Navigating the Complexity of Socio-scientific Controversies—How Students Make Multiple Voices Present in Discourse

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Abstract In this article, we argue that students' unfolding discourse on socio-scientific issues (SSI) can be fruitfully analyzed by using dialogical theories of language and communication (Bakhtin 1986; Linell 2009). While research in science education often reports on how individual reasoning changes when bringing SSI into the classroom, we argue for the relevance of analyzing *how the individual is “in dialogue” with present as well as remote interlocutors and contexts on the internet*. We suggest that the analytical approach is particularly sensitized to illuminate how students' handle multiple perspectives. A dialogical perspective takes as its premise that SSI are part of society, where politicians, interest groups, and scientists engage in debates and offer perspectives that are often in conflict. Rather than assuming that *the individual student* is the primary unit for analysis, a dialogical approach is premised on an analysis that incorporates several perspectives and voices—a multivocality that also resides with the individual. Arguing for the relevance of this analytical approach to studies of SSI in the classroom, we analyze a group of students in upper secondary school as they discuss hydraulic fracturing after having worked with online data. The results illuminate how students discursively manage multivocality and multimodality inherent in the following SSI online. We describe a set of discursive means that the students use to handle the many perspectives involved when communicating about the issue. In addition, we describe and articulate what kind of communicative competences that are involved and, hence, could be cultivated through education, when engaging in public debates.

Keywords Socio-scientific issues · Controversial issues · Video analysis · Dialogism · Communicative skills

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Introduction

This study aims to contribute to our understanding of how upper secondary school science students handle uncertainties and differences of opinion regarding issues generated by techno-scientific innovations as they are performed on the Internet. Techno-scientific innovations such as genetically modified organisms, hydraulic fracturing (fracking), and vaccines have opened up new possibilities. At the same time, however, such innovations have also drawn public attention to their uncertainties and limitations yielding dilemmas and controversies that are becoming increasingly present in people's everyday lives (Irwin and Michael 2003). While many technological innovations may be helping to make a better future, the emergence of risks, ethical concerns, and environmental problems also reminds us of potential dangers. For example, fracking, a process for extracting natural gas that has been previously difficult to reach, has prompted environmental concerns like contamination of drinking water supplies. Such issues, which we here refer to as *socio-scientific controversies*, are often identified as being in need of serious attention through different forms of expertise and public deliberation in a democratic society, making them particularly relevant for educative purposes in a broader sense. Educators can thus play an important role by attending to socio-scientific controversies and by arranging activities where students are invited to explore and discuss them in all their complexity, including differences of opinion, otherness, and plurality (Biesta 2007). Access to information about socio-scientific controversies has increased dramatically in the last few decades with the introduction of internet access to classrooms, and many educators are attuned to creating space for students to discuss these kinds of dilemmas. Still our understanding of what it implies for students to navigate their way through such complex issues online is insufficient (Klosterman et al. 2012). This in turn renders it difficult not only to evaluate how students manage to grasp such issues but also to understand what it means—in more general terms—to engage in deliberations based on the unfiltered masses of information available online.

Within the field of science education, there has been sustained interest in better preparing students to engage in discourses and decisions related to societal dilemmas and controversies; first in the area of Science-Technology-Society (STS) instruction (Aikenhead 1985; Solomon and Aikenhead 1994) and, more recently, in relation to the socio-scientific issue (SSI) movement (Kolst 2001; Sadler 2011; Zeidler et al. 2005). This interest is supported by the recognition that students need to learn skills that allow them to uncover how particular knowledge claims may serve the interests of different claimants, suggesting that if students are to take other points of view into account in developing their own positions on issues, they will be encouraged to unravel the interplay of interests that underlie these other points of view (Geddis 1991). Research in socio-scientific issues has traditionally focused on individual decision-making (Bencze and Alsop 2014), aiming to develop responsible citizens capable of applying scientific knowledge and habits of mind such as acquiring skepticism, maintaining open-mindedness, evoking critical thinking, recognizing multiple forms of inquiry, accepting ambiguity, and searching for data-driven knowledge (Zeidler et al. 2003). Although the notion of scientific literacy has been described as a property of collective situations within interactions that cannot be reduced to the properties of individuals (Roth and Barton 2004; Roth and Lee 2002), the majority of the research conducted to date reports on how individual students engaging with SSI develop aspects of scientific literacy. For example, studies have reported on the improvement of individual students' conceptual understanding of science (Zohar and Nemet 2002), their informal reasoning skills

](Sadler and Zeidler 2005), and their understanding of the nature of science (Lederman, Antink, and Bartos 2014). Across studies, the dominant analytical framework for evaluating student argumentation has been Toulmin's model (Nielsen 2013a). This model has been applied by investigating student and teacher use of the argumentation elements such as data, warrant, qualifiers, and rebuttals to back claims (Dawson and Venville 2010; Erduran et al. 2005; Osborne et al. 2004; von Aufschnaiter et al. 2008). Sadler et al. (2007) interviewed students who had engaged with SSI and identified four interrelated competencies or *reasoning aspects* they considered to be important: recognizing the inherent complexity of SSI, examining issues from multiple perspectives, appreciating that SSI are subject to ongoing inquiry, and exhibiting skepticism when presented potentially biased information. As advocates for SSI, Sadler et al. (2007) accordingly identified what they consider to be tangible learning gains from their educational programs and also provided ways for teachers to assess students' socio-scientific reasoning through an ordinal scale from 1 to 4 for each of the four reasoning aspects. Levels for the reasoning aspect *examining issues from multiple perspectives* had the following rubrics: 1—fails to carefully examine the issue, 2—assesses the issue from a single perspective, 3—can examine a unique perspective when asked to do so, 4—assesses the issue from multiple perspectives without having been asked to do so.

In this article, we aim to contribute to earlier work by adopting a dialogical approach (Grossen 2010; Linell 1998, 2009) that offers particular benefits for gaining insight into the kind of competence that examining issues from multiple perspectives entails. An essential part of the methods for teaching about socio-scientific issues concerns introducing students to multiple perspectives (Kahn and Zeidler 2016). Since students are expected to learn how to participate in dialogue about ongoing socio-scientific controversies as citizens in a democratic society, we have taken into account one of the most prominent arenas where such public debates take place—the internet. The internet has become the dominant medium through which the public, including science students, access knowledge and information in all areas and disciplines (Hodson 2011). As students turn to the internet, the debates they follow take place in a mixed stream of website genres, modalities, and differences of opinion (Lemke 2006). A challenge for students is to navigate their way through vast amounts of disparate positions, voices, claims, arguments, insights, and experiences. In order to tackle problems associated with the increasingly complex and interconnected nature of socio-scientific controversies online, digital mapping tools have been developed for their analysis¹ (Venturini 2010a, b; Venturini and Latour 2010). In our empirical case, they provide the meditational means for the students to discover and display the many actors and perspectives involved in a socio-scientific controversy, in a condensed and readable form.

While the introduction of SSI in schools has typically emphasized the exploration and appropriation of different scientific forms of reasoning and attention to ethical considerations to support individual decision-making (Sadler 2011; Nielsen 2013a, b), the engagement with controversy mapping provides alternative routes to engage with socio-scientific issues. The aim of the latter is to train students in exploring and visualizing socio-scientific controversies online through the use of these digital tools (Venturini 2010a, b).

¹ Algorithms and traditional statistical techniques help locate important points in the data gathered online, which are then visualized as networks. These networks then function as instruments of exploration and navigation (i.e., maps) intended to guide the reader through the territories (i.e., issues) that they represent, but they also invite our imagination to see and explore the digital world in different ways.

