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Attitudes and Language Use in Group Discussions on Socio-Scientific Issues

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The school systems of many countries have been pervaded by student-centred pedagogy making students' small group discussion a common feature of the classroom practice. However, there is a lack of studies focussing different modes of discussion for the purpose of finding out whether some modes are more beneficial than others. Hence, the aim of this study is to explore the underpinnings of student small group conversations on Socio-scientific Issues in order to develop an understanding of the key aspects of what interrupts or revitalizes the conversation. We focus on the importance of attitudes and language use for the fate of students' decision-making conversations. Our theoretical framework builds on Dewey's notion of Open-mindedness and Bernstein's communication codes. Students' use of morals, opinions and agitational talk interrupted conversations, whereas new aspects and new perspectives revitalized the conversation. Students need guidance to avoid using justifications in conjunction with a Close-minded attitude.

Keywords: attitude, critical thinking, elaborated code, group discussion, open-mindedness, socio-scientific issues

INTRODUCTION

Inspired by progressivist pedagogy, education for democratic citizenship has during the last two decades become part of science education curricula worldwide. This development, for the purpose of promoting students' competencies regarding participation in ethical and democratic discourses is known as the Socio-scientific framework. The Socio-scientific framework (Ratcliffe, 1997; Zeidler & Sadler, 2008) explicitly demands cross-curricular and student-centred approaches to stimulate deliberative conversations on authentic problems derived from the use of science and technology in society. Research shows that students develop the quality of their socio-scientific arguments (Zeidler, Sadler, Applebaum & Callahan, 2009) as well as their understanding of scientific content (Klosterman & Sadler, 2010). However, there are concerns about the students' still rather low levels of critical thinking (Ratcliffe, 1997; Sadler, Amirshokoohi, Kazempour & Allspaw, 2006; Schalk, van der Shee & Boersma, 2013). Furthermore, while the student interaction through group discussions is the centrepiece for developing their roles as participants in the societal discourses on socio-scientific issues (SSI), little is known about the process

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of untutored student group discussions (Gustafsson & Öhman, 2013; Lubben, Sadeck, Scholtz & Braund, 2010). Moreover, there is a lack of studies focussing different modes of discussion in order to find out if some modes are more beneficial than others (Howe & Abedin, 2013). Such knowledge about classroom conversations is especially important since student-centred pedagogy has pervaded the school systems of many countries. Hence, the aim of the present study is to provide an understanding of different modes of untutored small-group discussions and how they affect the fate of the conversation. The context for our study is group discussions in a classroom practice inspired by the SSI framework.

State of the literature

- Students' untutored decision-making discussions are recognized as important for developing critical thinking, but there are still concerns about the students' rather low levels of critical thinking.
- It is assumed that the conversation progresses in different ways depending on how the group members act during the discussion, and that some modes of talking are more beneficial than others.
- The students' ways of talking are related to structural factors such as students' achievement level and cultural background.

Contribution of this paper to the literature

- Students' use of Morals or Opinion as indisputable claims make rational reasoning meaningless. This hampers students' possibilities to create a fruitful discussion for an informed decision-making.
- Close-minded attitude, especially in combination with an elaborated language, interrupts the conversation and prevents the development of critical thinking. Thus it may be just as important for teachers to focus on students' attitudes as on their argumentation skills to enhance critical thinking through discussion on SSI.
- Agitational talk can fuel group discussion but prevents the explorative dimensions of the conversation, thus hampering understanding and critical thinking.

The quality of students' reasoning in socio-scientific issues

The possibilities for SSI to foster students' scientific literacy have inspired educators and researchers in science education. Much attention has been given to educational outcomes in research to consolidate the gains of SSI in education. For example, by making use of different pre- and post-assessments, SSI have been shown to be beneficial not only for students' development of their socio-scientific reasoning (Grace & Ratcliffe, 2002; Sadler & Zeidler, 2004; Zeidler et al. 2009; Zohar & Nemet, 2002), but also for their understanding of the scientific content (Klosterman & Sadler, 2010; Zeidler, Sadler, Simmons & Howes, 2005). In addition, this vein of research has shown that the quality of students' socio-scientific arguments appears to depend on the students' scientific content knowledge (Sadler, 2004a; Sadler & Zeidler, 2005a; Wu & Tsai, 2007). Hence, it appears that the synthesis between content knowledge and decision-making skills, made possible through SSI, is beneficial in the sense that a broader range of educational goals is attainable (Sadler, 2009).

