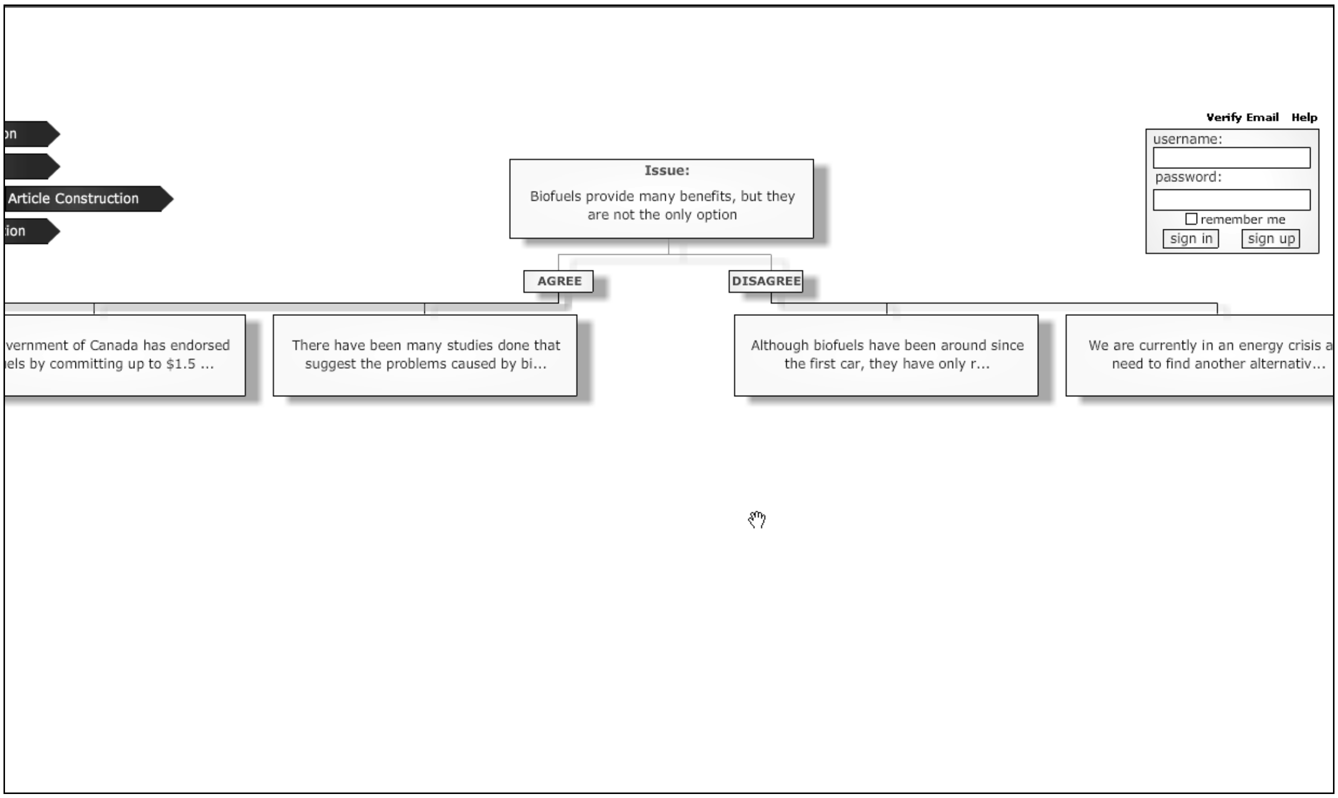
Gasification is the more exotic of the two technologies. It involves heating the waste material to around 700°C in the presence of a small amount of oxygen or steam. Critically, the process is not allowed to combust and the gaseous mixture that results from the high-temperature chemical reactions is syngas. This offers a better alternative to burning the material directly as a source of fuel because syngas can be burnt in different environments, including in fuel cells and existing gas engines.

Pyrolysis is the more often used process and is commonly used in the commercial world to produce charcoal and polyvinyl chloride (PVC). In fact, some scientists believe it is the process that is responsible for turning fossils into fossil fuels in the first place. It involves heating organic material to high temperatures without the presence of oxygen, which results in a substance known as “bio-oil” which is similar to synthetic diesel fuel.