While the introduction of controversy mapping in school calls for empirical studies of how these digital tools may occasion, constrain, and support student learning about socio-scientific issues, this is *not* our aim in this article. Our aim is to contribute with an analytical approach that provides means to understand how students engage in dialogue where multiple perspectives and modalities are salient and how they handle the discursive complexities this entails. We do so by adopting a dialogical approach (Grossen 2010; Linell 1998, 2009) to students' interactions, where the perspective of *the other* is seen as an inherent feature of an utterance and where the complexity of voices within single utterances has been theorized (Bakhtin 1981; Vološinov 1973). The perspective allows for investigation of how the individual is "in dialogue" with interlocutors and contexts, both situationally and socio-culturally, and how utterances of individuals are co-authored through the voices of others. We argue that such a perspective is beneficial for understanding how students handle the multiple perspectives inherent in SSI in the classroom, since, in society, a range of stakeholders create tensions that make these issues salient in the public eye. The dialogical approach we adopt conceptualizes the individual as infused by the inherent tensions of such debates, rather than reduce the analysis to the individual level of scientific reasoning.

We will further delimit our focus to specifically consider how students' interactions are both enabled and constrained through the mediational means (Wertsch 1998) they have at their disposal. Empirically, this means that we examine the ways in which the spoken and written discourse of others are drawn on among the students in the situated activity. Thus, we investigate how students navigate the discursive complexity of an issue through dialogue, making multiple voices present in their discourse.

A Dialogical Approach to Analyzing Multiple Perspectives in SSI

From a Bakhtinian perspective (1981), an inherent feature of any discourse (written or spoken) is that it is dialogical. This means that an utterance is always oriented to what has already been said by others and simultaneously formulated in anticipation of some kind of response. While it is crafted to make relevant certain meaning potentials in the unfolding of dialogue, its concrete sense is inevitably shaped by its response—it is other-oriented and other-dependent. Any issue may accordingly be seen as potentially characterized by multi-voicedness and tension, even so when embedded within a professional genre or an established point of view on the world.² Debates about controversies that are conducted through a mixed stream of multimedia resources and genres (such as those examined by the students in this study) are in this context seen as unfolding over time (Vološinov 1973). Analyses of how students engage in dialogue *about* them need to focus on their joint discursive activity in situ as it is achieved within the school context. As students engage in making sense of a controversy together, their utterances will be oriented to their fellow students in situ, in anticipation of active responsive understanding, while containing elements of previous utterances and disputes from the debate online, thus echoing voices uttered by other people in other places and at different times. For students to be able to deal with controversies as *hot issues* (Baker et al. 2013), they accordingly need to carefully manage *the traces of others' voices* in their own discourse, so that they are not at risk of being held accountable for someone else's claims.

² Scientific discourse and practices as a "canonized" genre reflect a certain interpretation of the world and, in this sense, reduce the multi-voicedness and heteroglossia of discourse

Voice as Perspectives on an Issue

Debates on controversial issues involve intense struggle between different stances and interests and involve several voices. Interlocutors who *talk about* controversies to make sense of them and explain them to others (like our students) are in dialogue both in the immediate environment and with other contexts, and their utterances are largely reconstructions of the voices of other individuals or groups. While an utterance may incorporate several perspectives, opinions, stances, and voices, some forms of discourse attempt to hold one and only one perspective on its topic. Such attempts are conceptualized as one-voiced or mono-perspectival (some scientific texts for instance belong here). Individuals' utterances may thus host many voices; some are more personal while others rely on social languages associated with a type of activity or genre. This gives relevance to two main notions of voice as a perspective on a topic: one is the notion of a generalized voice and perspective on a topic that is tied to the social language of a particular group, such as scientists or environmentalists. The other draws on several different voices, whether these voices are taken from other individuals or they are generalized voices. One perspective on an issue can accordingly be voiced by many persons, and one person can house several perspectives: hence, there is no 1:1 correspondence between person and voice if we talk of voice in the sense of perspective on a topic or issue (Linell 2009).

When speakers more or less openly use other's ideas, positions, and utterances, another analytical notion becomes relevant, the notion of *reported speech* (Vološinov 1973). Individuals' contributions to a conversation can involve references to or quotes from other people's utterances, and even dialogues between different voices can be embedded. However, as Vološinov (1973) reminds us, reported speech involves drawing on others' words while shaping them for one's own purposes. This *double-voiced* quality (Vološinov 1973) makes reported speech an interesting site for analysis. For instance, a speaker may use quoted utterances from other people for his or her own purposes while at the same time attributing them to somebody else. There are also subtle and intricate ways in which speakers can *comment* on the utterances they report, for instance by adopting a slightly ironic tone, while simultaneously appearing to simply reproduce them. In our analysis, we will show examples of how students draw on the ideas, opinions, and perspectives attributed to other people to bring in multiple perspectives and complexity of the issue. In the following section, we will briefly describe the context of our study and the activity we have been analyzing.

Controversy Mapping and Project Work in a Science Classroom: the Empirical Setting

The data we use in this article was collected in a grade 11 class in a natural science program where students worked with controversy mapping as part of a three-week-long school project concerned with science-in-society. The aim of the school project, as formulated by the teachers, was for students to develop an ability to assess different types of information sources, be able to distinguish between scientific and non-scientific claims, understand how science and the development of society both affect and are affected by each other, recognize the role of science in questions concerning how sustainable development issues are mutually influenced and influence each other, and recognize the role of science in sustainable development issues. These aims are in line with the notion of scientific literacy which is stressed in science

curricula all over the world (e.g., Roberts 2007), and closely follow the requirements set in the curriculum for Swedish upper secondary school.³

Prior to the start of the instructional unit, students were informed about the research project and most of them agreed to be video recorded through all the lessons. The teachers formed the five groups out of which one consisted of students that did not want to be video recorded. The students' project was initiated by the authors and collaboratively developed by teachers from upper secondary school together with researchers in education and science studies, along with a pedagogical developer focused on the integration of *information technologies* (IT). Working with SSI calls for cross-disciplinary projects (Levinson 2001) since the relevant science regarding these issues is complex, multidisciplinary, emerging, and contested. In addition, they encompass multiple ethical, social, economic, legal, and political dimensions. Coming from the subject areas of English, Physics, Swedish, and Biology, the four teachers involved in this study were used to working together in cross-disciplinary projects on sustainable development that matched the interests of our research. They used a unit of lessons normally allocated for a sustainable development project in grade 11 for the unit in this study. Each teacher had between 15 and 30 years of teaching experience with one teacher acting as the link between the school and the research team. This teacher was supported by their school principal and was allocated worktime for engaging in initiatives such as the one described here. During a period of six months, the teachers and researchers had monthly meetings to plan the unit and coordinate in terms of our different goals. This included, for example, finding appropriate controversies to work with since certain controversies were deemed inappropriate for digital mapping. Some controversies were judged not to be active enough online to produce usable maps while others, such as marijuana use, were deemed by teachers to be unsuitable for the particular school setting. Following this selection process, it was decided that the students would work in groups of four to six on either genetically modified organisms (GMO) or hydraulic fracturing (fracking).

At the start of the students' project, the teachers introduced the unit and gave the students information about the project including goals for what they were expected to achieve (see [Appendix 2](#)). This involved an introduction to the task:

Examine a controversy through a method called controversy mapping, not by finding one answer but examining different perspectives and actors within the area.