The quality of reasoning in SSI discussions is important for students' development of scientific literacy, including critical thinking and decision-making. Since SSI discussions include both formal and informal reasoning (Sadler 2004a; Zeidler & Sadler, 2008), the quality of formal as well as informal reasoning has been studied extensively. Students' formal reasoning has to be studied both in the context of learning the subject content only and in science teaching based on SSI. The quality of formal reasoning has in many studies been assessed by the use of Toulmin's Argumentation Patterns (TAP) (Erduran, Simon & Osborne, 2004; Jiménez-Aleixandre, Rodriguez & Duschl 2000). Studies on students' informal reasoning have also made use of TAP, both as the outcome of analogous classroom discussions (Gustavsson & Öhman, 2013; Lubben, Sadeck, Scholtz & Braund, 2010; Sadler & Donnelly, 2006), and of online asynchronous discussions (Lin, Hong & Lawrenz, 2012; Yeh & She, 2010). However, the importance of informal reasoning has brought the attention to models other than TAP to describe the qualities of socio-scientific reasoning (Sadler, 2004b; Sadler & Zeidler, 2005b; Sadler, Barab & Scott, 2007;

Zeidler et al., 2009). The assessment of reasoning quality is crucial and further attempts to integrate different aspects into one model to provide possibilities to analyse the different aspects of informal reasoning may still add to the field (Evagorou & Osborne, 2013; Gustavsson & Öhman, 2013). The question concerning how different aspects of socio-scientific reasoning, such as the moral, emotional and rational aspects, can be integrated into the classroom discourse in a fruitful manner still need further consideration (Lindahl & Linder, 2013).

The contribution of classroom discourse to students' reasoning skills on SSI

Classroom discourse has been studied empirically for about 40 years, according to a systematic review by Howe and Abedin (2013). The results from 225 studies between 1972 and 2011 show that a majority of publications deals with the organization of classroom dialogue. The cumulative research typically describes different modes of organization, but still little is known about what modes of dialogic organization support the intended learning. Yet, it is suggested that untutored student group discussions may be important for the development of decision-making skills (Driver, Newton & Osborne, 2000; Kolstø, 2000; Levinson, 2010), since they can share their thoughts among peers without the constraints of a teacher presence. Thus, we focus our study on different modes of untutored small-group discussions in a socio-scientific issue context with the purpose of gaining knowledge on how different features of the student conversation influence their decision-making.

The quality of formal, as well as informal, reasoning as studied in small student group discussions has been shown to be related to different external and internal factors. One type of external factor is scaffolding towards a better quality of reasoning through the use of written instructions to prompt students' discussions step-by-step. Research on this type of organization of group discussion has been done using analogous (Ratcliffe, 1997), as well as digitally presented, prompts (Cheong & Cheung, 2008; Lin et al. 2012). In general, both forms of scaffolding seem to enhance the quality of students' reasoning, but there are no in-depth analyses of the group interactions regarding how conversations on SSI progress. Another and more prominent form of external factor influencing the quality of students' socio-scientific reasoning seems to be the teachers' guidance. Research has shown that besides providing necessary affordances for students' development of content knowledge, the teacher's guidance in classroom discussions is important for the quality of students' argumentation skills, as well as the inclusion of aspects other than content knowledge (Liu & Yang, 2012; Ratcliffe, 1997; Sadler et al. 2006). Guidance by the teacher was shown to encourage the students to discuss in a more elaborate way, i.e. using more explanations and generalizations. Without presence of a teacher, the students' discussions were found to be more descriptive and superficial (Schalk et al., 2013).