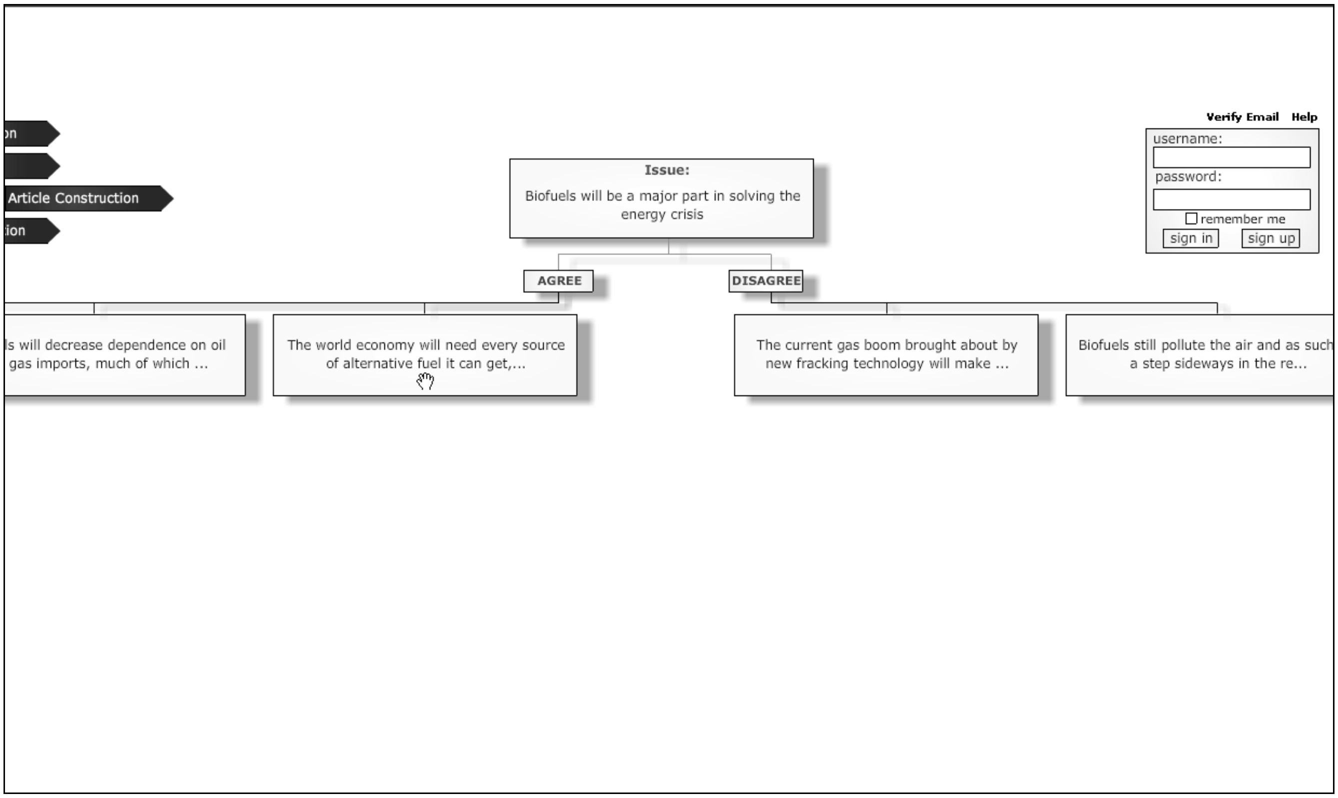
While commercialization of both techniques is already underway, these technologies still fall prey to some other downsides of biofuels including increased cost and carbon dioxide production. However, by eliminating the competition with food, Second Generation biofuel technologies could help the alternative fuel become a standard bearer of the alternative energy movement.

Appendix II

Example Maps Created by Journalists. Because the maps expand to a size much larger than this page allows, only partial representations can be shown.



Map 1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Article Construction
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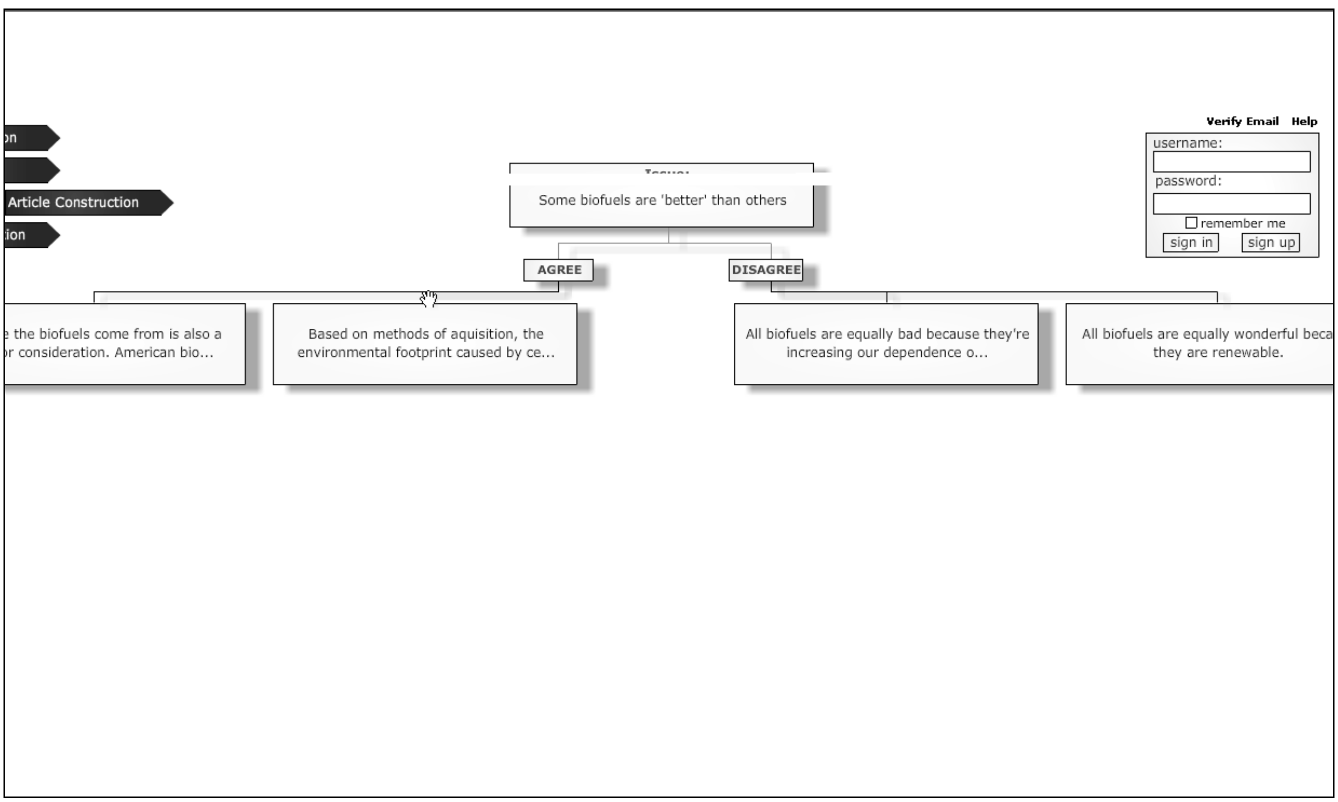
Issue:
Biofuels will be a major part in solving the energy crisis
AGREE
DISAGREE
ls will decrease dependence on oil gas imports, much of which ...
The world economy will need every source of alternative fuel it can get,...
The current gas boom brought about by new fracking technology will make ...
Biofuels still pollute the air and as such a step sideways in the re...