The purpose of the project was coupled to goals described in the curriculum such as developing skills for evaluating different types of information sources, differentiating claims as to whether they have scientific on non-scientific support, and illustrating the role of science in sustainable development. A document with how students would be evaluated and what was needed to achieve different grade levels was also provided. Finally, the notion of socio-scientific controversies was introduced by a researcher and the digital mapping tools were introduced and their use supported by the pedagogical developer (through 1–3 below). Following this hour-long introduction, students started working according to the following procedure:

³ The Swedish curriculum states that all students should be able to critically examine and assess what they hear and read in order to be able to discuss and take a view on different issues concerning life and values. They should be informed about international cooperation and global relationships and able to assess events from national to global perspectives. They should also be able to observe and analyze the interaction between people in their surroundings from the perspective of sustainable development and use modern technology as a tool in the search for knowledge, communication, creativity, and learning (The Swedish National Agency for Education).

1. Surfing and scraping the internet on one controversial issue. The program Navicrawler⁴ used in this process collects the URL of all the webpages visited and also adds information to locate all the files, databases, etc. that are linked to each visited website, 8 h.
2. Selecting (sorting out) relevant data produced with Navicrawler and importing it to Gephi,⁵ 2 h.
3. Re-presenting the data in visual form using Gephi (generating a digital map of “actors” involved in the controversy), 11 h.
4. Sharing and discussing the map with 12th grade peers (the activity analyzed here), 1.5 hour.

To prepare for this task, the students were given instructions to write a report addressing the following questions:

“The purpose of your research is to get a broad picture of the controversy in question. When you have your map, you are supposed to analyze it with regard to the following questions: What ‘sides’ are present in the controversy? Who are the stakeholders? What is their respective position in relation to each other? What connections are there between them? What arguments do you find on the different ‘sides’? What are these arguments based on? What interests do the stakeholders have?”

5. Preparing for a press conference by focusing on the different actors’ arguments, 8 h.
6. Participating in a press conference by enacting a specific actor in the controversy. While the term *press conference* was used in the project, the activity was in practice more reminiscent of a hearing of the type one might associate with legislative, or planning, bodies like councils and parliaments. Hearings provide a forum where opinions on an issue are presented by a variety of witnesses and stakeholders, 1.5 h.
7. Conducting a seminar led by teacher, reflecting on the controversy, and the learning process as a student. On this occasion, the students were asked to give their own opinions on the issue and encouraged to substantiate their claims, 3.5 h (mixed groups).

Throughout the project, the students sat with their groups and worked together to gather information and to make maps. Each student had their own computer to search the internet and to make maps with their group, but assessment of the project was individual. The expectation was that students make use of the time allocated for the project in class, and homework was not assigned. During project class time, at least one, but more often two teachers were present in the classroom. They were available for questions, but also periodically engaged with group discussions and work in progress.

⁴ Navicrawler: <http://webatlas.fr/wp/navicrawler/> is used with Firefox.

⁵ Gephi: <https://gephi.org/>

Visualizing an Issue Using the Digital Tools Gephi and Navicrawler

Gephi is a network graphing tool that can be used when mapping how different websites relate to each other. It displays the connections between sites and the status of a website in relation to a particular issue. To achieve this, one needs to first collect information from websites using a harvesting tool such as Navicrawler. This tool can be used to collect data on websites that are visited while surfing for a particular topic. It gathers information about how websites, files, or databases are connected through hyperlinks in the form of both inbound and outbound links. Visualizations can then be created in Gephi based on the data harvested with Navicrawler. They appear in the form of networks made up of nodes with edges between them. The nodes represent the websites that information has been collected from and the edges show the links between them (illustrative example, Fig. 1).

One way to visualize the status of webpages in the network is to emphasize nodes that have many inbound links. This can be achieved by scaling the nodes based on the number of inbound links so that websites that are linked to by many appear larger in the network. In addition, the program can be instructed to determine the spatial layout of the map based on features such as the quantity of links between websites. Thus, websites that connect to each other through many individual links appear closer to each other on the map, while those that do not, appear farther apart. This combination of properties provides an overview where it is possible to quickly discern the relative weight of the different websites as actors, as well as clusters of actors with many interconnections.

Data Production and Analytical Procedure

The activity of each group was documented using tripod-mounted video cameras positioned to record all the students in each group and with microphones placed on the tables they worked at. To ensure that as much activity as possible was documented, recording began before students entered class and continued until they left. This resulted in 41 hours of video

Fig. 1 An example of a map showing how websites connected to the issue of fracking are connected when visualized through Gephi. The students in this study used the search term *fracking* to produce their maps. The data visualized is based on tracking of the students' visits to approximately 400 websites while exploring the controversy and those connected websites that the visited sites link to. The resulting corpus has over 4000 individual websites or nodes

recordings from each group. The data collected includes dialogue between students as well as time for introduction by the teacher of the task of the day, and even time is for quite searching without interaction. Students were occasionally off-topic for small segments of their total interaction.

After we had followed and documented all the steps in the student project through video, Step 4 of the process *Sharing and discussing the map with peers from 12th grade* was selected for this study. We then selected relevant empirical instances where students discursively handled multiple perspectives on a controversy. In Wegerif's (2007) terminology, you could say this activity formed a *dialogic space*—a situation where two or more perspectives are held together in tension. These interactions were thus identified as opening up dialogical spaces for the students where the complexity of the controversies was discursively managed. Our data consists of video recordings of two groups of 11th grade students in this activity. They were asked to account for their respective controversies (from maps they had recently generated) for the 12th grade students (who had used ordinary search engines to orientate themselves and prepare questions).

Following data collection, the video recordings were time-logged and the recorded activities were analyzed by watching and discussing the video recordings, both independently and as a research group. The entire set of recordings was transcribed at a general level with detailed transcriptions performed once episodes of particular relevance in terms of dialogical spaces had been identified. The transcripts were translated from Swedish into English. A subset of Jefferson (1984) transcription conventions were used (Appendix 1). Analytical observations of students' interactions were made by the first author and brought to joint video seminars for discussion with the rest of the research group. Since the interest was in how students orient to multiple perspectives, excerpts where students identify stakeholders and the claims they make were chosen for closer analysis. For this study, we focused on which stakeholders or voices were brought into the discussion, from where, what they stated, or claimed, how voices within utterances were handled (the speaker's stance), and what the in situ response was. This detailed analysis was guided by orienting to the notion of voice as single- or multi-voiced, generalized voice, or reported speech (double-voiced) (Linell 1998; Myers 1999; Vološinov 1973). The analytical notion of reformulation (Grossen 2010) was used to analyze how the students made use of reported speech. At the operational level, we decided to analyze reformulation with regard to whether the following features were incorporated: (1) a reference to a source (earlier student interaction, webpage, database, other media, etc.); (2) a reformulation marker (i.e., *you told me that*, or *in other words, he said that*, etc.); (3) the reformulation itself; (4) a distance marker. This approach was employed in order to understand how students navigate the discursive complexity of fracking as a socio-scientific controversy through dialogue and how they make multiple voices present in their discourse. In this way, we were able to analyze how they orient to, account for, and handle multiple perspectives in interaction with each other.

Managing Perspectives on Controversies in Student Interactions

We selected the group working with fracking for our analysis in this paper. In the activity, students in grade 11 who had made the map were to share it with students in grade 12 (Fig. 2). The activity started as students oriented to the oral instructions given to them by their teacher. These instructions were to ask questions, explain to each other, and reach a common view of the map they had produced. This activity was also framed by the teacher as a preparation for a

Fig. 2 Group discussion. The students in grade 11, rapporteurs who had made the map (left side of the table), and students in grade 12, inquirers who ask questions (right side of the table)

formally assessed press conference activity to come later, where the 11th graders were expected to adopt the perspectives of various actors in the controversy and the 12th graders were to act as community stakeholders or journalists in attendance. As the students already anticipated the upcoming press conference, parts of the present activity came to resemble an activity type recognizable in society more generally as a hearing, enacted through the discursive roles of inquirers and rapporteurs.