The research on external factors remain important for the development of science education within the SSI framework, since students need scaffolding which does not jeopardize their ownership of the decision-making process (Levinson, 2010). Scaffolding, as known from current research, is likely to benefit from research on internal factors of student groups and their interactions, such as the elaboration of relevant values, students' motivation to engage in the issue, and an open attitude towards differing viewpoints rose in the group (Ratcliffe, 1997). Thus, it is assumed that the conversation progresses in different ways depending on how the group members act during the discussion. The students' actions are assumed to be related to structural factors such as students' achievement level, cultural background or gender. A small case study, comparing low-achievers with high-

achievers, showed that high-achievers were more engaged in the task and discussed in a more elaborate way, i.e. offering more rebuttals, qualifiers and warrants. The high-achievers' discussion was characterized as exploratory talk whereas that of low-achievers typically consisted of cumulative talk (Evagorou & Osborne, 2013).

Qualities regarding the interaction between students with impact on the SSI-discussion

Regarding discussions on socio-scientific issues, the use of complex and well-grounded arguments has also been put forward as a desirable feature. However, apart from explaining scientific knowledge in detail, students are supposed to develop their understanding of different perspectives related to the socio-scientific issue at hand. Hence, when working with SSI it is even more important that students use explorative talk, i.e. they need to consider alternative views and constructively criticize lines of arguments (Lewis & Leach, 2006). Lewis and Leach (2006) were able to show a loose relationship between the quality of students' group discussions and their use of criteria in their justifications. The successful qualities of group discussions were 1) the number of criteria used and 2) the use of cumulative/explorative talk. Hence, both the ability to justify claims and the use of explorative talk seem necessary for fruitful discussions on SSI. The importance of explorative talk for the quality of students' discussions was also shown in a small case study using two pairs of students characterized as high-achievers and low-achievers respectively (Evagorou & Osborne, 2013). The high-achievers were shown to discuss in an elaborate way, i.e. offering more rebuttals, qualifiers and warrants, and their discussion could also be characterized as exploratory talk. This was contrasted by the discussion of low-achievers, which typically consisted of cumulative talk and contained very little elaborate talk. The production of developed arguments is dependent on the skills of the students within the group. Thus it has been shown that the presence of at least one student with higher order reasoning skills is necessary for the occurrence of complex arguments in students' small group discussions (Grace, 2009). Another important factor seems to be the presence of students apt to take roles with beneficial functions for the group interaction such as: 1) promoting discussions by provoking questions, 2) adding necessary and correct scientific knowledge, and 3) keeping the focus of the discussion on the task. These functions do, in agreement with previous studies (Ratcliffe, 1997), contribute with qualities necessary for explorative discussions on SSI.

Aim and research questions

The aim of the present study is to explore the underpinnings of productive and unproductive modes of small-group discussions in order to develop an understanding for how the interactions can promote or impede students' development of skills in critical thinking through conversations. The investigation of students' discussions in untutored student groups is based on the assumption that such conversations can allow the explicit understanding and negotiation of diverse perspectives towards informed decisions on socio-scientific issues. It is assumed that it is beneficial for the conversation to go on exploring different perspectives and not just end in a quick agreement. Thus, our investigation will be informed by the following research questions:

1. What features characterize the interruptions of students' conversations?
2. What features characterize students revitalizing conversations at the risk of being interrupted?
3. What attitudes and language are of importance for the fate of students' decision-making conversations?