Map 2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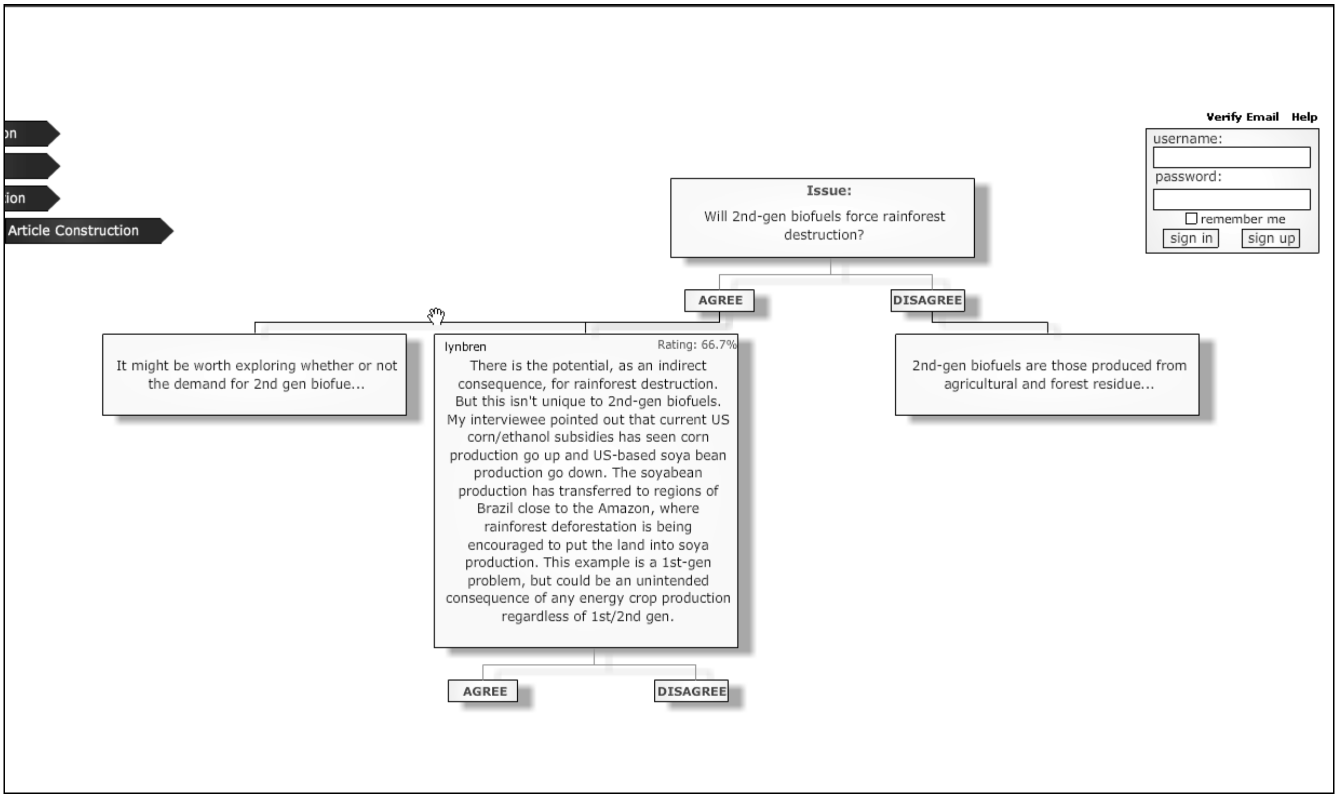
Some biofuels are 'better' than others
AGREE
DISAGREE
the biofuels come from is also a r consideration. American bio...
Based on methods of aquisition, the environmental footprint caused by ce...
All biofuels are equally bad because they're increasing our dependence o...
All biofuels are equally wonderful beca they are renewable.