Below, the students from 12th grade are referred to as the *inquirers*, given names beginning with I: Isaac, Isabella, Iris, and Ian.

The students from 11th grade are referred to as the *rapporteurs*, given names beginning with R: Rex, Ringo, Rita, Richard, and Robin.

When examining the group activity in detail, we noted how the printed controversy map functioned as a mediating artifact (Wertsch 2007) that supported the students' discussion by visually stabilizing stakeholders and positions, making them publicly and jointly available for use. It helped to support and sustain their discussion on this complex issue with multiple perspectives available. Since the map was a product of their earlier joint work, the younger students could rely on it as a memory device while acting as rapporteurs, engaged in the controversy of fracking. The map also offered a shared visual space and point of reference that functioned repeatedly to offload students' attention and create some distance from the hot issues at stake. The 11th graders presented the map they had produced by pointing out stakeholders, explaining their arguments, and discussing the reliability of various sites. As

rapporteurs, they found themselves in a position where they were held accountable, having to explain and answer to the inquirers' questions. As we mentioned earlier, parts of the activity came to resemble a kind of hearing simulated for pedagogical purposes. The students engaged in justifying positions, explaining together, evaluating sources, and used the map as a resource for pointing to conflicting versions. Accordingly, the students seemed to establish a space of reflection that made it possible for them to question their own assumptions and submit themselves to the tension of conflicting viewpoints. Within the frame of this activity, we could see that the students engaged in the following *communicative projects*⁶ (Linell 1998):

1. Identifying important stakeholders
2. Bringing out tensions between perspectives
3. Justifying claims with evidence
4. Challenging claims

In the following sections, we briefly describe the first communicative project and examine the remaining three more closely with an analytical focus on how different perspectives and voices in the controversy are managed discursively by the students.

Identifying Important Stakeholders

During the first phase of the discussion, the students engage in a communicative project where major actors in the controversy are identified. This phase is initiated by one of the inquirers orienting to the map and asking “who are the biggest dots? who are the biggest actors?” In response, all the students orient to the map by leaning forward and three of the rapporteurs point out and name the US Environmental Protection Agency (EPA), the Wall Street Journal newspaper, and the documentary film *Gasland*.⁷ When *Gasland* is pointed out as a node on the map, the inquirers note that they have heard of it.

Bringing Out Tensions Between Perspectives

As the conversation continues, *Gasland* is discussed as a well-known actor in the debate on the grounds that the film has been shown on national television in the USA. In comparison to the EPA and Wall Street Journal, however, the film is represented by a relatively small dot on the controversy map indicating that relatively few websites link to it. This initiates a brief discussion of the relative importance of different actors in relation to the size of their nodes on the map. At this point, important conflicting perspectives are introduced into the discussion as the rapporteurs refer to actors who are critical towards the message of the *Gasland* film arguing for its importance in the controversy despite the small size of its dot on the map.

⁶ Here, the students interact to establish a mutually recognized interpretation of different aspects of SSI. The term “communicative” is designed to emphasize that the accomplishment of establishing these interactive projects presupposes the active involvement and shared concern by the interlocutors (traditionally called speaker and listener/recipient/ addressee) and that such an act cannot be reduced to a single speaker's uttering something.

⁷ See www.gaslandthemovie.com. *Gasland* is a 2010 American documentary; the film focuses on communities in the USA affected by fracking. The film was an important mobilizer for the [anti-fracking movement](#).

Excerpt 1

- 102 Rita: but you had like found er there was a page that was really against this film
- 103 Rex: yes ((smiles))
- 104 Rita: that he was just a like a conspiracy theorist-
- 105 Rex: yes exactly =
- 106 Rita: = who was totally wrong
- 107 Rex: uh I even think actually that it was this ((pointing at the map))
- 108 Rita: ((checking the map on her computer))
- 109 Rex: or someone that it links to in some way where there was a politician who had spoken out about this ((looking at the inquirers))
- Gasland the movie and they just cut it down that it was made-up=
- 110 Rita: =yes it was this on Energy in depth ((found it on her computer))
- 111 Rex: yes it is just made-, it is just made-up
- 112 Rita: and that they mean that then those who hate this film they mean that
- 113 Rex: ((smiles and looks at Rita))
- 114 Rita: these environ(h)mental effects ((laughing tone)) are so small that they should not be recognized so that
- 115 Rex: right, so it is better than oil and coal as an energy source ((low and fast voice))
- ((Two omitted turns))
- 118 Iris: did you find any actors who were more neutral or
- 119 Rita: mm ((nods))
- 120 Iris: more fact-based than others?

In *Excerpt 1*, Rita refers to something that Rex told her earlier, that he had read a webpage where someone was strongly opposed to the *Gasland* film (102). Rex confirms that he recognizes the occasion (103, 105) and reformulates the account that had described the *Gasland* film maker as a conspiracy theorist (104) who is totally wrong (106). By referring to an actor who is critical and by reporting statements that position that actor's view of the controversy, Rita opens up a space for incorporating opposing perspectives on the controversy in their discussion. At the same time as arguments against *Gasland* are reported (104–115), the group also locates the critical actor on the printed controversy map (107) identifying the actor as *Energy in Depth* (110), which is the website of an American energy industry lobby association. Here, the interactional use of reported speech is rhetorical, that is, the participants assume

the existence of opposing views and use reported speech to bring out the tensions between views (Myers 2004).

None of the claims made in the *Gasland* film are given voice during the discussion suggesting that they are assumed to be known among the participants. However, in the reformulation of opposing voices, the participants echo claims that characterize *Gasland* as untruthful (111), fracking is better than oil and coal (115), and the environmental impact of fracking is small (114). The rapporteurs reformulate a variety of voices for this task including the specific webpage where opposition to the film is published and a politician expresses disapproval. They also use a form of super-addressee, in Bakhtinian parlance, when referring to critics more generally as people “who hate *Gasland*,” who claim that the data reported in the film are fabricated. In this way, the voices used shift during the students’ conversation, but considered together, they can be seen to represent a generalized view held by supporters of fracking who are critical of the film.

Rita and Rex can be seen to distance themselves from what is reported by holding up claims to scrutiny and implicitly acknowledging that the claims are open for discussion. They use humor as a distance marker (112–114) while subtly evaluating the claims made by the supporters of fracking. At the same time as Rita says “They mean then, those who hate this film, they mean” (112), Rex is smiling and looking at Rita (113) and saying “environmental effects” (114) in a laughing tone. Thus, they implicitly criticize the pro-frackers’ claim that environmental effects are so small that they should not be recognized (114) and that it is better than oil and coal as an energy source (115). Here also, reported speech allows the reporting speakers to distance themselves from the message by positioning themselves as merely reporter, not the source of what is being said. In discussing contested topics, this distancing function of reported speech is especially salient (Myers 2004).

In response to the reported speech from people who dislike the *Gasland* film, portray its creator as a conspiracy theorist, and claim the evidence presented in the film is fabricated, Iris, one of the older students, reintroduces the topic of identifying major actors by calling for the identification of actors that are more neutral or fact-based (118, 120). This initiative invites the inclusion of other perspectives and voices relevant to the controversy. In turns 121 to 127 (not represented in the excerpt), the rapporteurs respond to Iris’ request by identifying a newspaper section, *Business Reporter*, that is presented as an important and neutral actor on the map. They describe how this newspaper section that is distributed as part of the British *Daily Telegraph* gives accounts of relevant perspectives from both sides of the controversy. They note that no evaluative stance is noticeable in the voice of the newspaper and evaluate the actor as providing references to identify opposing perspectives in the controversy. The rapporteurs also explicitly note that there are few neutral actors since they all have a slant towards one side of the controversy or the other.