THEORETICAL FRAMEWORK

SSI provides opportunities for discussions in the science classroom aimed at decision-making based on critical thinking. Critical thinking has been described in several ways using definitions similar to Dewey's notion of reflective thinking (Zeidler & Sadler, 2008). For the purpose of this study "reflective thinking" and "critical thinking" will be used as equivalent concepts. According to Dewey (1933), reflective thinking is favoured by certain attitudes that he describes as: open-mindedness, whole-heartedness and responsibility. Our theoretical framework builds on Dewey's assumptions regarding this prerequisite for reflective thinking in the classroom. We focus on the attitude Dewey denominates as "open-mindedness", as it seems to be particularly important for classroom discussions aimed at exploring and valuing perspectives related to SSI. Open-mindedness is an attitude that favours students' interest for new ways of seeing and understanding, their readiness to consider different perspectives, as well as their willingness to change opinions and stance. The importance of an open attitude is also pointed out by Bernstein (1974). He assumed that an open attitude is prevalent in families wherein different perspectives are open for discussion. Conversely, in other families, discussion is superfluous since norms are taken for granted. This difference in attitude was described in a theoretical model wherein the concepts of Open or Closed communication codes were used to describe sociolinguistic behaviour, i.e. how meaning is expressed in different families. It is assumed that when a Closed communication code predominates, a habit to express general and unequivocal meanings is fostered. Conversely, an Open communication code affords many alternative views and fosters a habit to express specialized meanings and to cope with ambiguities. Hence, when using an Open communication code, nothing is taken for granted and, therefore, all statements call for justifications and explicit ways of talking. To describe these different habits of talking, Bernstein used another pair of concepts, namely Restricted and Elaborated codes. An orientation to a Restricted code hampers, whereas an orientation to an Elaborated code facilitates the possibility of clarifying subjective intentions. The codes describe the syntax by which meanings are expressed in conversation. The Restricted code is described as an implicit way of talking characterized by a lack of explanations and motives. In contrast, the Elaborated code is explicit and typically includes explanations and justifications. Bernstein also pointed out that sociolinguistic behaviour is not to be understood as a capacity, but rather a linguistic habit that is related to context. Although fostered in using an Elaborated code, a person may choose to use a Restricted code if an Elaborated code would prevent a fluent conversation. However, a person fostered in using a Restricted code is assumed to have more difficulties using explicit explanations even when required, for example in a school context (Bernstein, 1974).

In our interpretation of Bernstein, Elaborated and Restricted codes would differ in the sense that the former is associated with more developed arguments (c.f. Toulmin's argument pattern; Toulmin, 1958) than the latter. Hence, we anticipated a more nuanced and complex group discussion recognizing new perspectives, i.e. a more productive dialogue, when an Elaborated code was present as compared to group discussions for which a Restricted code was typical. To enable the use of the abovementioned concepts, we made adaptations to better suit the specific educational context. For the purpose of this study, we will use the definitions below as analytic tools.

Elaborated code

Claims are made with an adjacent explanatory justification for being relevant to the context, i.e. the students appear to assume that the meaning and relevance of claims need to be made explicit to the other students in order to be understood in the intended way. Claims expressed with an Elaborated code can also have an apparent relationship to previous utterances by the talking student or by any of the students in the group, i.e. there is an explicit relationship to the context of the conversation.

Restricted code

Claims expressed with a Restricted code lack adjacent explanatory justifications for being relevant, i.e. the students appear to assume that the meaning and relevance of claims are unambiguous and obvious to everyone. Claims expressed with a Restricted code are uttered without apparent relation to previous utterances by any of the students in the group.

Open-mindedness

Students propose something that is open for discussion. Hence, utterances are probing and exploratory whether given as new input or as conclusions made on the preceding utterances in the conversation. Suggestions are given as alternative views that seem to stimulate further discussion.

Close-mindedness

This attitude is the opposite of Open-mindedness. Close-mindedness closes discussions by making other students' inputs superfluous or irrelevant. Close-mindedness can be observed as students' unequivocal statements given as more or less unchallengeable claims or dismissals of other students' inputs.

METHODS

The 22 participants in this study were 15–16-year-old students enrolled in the "Social Science Program" (preparation for higher education). The setting was a public upper secondary school with approximately 900 students in a small Swedish city. They participated in "Science Studies", a course that is compulsory for all non-science bound students in the upper secondary school in Sweden, and covers aspects of sustainable development, human sexuality and relationships, individual health and lifestyle, and biotechnology and its implications. Prior to the present investigation, the students were divided into groups of 4-6 students. For the purpose of giving the students' equal opportunities to express themselves in their group work they were assembled into homogenous groups based on their use of elaborated language (i.e. explanatory justifications) in their first argumentative text on an SSI.