Map 3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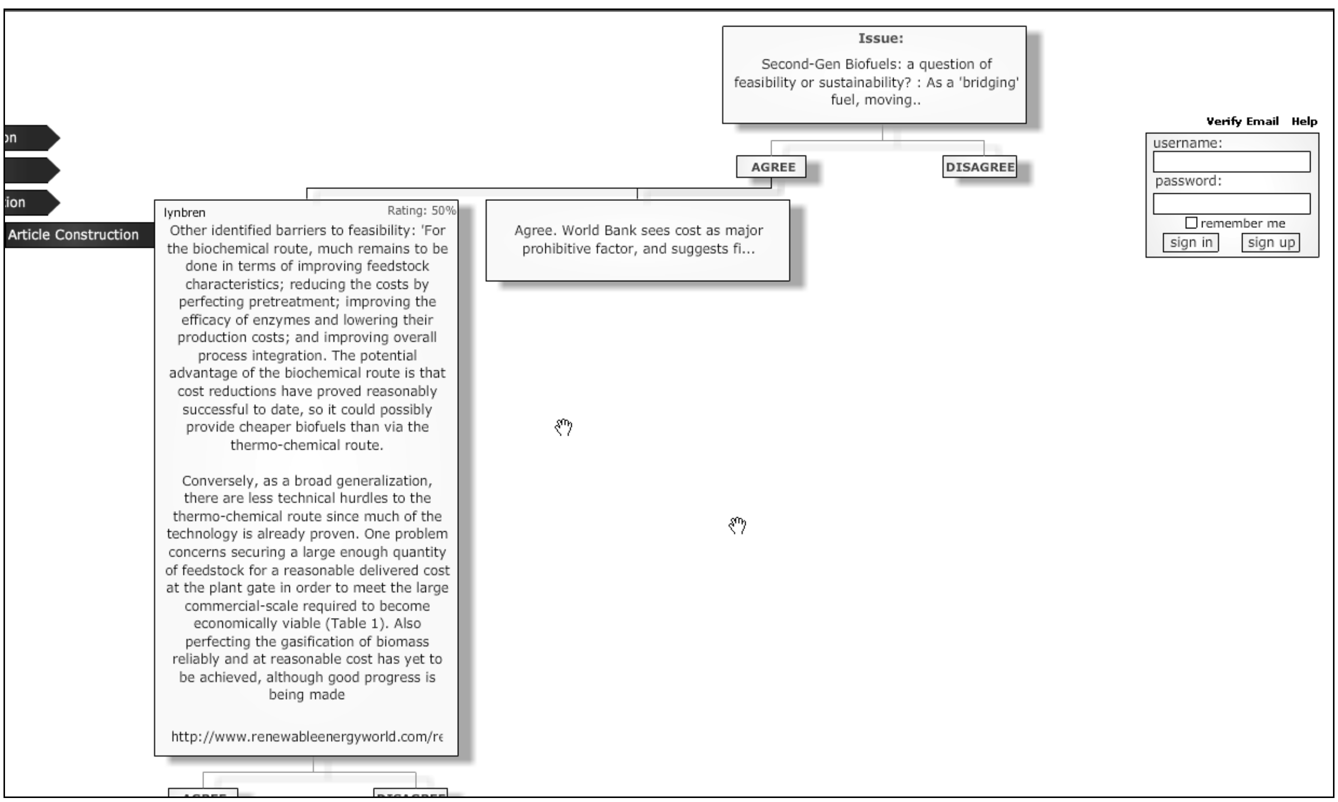
Article Construction
Issue:
Will 2nd-gen biofuels force rainforest destruction?
AGREE
DISAGREE
It might be worth exploring whether or not the demand for 2nd gen biofue...
lynbren
Rating: 66.7%
There is the potential, as an indirect consequence, for rainforest destruction. But this isn't unique to 2nd-gen biofuels. My interviewee pointed out that current US corn/ethanol subsidies has seen corn production go up and US-based soya bean production go down. The soyabean production has transferred to regions of Brazil close to the Amazon, where rainforest deforestation is being encouraged to put the land into soya production. This example is a 1st-gen problem, but could be an unintended consequence of any energy crop production regardless of 1st/2nd gen.
2nd-gen biofuels are those produced from agricultural and forest residue...
AGREE
DISAGREE