Justifying Claims with Evidence

Following the discussion of neutrality, Ian re-initiates the conversation about facts that was introduced by Iris in the excerpt above (120) but left unattended by asking for proof for environmental effects. In response, the students turn to the issue of how

claims are justified and distance themselves as they discuss which environmental effects “one” has actually been able to prove. These claims are justified according to sources explicitly demarcated with reformulation markers such as “there are many blogs that link to these news sites address” (134).

Excerpt 2

128 Ian: Which eeh are the environmental effects that one has actually been able to prove?
(3 s)

129 ((all rapporteurs are looking at Richard))

130 Richard: yeah well

131 Rita: ((Exhales audibly))

132 Richard: mm [I guess it is]

133 Rita: [Pennsylvania]

134 Richard: yes one can see quite contaminated water one has (1 s)
uh one sees that the news site has addressed that (.)
there are many blogs that link to these news sites address
most of the environmental problems like contaminated water, for
instance air pollution in neighboring areas to (.) the big plants

135 Isaac: The atmosphere

136 Richard: [yes]

137 Rita: [yes]

138 Rita: but then there is this extreme one, Pennsylv[ania]

139 Ringo: [yes]

140 Rita: what is it alliance-

141 Ringo: yes Pennsylvania cl -[Alliance for Clean Water and air] (looking at Rita)

142 Richard: [it was them who listed] many families

143 Ringo: yes they had sort of a list
of as many pages as you like it only listed names and where they became sick and which symptoms and so on

Confronted with the question of what proof exists, the rapporteurs first pause (129). Their pause suggests some hesitation when it comes to formulating a response. It is plausible that the question is taken as a call for scientific proof; one that could be taken as a challenging invitation to enter into the controversy rather than talking *about* it. The rapporteurs have not encountered any scientific literature so far in their

investigation and so do not have readily identifiable scientific arguments available. There are also few, if any, scientific texts that clearly state if and how fracking causes health problems (Rawlins 2014)⁸. Following the pause, the rapporteurs introduce the voice of a local public interest group, the *Pennsylvania Alliance for Clean Water and Air*, and the newspapers already mentioned earlier (133, 134). Together, Rita, Ringo, and Richard report that the Pennsylvania Alliance (138–141) provides a list of families (142) who have shown symptoms of diseases linked to fracking (143). The question of proof is not only answered by reporting the environmental effects and the health issues associated with fracking (also “Excerpt 3”) but also by identifying actors who report them in terms of which side of the controversy they align with. In this way, the students’ align the arguments and positions reported to the interests of the actors’ voices they reformulate.

The voice of the public interest organization, Pennsylvania Alliance⁹ (“a group of concerned citizens with a goal of protecting the environment from the dangers of fracking”), is first reformulated as an authoritative voice providing proof of effects on the environment. Later, evidence in the form of the voices of the affected local residents is reported through reference to lists on the webpage that shows the nearest fracking facility to a family, what they have been exposed to, and their symptoms. Following this, Richard draws on a previously mentioned voice that has been introduced as neutral, the newspaper that has reported on environmental problems, and shares blogs written by worried and affected citizens (134). The students’ stance towards the voices mentioned in this excerpt is hinted at in (137) where the Pennsylvania Alliance is described as “extreme.” If analyzing this utterance in isolation, it might be possible to assume that the students adopt a negative or critical stance towards these actors through their use of the word “extreme” as a distance marker. However, as this actor is also referenced later in the conversation, we can interpret their stance differently. In the excerpt that follows, the term extreme is used when referring to the fracking impact cases recorded by Pennsylvania Alliance (151). This supports an interpretation of “extreme” in these instances not as denoting the actor as opinionated, but rather as referring to the evidence produced. In the analysis of the next excerpt, we will come back to the relevance of this instance in relation to how students take stances that echo different sides in the controversy.

As the conversation continues, the discussion about substantiating claims by providing evidence as support proceeds. In response to Rita, Richard, and Ringo’s references to environmental effects and claims of diseases reported by Pennsylvania Alliance, Isaac asks how one knows that the reported diseases were caused by fracking.

⁸ It is an ongoing debate whether the chemicals injected or toxins spilled at the surface may contaminate soil or make their way into drinking water supplies. Particularly problematic are the endocrine-disrupting chemicals, which are known to cause latent abnormalities at infinitesimally small levels of exposure. Health effects may not surface for decades. Even where chemicals associated with gas industry operations have been disclosed, they may still slip by undetected given limited surface and drinking water quality monitoring systems that focus narrowly on a short and dated chemical lists. There is no comprehensive or systematic monitoring for industrial chemicals in groundwater. Considering the difficult burden of proof, common law is also unlikely to hold industry accountable.

⁹ <https://pennsylvaniaallianceforcleanwaterandair.wordpress.com/>

Excerpt 3

- 144 Isaac: how did they know that it depended on that then?
- 145 Rita: because they lived, it was listed how close they were to such a (1 s)
drill station uh
- 146 Ringo: and if you check all things that looked like it could depend on
one another if they were–
- 147 Rita: yes it was like that kind of theme throughout
- 148 Ringo: exactly
- 149 Rita: a lot of those nosebleeds, sore throat
- 150 Ringo: headache
- 151 Rita: yes headache (.) and then there were some extreme cases who lived
very close who had also gotten those rashes like the beginning of
leukemia and stuff those that were extremely affected but it was still
like these themes running through with like nosebleeds and a little
more of that
- 152 Isaac: ((Nods))

Told as a collaborative accomplishment with constant reciprocal adjustment to and completion of each other's utterances (145–151), the rapporteurs Rita and Ringo respond to the question of how one knows that the health problems reported are a result of the environmental effects of fracking. They do so not by reporting the results of scientific studies, but by referring to what was listed (and could be checked) on the Pennsylvania Alliance webpage and by reformulating the stories of local residents. They take the perspective of the victims of fracking, as described on the webpage, as evidence, but echo the kinds of scientific arguments that are familiar in a school science context including a principle of cause and effect (146), similar symptoms (147–151), and observed differences in symptoms depending on exposure (151). The speakers report the symptoms without taking a critical stance and in a matter-of-fact style, for example “because they lived (close to a drill station)” and “then there were some extreme cases (for those who lived very close).” The students do not employ distance markers in their reformulations, but rather align with the residents' stories talking in a serious tone of voice, emphasizing “leukemia” and “extremely affected.”

So far, we have seen how the students in their conversation offer a range of voices besides their own including those of stakeholders in the controversy such as politicians, public interest groups, and sufferers of illness. These voices are echoed to report information about the controversy, to show conflicting issues, and to add perspectives. Through the students' reformulations, the voices are mocked, challenged, and aligned to. The students show an awareness of an archetypal school science voice

typified in curriculum statements that call for students to “develop an ability to assess different types of sources and be able to distinguish between scientific and non-scientific claims” (curriculum for science program for upper secondary school¹⁰). They orient to and echo this school science voice by focusing on referencing relevant sources and reformulating these voices to substantiate the claims made. In this study, the issue is particularly relevant for the claims made about the development of symptoms linked to particular diseases where cause and effect is difficult to establish. This reflects what Veel (1997) studied as apprenticeship into scientific discourse in secondary school, showing how students develop distinctive and favored ways of thinking about the world that can be recognized as scientific. It is in line with most science curricula that expect students to be able to form explanations which are based on logical reasoning such as cause-and-effect relationships (Veel 1997).