Their teacher had four years' experience as a teacher and had participated in a 15 ECTS (European Credit Transfer and Accumulation System) course for practicing teachers on the use of SSI in science education. The primary source of course literature was "The role of moral reasoning on socioscientific issues and discourse in science education" (Zeidler, 2003). During the school year preceding this study, the teacher had implemented the use of SSI in "Science Studies" throughout the academic year (about 90 hours of instructional time). The classroom can be described as more student-centred than teacher-centred. At the time of data collection for this study, the course was in its 12th week.

The SSI-project in focus, "Wolves in Sweden and Biodiversity", had been introduced to the students through a short (five-minute) presentation focusing on

Table 1. Official stances regarding the Swedish wolves among Swedish parties of interest

Party of interest	Official stance on the Swedish wolf population
Swedish politicians	Reduction to 180
The Sami people	Reduction for the protection of reindeer herds
Swedish hunters	Reduction to protect their game
The ecowarriors	Increase to 1000
The contracted researchers	Increase to 450
Researchers	Increase to 1000
The EU	Sweden should protect and keep a healthy population of wolves

the inbreeding of the Swedish wolf population (population size 350 wolves) and how the authorities tried to resolve the problem by importing Russian wolves. The brief introduction covered the conflicting demands from the European Union (EU), the Swedish politicians and their contracted researchers, the demands from the Sami people, the diverse views among scientists, and the opinions of Swedisch hunters and the ecowarriors concerning the size of the smallest healthy wolf population. In addition, four objectives for the work for biodiversity were presented: ecological variation, species variation, genetic variation and ethical considerations concerning the extinction of organisms. After the teacher's introduction, the students studied two newspaper articles presenting the views of different parties of interest. The conflicting views were related to the scientific facts indicating that the Swedish wolf population is inbred (the descendants of merely 5 genetically different wolves). Hence, the controversies regarded the introduction of wolves from other gene pools (Russian wolves), the size of the Swedish wolf population, a conceivable impact on reindeer husbandry as well as the opinions of hunters and ecowarriors (see Table 1). The students' task was to discuss the given information in their groups guided by the following questions and suggestion:

- What is your opinion?
- Can you understand the different perspectives of the debate?
- Give your view on the different perspectives.

Data collection

The two consecutive lessons (60 minutes each on two subsequent days) that were observed consisted of information and lecture by the teacher, students' reading and classroom discussions. Students sat in their small groups during the two classroom discussions (20 and 23 minutes) that were audio-recorded for four out of the five groups. The fifth group was not audiotaped with respect to the only student in the class who did not approve of being audiotaped. During both lessons, the classroom discussions took place first within the small groups and then between the teacher and the student groups. The latter was done with the purpose of, without judgement, making the student groups aware of the presence of presumably different positions taken in other groups.

Analysis

Students' group discussions were transcribed verbatim. Parts of the transcription consisted of discussions between the teacher and student groups. These were not considered as belonging to the conversation of each specific student group and were subsequently omitted from the analysis. The resulting data, in total 80 minutes of group discussions, was divided into conversation parts. A part could contain different views and themes of conversation, but was considered a distinct unit if the conversation appeared to be exhausted as it faded into murmur or took a noticeable pause. Typically, a new conversation part started with a new angle to the task, either through a claim or as a question to the fellow students. However, there were exceptions such as repetitions of claims. These were understood as part of a

Table 2. Steps for the analysis of conversation parts

Step no.	Analytical step
1	Coding and interpretation of inputs interrupting conversations
2	Coding and interpretation of inputs "revitalizing" conversations
3	Categorization of key inputs and interpretation of their function

debating strategy. Two researchers did the division into conversational parts, and the inter-rater score was estimated to be 92%. After discussing the discrepancies and listening to the indicated parts of the students' conversations a second time, all conversation parts could be agreed upon. The resolved discrepancies brought attention to the need to be consistent concerning the separation of conversation parts. First, a conversation part should consist of the main dialogue of the group. Thus a couple of students' side talk has to be disregarded. Second, the division into conversation parts by using noticeable pauses may lead to inconsistencies that can only be resolved by repeated listening in order to determine when the conversation was exhausted for the time being. The analysis of conversation parts was made in three steps (see Table 2).