Map 4


Issue:
Second-Gen Biofuels: a question of feasibility or sustainability? : As a 'bridging' fuel, moving..
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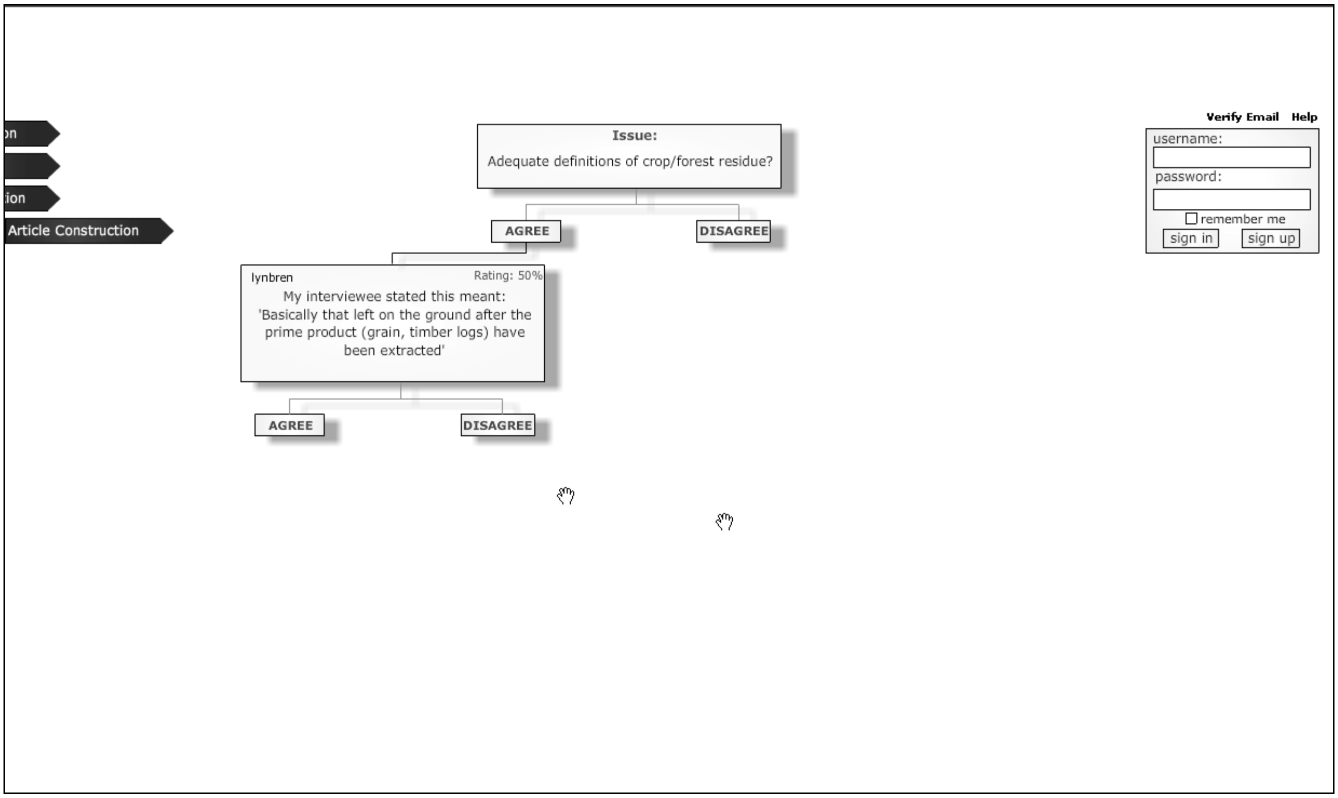
Article Construction
AGREE
DISAGREE
lynbren
Rating: 50%
Other identified barriers to feasibility: 'For the biochemical route, much remains to be done in terms of improving feedstock characteristics; reducing the costs by perfecting pretreatment; improving the efficacy of enzymes and lowering their production costs; and improving overall process integration. The potential advantage of the biochemical route is that cost reductions have proved reasonably successful to date, so it could possibly provide cheaper biofuels than via the thermo-chemical route.
Conversely, as a broad generalization, there are less technical hurdles to the thermo-chemical route since much of the technology is already proven. One problem concerns securing a large enough quantity of feedstock for a reasonable delivered cost at the plant gate in order to meet the large commercial-scale required to become economically viable (Table 1). Also perfecting the gasification of biomass reliably and at reasonable cost has yet to be achieved, although good progress is being made
http://www.renewableenergyworld.com/re
Agree. World Bank sees cost as major prohibitive factor, and suggests fi...

Map 5


on
ion
Article Construction
Issue:
Adequate definitions of crop/forest residue?
AGREE
DISAGREE
lynbren
Rating: 50%
My interviewee stated this meant: 'Basically that left on the ground after the prime product (grain, timber logs) have been extracted'
AGREE
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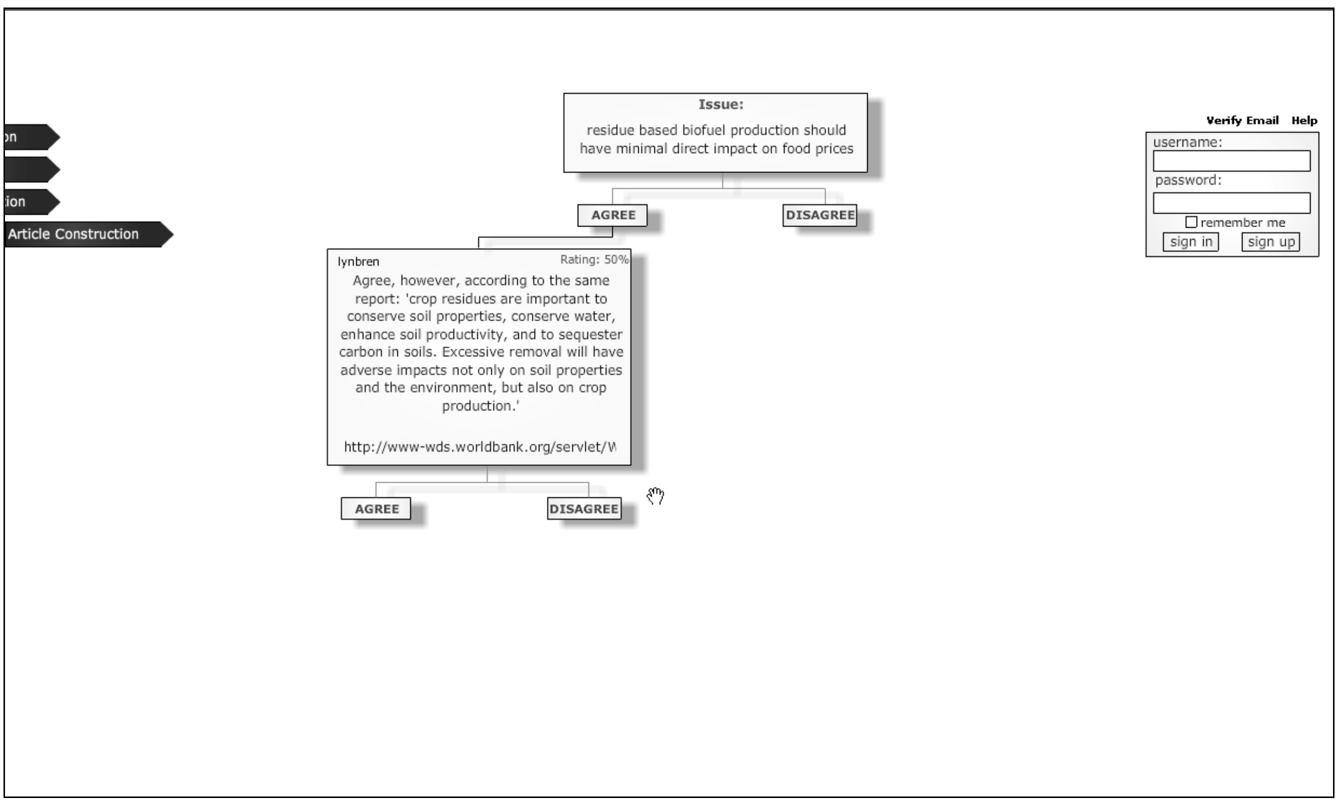
Map 6