Challenging Claims

In the previous excerpts, we have analyzed how the group working on fracking attaches particular weight to one-voiced sources found on the internet and that they tend to emphasize the environmental discourse represented by the film *Gasland* and the public interest group Pennsylvania Alliance.¹¹ The rapporteurs seem to have taken a stance in the controversy without showing much reservation. Without distance markers, they have provided evidence for ways the environment and local residents have been affected by fracking while the inquirers have challenged them by representing the critical voice of an archetypal science. They have accomplished this by asking for evidence and data that support the claims made and bringing forth additional perspectives in the controversy. In this school situation, the students are expected to be critical of claims. The questioning thus echoes a particular school science voice that is further invoked later on in the student project when they are asked to engage in a staged press conference around the controversy.

In the remaining excerpts (*Excerpt 4* and *Excerpt 5*) from the present activity, the questions and claims shift character from investigating and disentangling the claims made by different sides of the controversy to challenging and confronting those claims. This is particularly evident as one of the inquirers, Ian, enters into the controversy by engaging in argumentation. In *Excerpt 4* below, Ian can be seen to present an alternative hypothesis to the claim that fracking causes methane pollution, inviting the other students to consider the idea that methane is naturally occurring in the water in methane-rich areas. In response, Rita, Rex, and Ringo argue against his suggestion.

¹⁰ www.skolverket.se

¹¹ At the end of the project when students in the final seminar reflected on which voices were most frequent/dominant online in their respective controversies, they observed that relatively few voices were distinctly *pro-fracking* or *GMO* etcetera. They concluded that those who want to make a change need to make their voices heard.

Excerpt 4

- 153 Ian: uh a spontaneous thought then when you look at this with fracking one
 of those things that comes up is the methane contamination in the
 groundwater
- 154 Rita: ((nods)) mm
- 155 Ian: and how does one really know that it depends on the fracking?
 so you think of course that they will drill in a place where there is a
 lot of methane can one not then imagine that there is methane in the
 groundwater from the beginning sort of?
- 156 Rex: thus the methane-
- 157 Ringo: but the methane lies so many miles underneath the groundwater so that
 it is not supposed to be affected unless one has a drill that drills
 drills through
- 158 Rex: and then in this Gasland the movie they do say that before they started
 drilling, then we couldn't set fire to the water coming from the faucet
 sort of
- 159 Rita: mm
- 160 Rex: eeh and then so yes (1 s) that it depends on the cracks then
 that are going up all the way
- 161 Rita: they've like taken many water samples and stuff then like for uh
 people who have not been exposed to it yet have taken water samples of
 their water and those who have been exposed and then seen that there
 are some yes differences between them then in chemical levels

Ian's queries are suggestive in the sense that they may potentially be questioning the earlier accounts provided by the rapporteurs. He introduces these questions by exhibiting relevant skepticism, that of having been provided with potentially biased information. That he uses hedges such as "a spontaneous thought" (153) and "can one not then imagine that there is methane in the groundwater from the beginning sort of?" (155) are ways of mitigating this potential imposition on the rapporteurs. These hedges suggest that he has perceived earlier accounts made in the discussion as uncritically adopting a critical stance to fracking. In response, the rapporteurs who have studied and mapped the controversy reject this possibility, disputing it by rebutting, providing reasons or evidence in their own voice for the position that Ian's suggestion is wrong. The first reason provided is that the methane is not in contact with the groundwater (157). Here, no marker for the reformulation of a voice other than Ringo's own is evident. He echoes science texts on geology about layers of gas and water that he has encountered during the group's work on fracking, but does not directly report or demarcate them as sources of information. In support, Rex makes use of the film *Gasland*, a voice echoed

previously in the conversation that the younger students seemed aligned with. Here, it is reformulated as a source when claiming that one couldn't set fire to the water before the fracking began (158) and that the methane in the water is a consequence of cracks in the bedrock made by fracking (160). Without referring to a specific source, Rita also reformulates claims referring to people who have taken water samples with results showing that there is a difference in chemical content for exposed sites and those that have not been exposed (161).

As a continuation of the reporting students' argumentation, Ian continues challenging the idea that water can be set on fire because it is polluted, a phenomenon shown in the film *Gasland*. In the following excerpt, however, Ian uses the voice of an unidentified source as he refers to something he read on a webpage that suggests that high levels of methane measured at sites near fracking facilities are a scam. In their response, one of the rapporteurs reengages with the controversy map they have made to bring the discussion on data and evidence to a close.

Excerpt 5

- 162 Ian: I read on some site about this thing about setting fire to the water now I don't know if it was a good site or ((smiles)) but I read that it was just a scam that it was not due to methane in the water that that one could set fire to it that it was like not really reasonable if one-
I found some site where one calculated sort of the levels uh of methane and what one needs for it to be dangerous or something and now I don't know if he had the right levels and
- 163 Rex: ((takes up the map and looks at it))
- 164 Ian: so but then they came to the conclusion that it was quite simply incorrect (1 s) ehm (.)
- 165 Rex: uh ((puts the map back on the table)) this is the scientific controversy in this
- 166 Rita: mm
- 167 Rex: they say(.) they are putting words against words ((showing with his hands in the air))
sort of who is more right is it because of the chemicals or not, methane gas and so forth so it is very hard to know (.)
for us as well

Ian carefully introduces the potentially controversial utterance with distancing markers that render the claim vague: "I don't know if it was a good site ((smiling))", "I don't know if he

had the right levels” (162). This might seem to be an entirely casual supplement, but its use allows the speaker to establish that they have no “stake” in, or commitment to, the sensitive issues that have been introduced (Potter 1996). His choice of reformulation can be seen as a way of presenting a potentially face-threatening topic in a way that detaches it from his own stance: “I read that it was only scam,” “that it was not due to methane” “it was like not reasonable” (162). To accomplish this, Ian introduces another potential actor who is neither present nor specifically identified: “I read on some site,” “I read that it was just a scam” (162). Echoing this voice, he makes claims about methane levels being a scam. This exchange demonstrates how challenges can sometimes bring to the surface opposing points of view that might otherwise remain undisclosed.

In response to the challenges to claims made by the rapporteurs reformulating Gasland and Pennsylvania Alliance, Rex suggests that this challenging is what scientific controversy is all about (165). That what they are doing is setting claims against claims, stances against stances (167), and that it is difficult to assess the validity of opposing claims. This serves as a distancing marker that allows Rex to shift to a discussion about the controversy itself, positioning the conflict as one beyond clear-cut questions of evidence and neutrality. He notes that it is difficult, if not impossible, to find the “right answer” by examining data and evidence and that one can discuss endlessly “who is more right” (167). The controversy map that he lays on the table represents the younger students’ construction of the controversy. When different sides present data and evidence to support their claims that are in conflict with each other, one way to make sense of that conflict is to distance oneself and, as Rex does, by invoking the map where multiple perspectives of the controversy are represented.

Discussion and Conclusion

Studies of SSI are predominantly derived from analytical traditions that presuppose that knowledge is transmitted through language and where single-student utterances are understood to be indicators of what they *believe*. Using talk, often from interviews, to derive an individual’s conceptions, thoughts, or beliefs, is a common practice in science education research and is based on the assumption that language is a stable system (Roth 2014). An example of this approach, referred to in the introduction to this article (Sadler et al. 2007), described the competences students had developed through engaging with SSI. The study is valuable as it provides guidance for teachers who need to assess individual students’ socio-scientific reasoning. Our argument here is that consideration of voices when students are engaged in communicative projects can offer a more nuanced understanding of how students are in dialogue with and engage in managing multiple discourses on SSI. Rather than analyzing individual retrospective accounts as student beliefs about these issues, the dialogical approach invites an analysis of students’ discursive management of multiple perspectives, a multivocality which is not only recognizable in ongoing public debates, but also part of our internal dialogue when confronted by controversial issues in our everyday lives. The dialogical tradition we have taken as our point of departure (Bakhtin 1986; Linell 1998, 2009) takes as a premise the social, dynamic, and contextual nature of our communication and forms of reasoning. The speakers’ direct and indirect relations to others, individuals, and groups play a decisive role and are not compatible with product-centered, individual models of communication.