In the first step, distinctions were made between inputs, i.e. utterances that added something new to the conversation, and sustaining utterances, i.e. diverse forms of acknowledgement of a previous utterance including added factual and clarifying details. This analysis focused on the conversation turns that could potentially be understood as how a conversation is interrupted, i.e. what happens immediately before the end of a conversation part. Conversation turns, i.e. students' inputs, were first coded in terms of attitude (Open-minded or Close-minded) and then in terms of sociolinguistic code (Elaborated or Restricted).

In the second step of the analysis, all remaining inputs in the conversation parts were coded as above. The purpose of this step was to enable falsification of the results of the previous step by way of finding explanations as to why potentially interrupting inputs would not close the conversation. Hence, attention was given to the inputs immediately after potentially interrupting utterances, which can be assumed to have the function of revitalizing a conversation.

The coding procedure for the first two steps was done by one of the researchers and the result was re-examined by the second researcher. The interpretation of 11 (6%) out of the 187 inputs coded were judged as doubtful and were subsequently reinterpreted by both researchers after a second listening to the audio files. Eight of the 11 interpretations were, instead of being Open-minded utterances, reinterpreted as Close-minded when appropriate consideration had been made of the students' intonations, i.e. when said as a statement and not as a question. The remaining three inputs were initially interpreted as expressed by Restricted code, but after listening to each students' previous utterances, the interpretation of the utterances was considered as, in the context, being expressed with Elaborated code.

In the third step, key inputs (interrupting, potentially interrupting and those revitalizing a conversation) from the previous steps were categorized for further interpretation of their function in students' group discussions on SSI.

RESULTS

The results are presented in three sections. The first section deals with how the students' conversations are interrupted; the second section presents examples of how students revitalize their conversations. In the utterances presented below, stressed words and phrases are underlined to facilitate interpretation. In a third section, we present how the fate of students' conversations can be understood in light of attitudes and codes.

Students' inputs interrupting the conversation

Interrupting inputs could be categorized as *Solution*, *Morals*, personal *Opinion*, *Joke*, *Questioning* and *Problem*. Typically, *Solution*, *Morals*, *Opinion* and *Joke* were uttered in a Close-minded (CM) way, whereas *Questioning* and *Problem* were found to be uttered in either Close-minded or Open-minded (OM) ways. These interrupting inputs are exemplified below.

Solution

Interrupting solutions were presented as one-dimensional claims with or without justification, i.e. using either Elaborated or Restricted codes, concerning a partial problem of the issue. Interrupting solutions were invariably uttered in a Close-minded way.

> Otto: If the EU says we should keep them [the wolves], then I think we should do so, absolutely, it would be stupid to argue with the EU about that. //Interrupting utterance//[Conversation fades into murmurs]

In the excerpt, the student argues that there is no other solution than to follow the EU policy to increase the Swedish wolf population by using the EU as an unchallengeable authority to justify his claim (Ec). Thus, this utterance is considered Close-minded since it makes previous inputs superfluous.

Morals

Morals represented general values and were always sustained with additional justifications, i.e. expressed using an Elaborated code (Ec). All interrupting inputs using Morals were Close-minded.

> Eve: Why can't we just let it be? I mean nature has, like, made it work, it's us making those problems. //Interrupting utterance//[Conversation fades into murmurs]

The student states a one-dimensional view that implies that no further discussion is needed (CM). Here, the student's idea of what is right and good is justified by her concept of nature (Ec).

Opinion

Opinion was a personal view that was always expressed in a Close-minded way using a Restricted code.