on
ion
Article Construction
Issue:
residue based biofuel production should have minimal direct impact on food prices
AGREE
DISAGREE
lynbren
Rating: 50%
Agree, however, according to the same report: 'crop residues are important to conserve soil properties, conserve water, enhance soil productivity, and to sequester carbon in soils. Excessive removal will have adverse impacts not only on soil properties and the environment, but also on crop production.'
http://www-wds.worldbank.org/servlet/W
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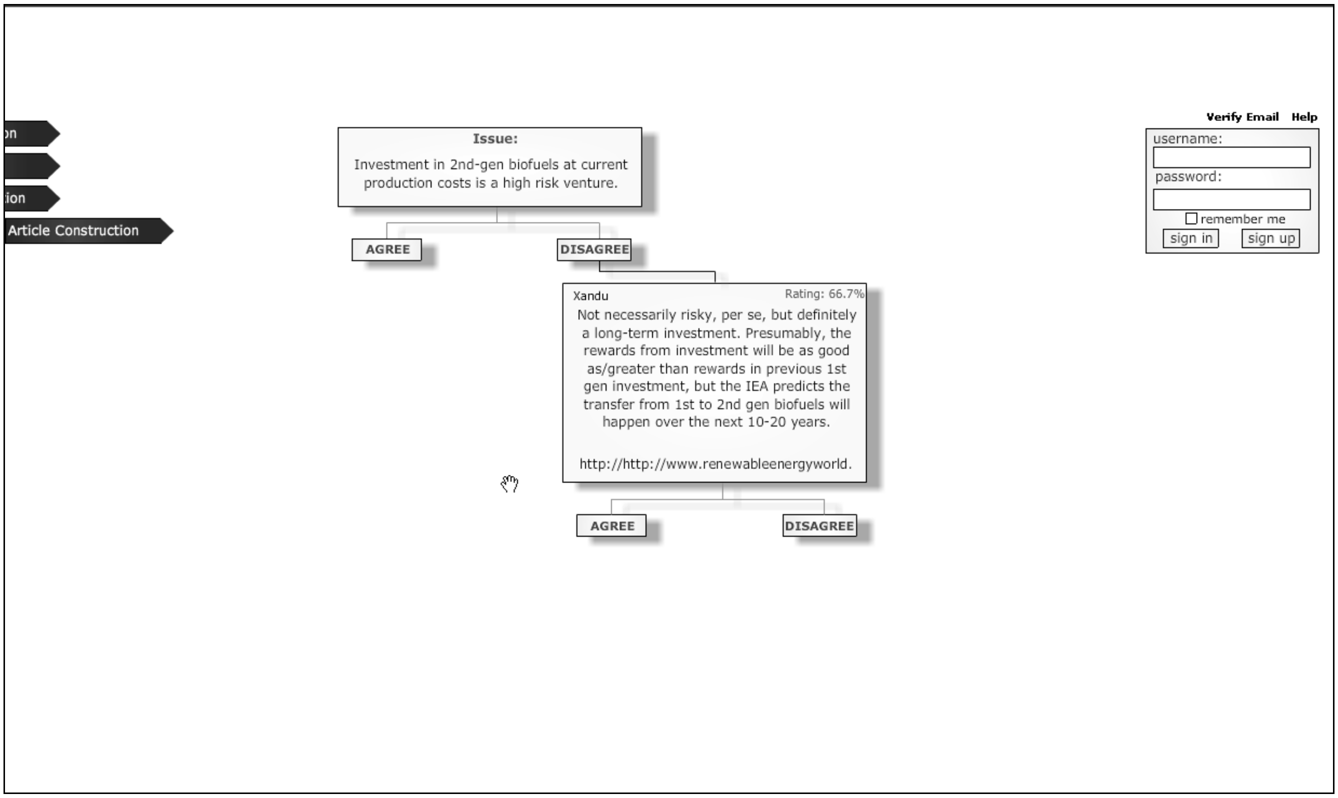
Map 7