Dialogism is a broad framework with many options for development of analytic approaches. For those who ask evaluative questions regarding the effectiveness of teaching and learning, this paper/approach provides no answers and this is clearly a limitation from that perspective. However, this is a deliberate choice in this study in order to illustrate an alternative analytical perspective that reveals the particulars of the discursive activities in which students engage. Our contribution aims to establish a more relevant and dynamic understanding of the ways students learn to engage in SSI, in terms of how public debates are mediated and unfold in society. In our view, this study highlights the significance of employing a dialogical approach to understand how students engage with SSI online and in a classroom context. More specifically, we argue that it helps us to identify and unpack the communicative and discursive skills required when examining issues from multiple perspectives. Students' interaction prepare them for engaging with others by participating in discussions of public issues of concern in a democratic society, not merely developing critical *thinking* skills or science content for the *cultivation of the self* (Biesta 2014). We have reported on an activity where the establishment of a space of reflection made it possible for students to submit themselves to the tension of conflicting viewpoints. Together, they were engaged in four emerging communicative projects (Linell 1998): that identified important stakeholders, brought out tensions between perspectives, justified claims with evidence, and challenged claims. In the course of such actions, competences that require training in a dialogical context can be developed, competences that are considered important for scientific literacy and reflective judgment (i.e., Sadler 2009; Zeidler, Sadler, Applebaum, and Callahan 2009). Particularly relevant to this process, as shown in our analysis, is how students make use of reported speech by the analytical notion of reformulation (Grossen 2010). Here, reported speech may be seen as conversational resources that speakers can make relevant for invoking voices in controversial issues, and in the following, we will summarize how our analysis shows reported speech enabled students to engage with socio-scientific issues in the classroom, focusing on how it worked as ways of (1) referring to relevant sources and making evaluations, (2) distancing to the stakes, and (3) providing evidence.

Referring to Relevant Sources and Making Evaluations/Assessment

In their conversation, the students offer a range of voices beside their own including those of stakeholders in the controversy such as politicians, public interest groups, the energy lobby, and sufferers of illnesses (*Excerpt 1* and *Excerpt 2*). These voices are echoed to report information about the controversy, to show conflicting issues, and to add perspectives. Similarly, in the GMO group, students decided upon relevant voices in their controversy such as those of the plant seed industry like Monsanto, research like Serralini, consumers with concerns regarding allergies and labelling, and conservationists concerned with wild plants at risk for contamination. Through the students' reformulations of the stakeholders' claims, the voices are challenged and responded to. We have shown examples of how students' co-author utterances, making use of ideas, opinions, and perspectives attributed to other people to bring in multiple perspectives and complexity of the issue. Reported speech can also make relevant assessment from the reporting speaker. The connection between reported speech and its assessment can be accomplished in various ways, to support their own views or as counter-positions that the speakers wish to resist or argue against. Examples of the latter were seen in *Excerpt 1* where Rita and Rex subtly evaluate the claims made by the supporters of fracking (112–115) by implicitly criticizing them. Rita refers to supporters as “those who hate this film

(Gasland)” (112) while at the same time Rex is smiling and looking at Rita (113) and saying “environmental effects are so small” (114) in a laughing tone, which can be seen as questioning the relevance and downgrading the weight of the claim. The reporting speakers are displaying their positioning towards the direct quote that follows (114 and 115) where they report that those who hate the film do not think that environmental effects need to be recognized and that fracking is better than oil and coal. By using this assessment component, the interlocutors are told how to interpret or frame the reported speech.

Enabling Distancing to the Stakes

Reported speech also allows reporting speakers to distance themselves from the message as they can position themselves as merely the animators and not the sources of what is being said. It allows the students to use distance markers to talk about these issues without putting themselves at risk of judgment. These markers consist of strategies students use when listening to and learning from divergent perspectives that reduce the risk of engaging and being perceived as too intrusive or impertinent or politically incorrect. For example, we reported how one of the inquirers, Ian, questions the rapporteur accounts ([Excerpt 4](#) and [Excerpt 5](#)) by using hedges such as “a spontaneous thought” (153) as a way of mitigating a potential imposition on the rapporteurs. He uses distance markers that render his own claim vague such as “I don’t know if it was a good site” (162). In this instance, he is echoing another voice that claims that the methane levels reported are a scam, positioning himself as merely a reporter of what somebody else has said. This resonates with other research showing that the distancing function of reported speech is salient when discussing contested topics such as race ([Buttny 1997](#)). This puts potential critique on the table without any danger for the speaker. Yet, as such claims are recognizable for those to whom they are addressed, they inevitably call for some kind of response. On the other hand, at the end of the project in the seminar led by the teacher, we noticed how students occasionally provided a stance without needing to distance themselves from the claims (here Rex in the fracking group): “I am against fracking eh on several levels one can say. Firstly, I think it’s a risky process and we do not have the natural resources or time to risk such things... natural gas is a greenhouse gas that is much worse than carbon dioxide because it mostly contains methane... instead of spending money on it and then slow down the development of renewable energy, we should not help doing this. ..so I think solar cells, wave power and wind power and everything will develop so much much faster if we don’t encourage the use of natural gas from fracking.”

Providing Evidence

Yet another way reported speech can be used is to provide evidence in the form of a secondhand account in support of a claim. In this study, this feature allows for general assertions about the environmental effects of fracking to be made. By quoting other’s words, the speaker is removing his or her own interpretation and “objectively” reporting what another said. In [Excerpt 3](#), the rapporteurs are asked how the ones reporting health problems knew that it depended on fracking. They take the perspective of the victims of fracking (as described on the webpage) as evidence and echo the kinds of scientific arguments that are familiar in a school science context. These include a principle of cause and effect, similar symptoms, and observed differences in symptoms depending on exposure. The students can be seen to, in dialogue with

interlocutors and contexts, constructing their understanding in a domain and to respect disciplinary norms by for example giving evidence for their claims. Similarly in the GMO group, inquirers also ask for evidence in response to rapporteurs who refer to a scientific study about the development of cancer in rats fed only GMO. More specifically, they asked whether a chemical substance was identified as causing the cancer.

The students' discussion reflects the relevance of questions about evidence, objectivity, and neutrality when knowledge is put to use in SSI reasoning (Kolstö 2001). The science of relevance to current SSI and decision-making is often *science-in-the-making*, characterized by a lack of consensus on whether the evidence is conclusive. We reported here how the controversy map offered an understanding of the conflict that is beyond questions of evidence and neutrality (Nielsen 2013b). The rapporteurs represented by Rex claim that it is not possible to arrive at a correct decision by merely examining data and evidence provided by the different sides in a conflict, but that instead, one way to make sense of that conflict is to make a controversy map where multiple perspectives are represented.

A Descriptive Account of an Unfolding Discussion of Socio-scientific Issues

In relation to the following, we suggest that readers refrain from considering the analysis presented in this study normatively. The depiction of the particulars of everyday conditions we present does not necessarily suggest ways discussions ought to be, or ways SSI education programs should be formulated. Rather than sharing ways SSI should be addressed in schools or showing how students achieve or fail to achieve a standard, we wish to contribute to fundamental understanding of how students interact when SSI as presented unfiltered on the Internet are introduced into science classrooms that can then be examined further. Descriptions of science classrooms offer empirical examples for discussion of epistemic shifts in studies of cognition and practice from individual minds to communities and groups (Kelly 2008).