> Ernest: We actually had a wolf down here, do you remember?
> Isabel: Yes, I remember.
> Ernest: That's sooo awesome! //Interrupting utterance//[Conversation fades into murmurs]

As can be observed in the example above, what is stated does not appear to be open for discussion (CM) and is difficult to question since it is personal and without any justification (Rc) that can be challenged.

Joke

Students occasionally dismissed previous inputs with a *Joke*, which was typically uttered in a Close-minded way using a Restricted code.

> Fred: Figure you see a wolf and want to take a picture of it, WOW! A threatened species!
> Michelle: Figure it's totally inbred.
> Maria: With three legs. //Interrupting utterance//
> [Everyone laughing].

The sarcasms provided by the two girls in the excerpt above are considered Close-minded since they dismiss the previous input. Since they are given without

justification for their relevance, both inputs are considered to be given by using Restricted codes.

Questioning

Students' *Questioning* could be expressed in a Close-minded or Open-minded way, using either Elaborated or Restricted codes.

> Ethel: If they take some area …//… and the Sami people gets to know where, then they'll keep their reindeer away from it, and then the problem is solved, at least that problem.
> Eve: Okay, but in that case you're counting on that they won't move around, I mean the wolves, because they seek food you know. //Interrupting utterance//[Agreeing murmurs from the group]

The questioning of the solution suggested by Ethel is expressed in an Open-minded way since the objection is conditional, thus leaving the issue open for further adaption or discussion. This input is underscored with an explicit justification (Ec).

Problem

Raised problems were typically expressed in a Close-minded way using either Elaborated or Restricted codes.

> Sandra: But in that case, I guess we should get some wolves from, like Russia…//…then we'll get a pure population of wolves.
> Monica: This is damn hard because, you know, whatever we do it's going to be "wrong" in some way. //Interrupting utterance//[The group suddenly becomes quiet]

Problems, when raised, increased the difficulty of making decisions by, for example, making simple solutions less useful. In the excerpt above, the second input problematizes the first solution in an Open-minded way as it suggests that previous suggestions have to be re-considered instead of settling for a simple solution. This second input is made using an Elaborated code explaining why their task is difficult to justify.

Students' inputs revitalizing the conversation

There are situations when conversations continue in spite of close-minded utterances with the potential to close conversations. Inputs that could revitalize the conversation were characterized as *Agitational talk*, *Solution*, *New aspect*, *New perspective* and *Questioning*. Characteristically, open-minded utterances revitalize and promote further conversation. However, close-minded utterances can also stimulate further discussion, especially as part of an agitation for a one-dimensional view of the SSI dealt with. Examples of these revitalizing inputs are shown below.

Agitational talk

Agitational talk was used both with and without justifications, i.e. using either Elaborated or Restricted codes, and was always uttered in a Close-minded way (CM). This way of talking was found when some students had already taken a firm position in favour of the protection of wildlife.

> Ernest: But, you know, the Sami people still must feel rather …
> Isabel: The reindeer, that's what they live for.
> Otto: Yes, I can see that. It should be possible to fix, yes.
> Ernest: But, you know, the way to fix the problem should be a big fence on their land. //Interrupting utterance//

> Otto: It has to be a robust fence that is sort of resistant. //Revitalizing utterance//[The group continues a conversation about a solution using fences]

In this excerpt, two students are taking a decisive stance to protect the wolves at all costs, but they also understand that the wolves are threatening the Sami people's interest. Hence, they propose, without justifications (Rc), to build fences around the reindeer herds, and even when other students and the teacher explain that this is not possible, they continue their agitation through the whole discussion. This way of talking is assumed to be Close-minded (CM) since they neglect alternative solutions.

Solution

Solutions could both interrupt and revitalize the conversations and they were presented with or without justification, i.e. using either Elaborated or Restricted codes. However, it is important to notice that a revitalizing *Solution* was always expressed in an Open-minded way (OM).