Article Construction
Issue:
Investment in 2nd-gen biofuels at current production costs is a high risk venture.
AGREE
DISAGREE
Xandu
Rating: 66.7%
Not necessarily risky, per se, but definitely a long-term investment. Presumably, the rewards from investment will be as good as/greater than rewards in previous 1st gen investment, but the IEA predicts the transfer from 1st to 2nd gen biofuels will happen over the next 10-20 years.
http://http://www.renewableenergyworld.
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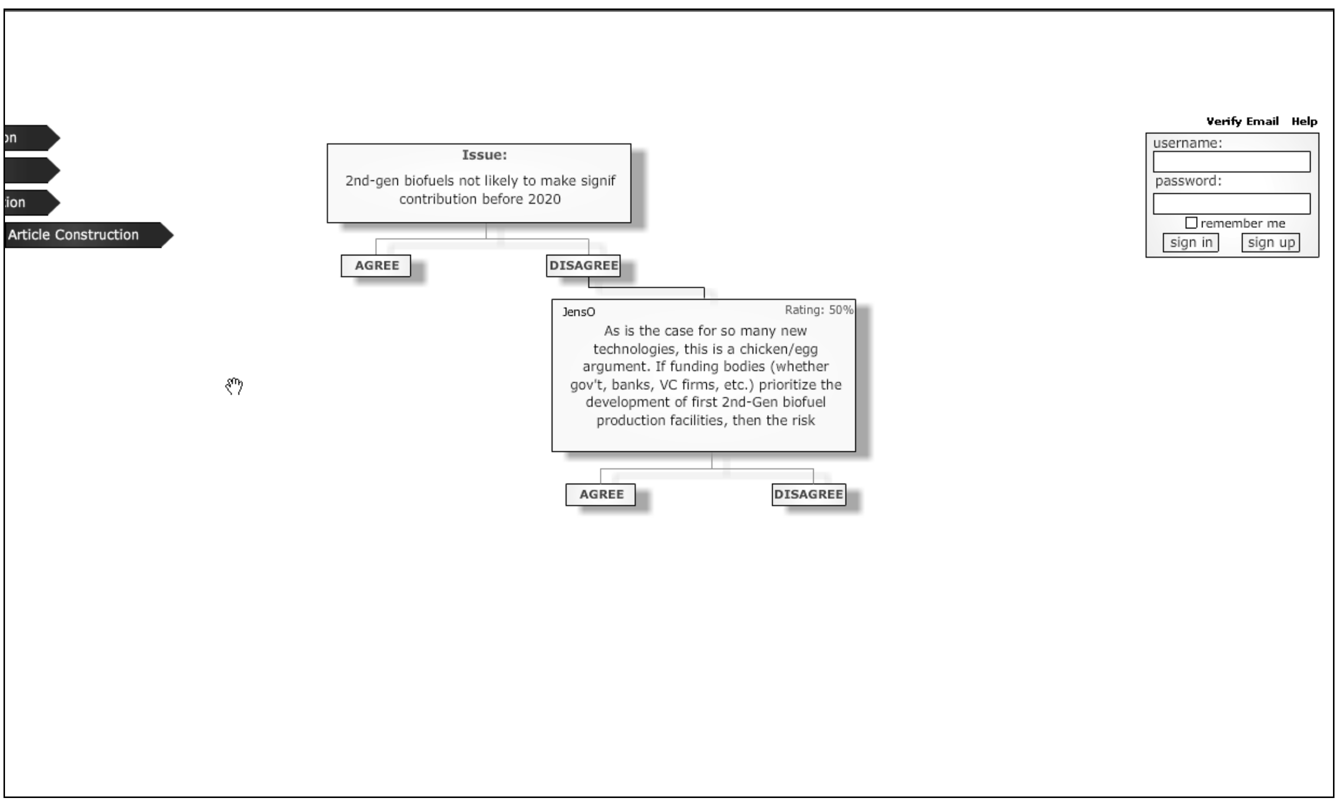
Map 8



Article Construction
Issue:
2nd-gen biofuels not likely to make signif contribution before 2020
AGREE
DISAGREE
JensO
Rating: 50%
As is the case for so many new technologies, this is a chicken/egg argument. If funding bodies (whether gov't, banks, VC firms, etc.) prioritize the development of first 2nd-Gen biofuel production facilities, then the risk
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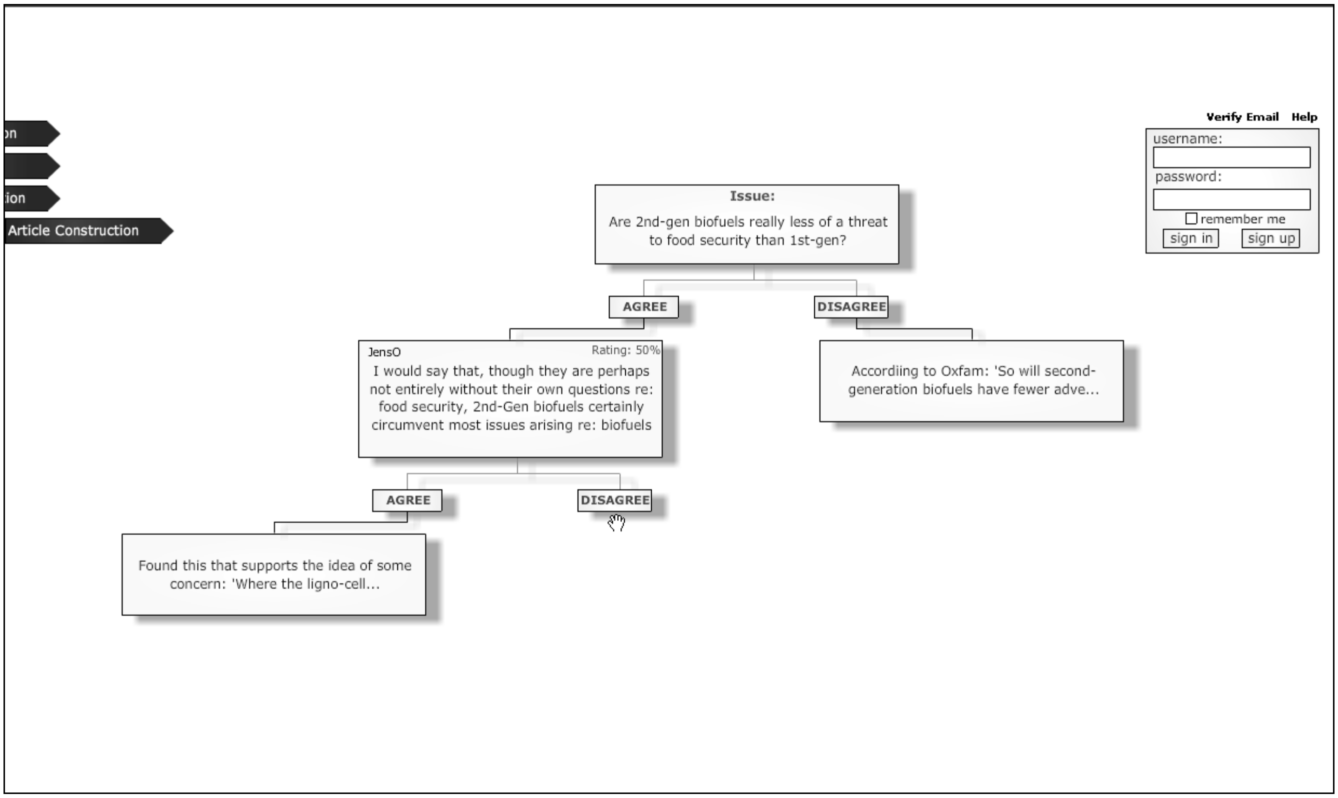
Map 9