There are many ways to describe everyday life in science classrooms: we have offered a dialogic framework as a plausible approach. The practices that count as science for a group are defined in and through social interaction including uses of language in particular ways for particular purposes. This suggests that in analyzing educational opportunities for students, educators need to consider the linguistic resources made available and how students are positioned to engage with such resources. In the activity we investigated, knowledge claims concerning fracking were proposed, debated, and evaluated within this school science discourse community. This process of knowledge legitimization was unpacked through the empirical investigation, and our analysis offers ways of understanding the differences between students' ways of talking and the discourse of more formalized epistemological communities. In future research, we will augment this work by producing analytic accounts of how science teachers in particular play a role in inviting and supporting reflection in situations where students encounter differences of opinion, otherness, and plurality. This work combined with the present study will further contribute to providing an analytic grounding for applied research that engages with normative considerations for developing teacher training and classroom practices.

Group Discussions as Facilitating Democratic Conversation

Learning to engage in the discourses of socio-scientific controversies requires developing new repertoires for interaction with people, texts, and technologies. Small-group discussion is relatively rare in science classrooms (Osborne 2012). Detailed analyses of students unfolding SSI discourses have shown how both the complexity of the student's arguments increases as a result of group discussions (Rudsberg et al. 2013) and also how socio-scientific issues are challenging to students as they have to allude to a diversity of genres causing them to oscillate between very different issues. Digital mapping methods allow students to navigate the complexity of ongoing debates and re-present ongoing controversies in visual-material form. It becomes possible to observe controversies from many concerned viewpoints' and from the actors' voices more than when working from students' own presumptions. The results of our study suggest that using instructional approaches committed to dialogical interaction which incorporate the use of digital tools to produce controversy maps shows promise for critical multi-perspectival appraisal of socio-scientific controversies, although additional empirical studies are required to be able to make claims regarding the instructional approach's affordances and constraints. In the setting studied here, the science/language classroom brought voices representing different perspectives that were reflected upon and enabled students to reflect on other voices across difference, time, and space. Authoritative voices are appropriated and sustained in human interaction, but through dialogue, especially argumentative verbal interaction, ideas may be questioned, particularly when we are helped by others to become aware of alternative ideas. Discussions of any sort are difficult and, because of their potential to engender emotional reactions, discussions of controversial issues more so (Hess 2002). Since conflicts inevitably arise in pluralistic societies as a result of differences between both individuals and groups, these skills and commitments can be considered to be essential civic competencies necessary for students to participate in democratic public life. In the emerging global network society, schools play an important role in giving students the opportunity to live constructively in a situation where there are multiple voices.

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Appendix 1 Transcript Conventions

[text]	Simultaneous/overlapping utterances
(3s)	Shows pauses from one second and longer
(.)	Pauses shorter than one second
?	Marks intonation of a question
<u>Text</u>	Underlining indicates emphasis

((text)) Transcribers' commentaries on inaudibility, nonverbal aspects, characterizations of how talk was delivered, and extra discursive activities

text= Indicates latching turns

=text

text- A sharp cut-off

te(h)xt Talk with a laughing tone

Appendix 2 Information Sheet to Students from Teachers

Get the hang of it

Controversy mapping

Description

Your task will be to investigate your “area” based on a method known as “Controversy mapping.” The name implies that the method involves mapping controversies within an area. Thus, it is not a matter of finding one answer but rather exploring different perspectives, divisions and actors in an area.

Purpose

The purpose of the project is to work with the following objectives from the curriculum:

- “Students should therefore be given the opportunity to develop an ability to evaluate different types of sources and to distinguish between scientific and non-scientific claims.
- Students should be given the opportunity to develop interest in science issues. The education should provide an understanding of how mutual science has influenced and influenced each other and, in particular, highlighting the role of science in sustainable development issues.
- Students will also be given the opportunity for ethical discussions about the role of science in society.”

Procedures

The project will be conducted in various stages - investigation - analysis - role play and seminar:

Investigation

You will, individually and in groups, map your “area” using the “Controversy mapping” method. You will be introduced in how to use the digital mapping tools and when you get started with the work you will also have access to tutorials. Your searches will generate a physical image, a map, where different actors and how they are linked to each other are displayed. This map will give you “control of” your controversy.

Analysis

Once you've got your map, it's time to figure out and review the different pages, actors and arguments you've seen. The analysis should be summarized in the form of a shorter PM, which will then be presented orally and an analysis in English. You will analyze both the pro and the cons.

Role Play - Press Conference

Once you have examined the area and analyzed your maps, prepare for a press conference with invited "journalists". During the press conference you will represent one of the actors identified from the map. You and your side of the controversy will then present a picture of the area and be able to answer the journalists' critical questions.

Seminar

Here you will have the opportunity to show your knowledge in the entire area that you and your group have investigated. You will also be given the opportunity to reflect on the maps of the other groups and the conclusions they have drawn.

Planning and time table

Week	Day	Activities
41	Thursday 8.20–11.40	Introduction of the project. Introduction to Navicrawler and searching the internet.
	13.30–14.30	
42	Friday 13.00–14.20	Working with Navicrawler when searching the internet
	Monday 10.10–13.00	Pooling individual files to the group, importing it to Gephi Working with Gephi.
43	Wednesday 8.20–14.30	Working with Gephi.
	Thursday 8.20–14.30	Working with and maps and analyzing them(use task 1)
44	Friday 13.00–14.20	Meeting with students from grade 12. Discussing the map.
	Monday 10.10–13.00	Preparing for the press conference(Use task 2)
45	Tuesday 12.35–13.55	Preparing for the press conference
	Wednesday 10.10–14.30	Preparing for the press conference
46	Thursday 8.20–11.40	Press conference
	13.30–15.30	
47	Wednesday 13.15–14.30	Preparing for the seminar (use task 3)
	Thursday 8.20–11.40	Seminar

Task 1

Research

The purpose of your research is to get a broad picture of the area in question. When you have found your map, you are supposed to analyse it with regard to the following questions:

- Which "sides" are there in the area?
- Who are the contributors? What is their respective position in relation to each other? What connections are there between them?

- What do the arguments on the different “sides” look like? What are these arguments based on? Which or whose interests do the contributors have in mind?

Your thoughts should be summarized on approximately one A-4 page according to the following guidelines:

A short presentation of the area.

Your ‘answers’ to the questions above.

Summing up and a discussion.

It is important to use a formal language.

Task 2

Role Play - Press Conference

Now you have gathered a lot of information, arguments and opinions in your area - then it's time to test if this holds. You are now to enact a role (the role will be assigned to you) of one of the actors you have identified in the mapping - you will then prepare for the press conference. You will not know which questions that the “journalists” will ask, but you should be prepared for the following:

- How would you describe the area? What is your attitude towards it?
- What arguments do you have for your case? What kind of opposing argument do you usually encounter?
- What are the consequences of your reasoning in the long term? In short term? Why?
- Which interests do you represent? What kind of perspectives?
- What are your arguments based on? Why?

Task 3

The seminar

In the seminar you will be divided into groups and you will discuss overall questions that concern both the areas (GMO/Fracking) you have had in the class. For this purpose, you should consider the maps produced in both areas

- What constitutes the controversy? Explain by using your map.
- Who is interested in the existence of a controversy? Who would have an interest in reaching an increased consensus on the issue?
- What does the mapping show?
- Who or whose voices are heard the most? Why is that? Does it differ between the controversies? Between the groups?
- What does the media's role look like?
- Were you surprised by anything when you investigated the actors? Why?
- What have you learned from the controversy mapping? Has the work raised any new questions?
- Are there any issues you think would be interesting to map? Why?

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