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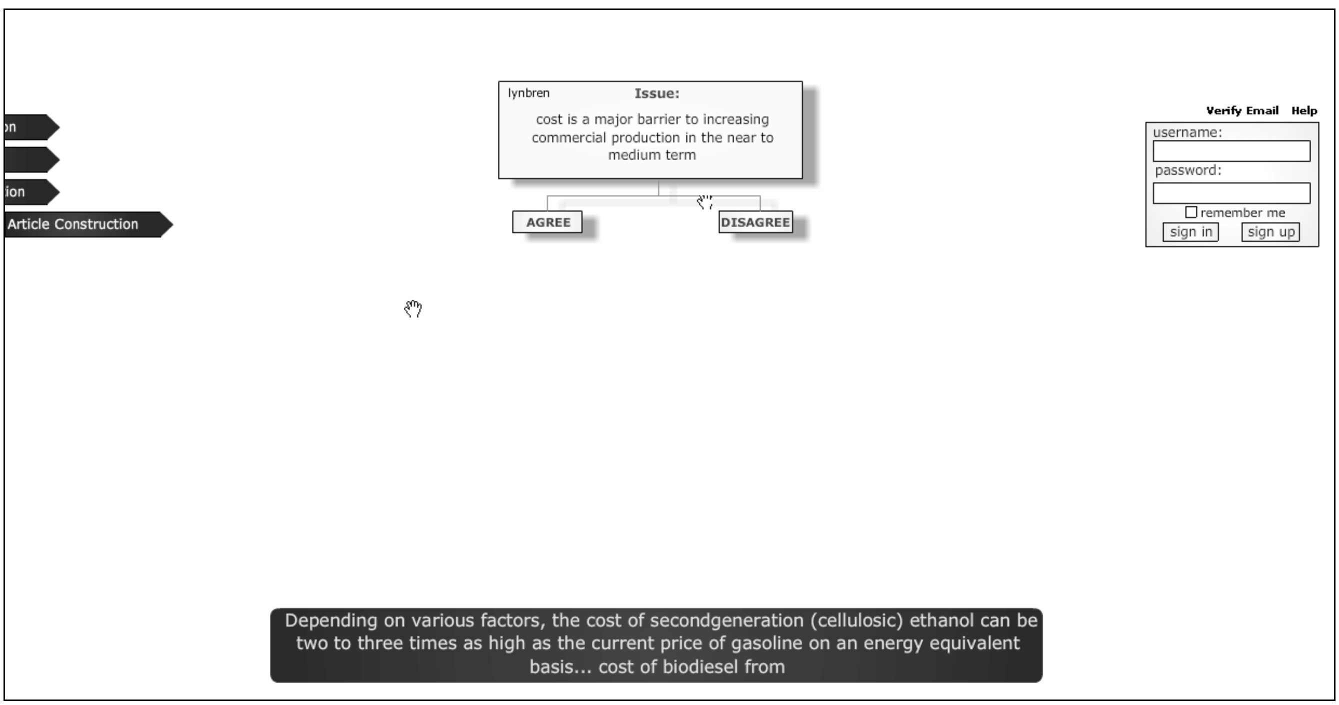
Issue:
Are 2nd-gen biofuels really less of a threat to food security than 1st-gen?
AGREE
DISAGREE
JensO
Rating: 50%
I would say that, though they are perhaps not entirely without their own questions re: food security, 2nd-Gen biofuels certainly circumvent most issues arising re: biofuels
Accordiing to Oxfam: 'So will second-generation biofuels have fewer adve...
AGREE
DISAGREE
Found this that supports the idea of some concern: 'Where the ligno-cell...

Map 10



on
ion
Article Construction
lynbren
Issue:
cost is a major barrier to increasing commercial production in the near to medium term
AGREE
DISAGREE
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sign up
Depending on various factors, the cost of secondgeneration (cellulosic) ethanol can be two to three times as high as the current price of gasoline on an energy equivalent basis... cost of biodiesel from

Map 11