> Emily: But if there is a special wolf area, then the Sami people can keep their reindeer away from there. //Interrupting utterance//
> Ethel: But instead of going for less wolves, we can go for protecting the reindeer. //Revitalizing utterance//[The group conversation continues regarding how to control wolves]

In the first utterance, there is a justification (Ec) and a one-dimensional solution, thus the discussion is at risk of coming to an end. The second utterance opens for discussion (OM) by suggesting an alternative solution building on the first. There is an apparent relationship with the previous utterances, i.e. there is an explicit relationship to the context of the conversation, thus uttered in an elaborated way (Ec).

New aspects

New aspect had invariably a revitalizing function. These inputs were expressed both with and without justifications, i.e. using Elaborated or Restricted codes. The attitude was in most cases Open-minded (OM).

> Michelle: It's going to be too many hares and stuff, if you take away the wolves.
> Fred: But it is good to have hares! //Interrupting utterance//
> Michelle: It's not good to have too many hares … // … they can make damages. //Revitalizing utterance//[The group continues a conversation on damages made by different animals]

In this excerpt, the two students, Michelle and Fred, discuss why the amount of wolves could be a problem. Fred makes a Close-minded (CM) claim without justification (Rc), but the discussion is revitalized by the next input, where Michelle gives a justification (Ec) and opens for new discussion (OM) about the relationship between the populations of hares and wolves.

New perspective

New Perspective was found to revitalize a discussion and was in most cases expressed in an Open-minded (OM) way. In addition, *New Perspective* was often accompanied with justifications (Ec).

> Emily: It has always been that way [wolves prey on reindeers]. //Interrupting utterance//
> Eve: But, one can see that they [the Sami people] get angry, they eat their reindeers. 'Cause that's how they [the Sami people] make a living. //Revitalizing utterance//

Herman: What's the role of wolves anyway? [The group continue their conversation regarding what food wolves prefer]

In the first utterance, Emily concludes, in a Close-minded (CM) way, that the wolf population should not be delimited on the grounds that wolves prey on reindeers. However, Eve introduces a new perspective in an Open-minded (OM) way, together with a justification (Ec), when she suggests that this would cause the Sami people a problem. This fuels the conversation on the issue of wolves and their prey.

Questioning

Students' questioning could not only interrupt conversations, as described above, but also revitalize them. *Questioning*, when having a revitalizing function, was in most cases Open-minded and could be presented with or without justification, i.e. using either Elaborated or Restricted codes.

Ernest: Then they [the Sami people] can keep their reindeers there [fenced in]**!** //Interrupting utterance//

Felicia: Then it has to be a really, really big area with fences, otherwise the pasture will not grow, I mean they have to move the fences because too intense trampling will disrupt the graze land and then the pasture will not grow. So there must be at least two areas. That will take quite a lot of land. //Revitalizing utterance//[The group continue their conversation regarding how to improve the fence solution]

The first utterance, a one-dimensional solution (CM), has the potential to interrupt the conversation. However, the second utterance is considered Open-minded as it questions the solution in a conditional way, describing the many difficulties with suggestions of how they might be overcome. The many details and justifications exemplify the use of Elaborated code.

The impact of attitudes and language on the conversation

The different inputs, as categorized above, were found to interrupt or revitalize conversations depending on how they were expressed with regards to sociolinguistic codes and attitudes (see Table 3).

Codes

As for sociolinguistic codes, we find that they do not in general seem to be of importance for interrupting student group conversations. The majority of inputs, for example *Questioning, Agitational talk, Problem* and *Solution*, were expressed by using either Elaborated or Restricted codes (Table 3). However, Elaborated code appears more frequently among the interruptive inputs indicating a detrimental effect on the conversation. Furthermore, it is interesting to notice that there is a

Table 3. Summary of key inputs with regard to attitudes and socio-linguistic codes

Interruption			**Revitalization**		
Input category (number of inputs)	**Attitude (OM/CM)**	**Code (Ec/Rc)**	**Input category (number of inputs)**	**Attitude (OM/CM)**	**Code (Ec/Rc)**
Questioning (7)	4/3	4/3	Questioning (5)	4/1	2/3
Solution (12)	0/12	7/5	Solution (5)	5/0	1/4
Morals (8)	0/8	8/0	Agitational talk (8)	0/8	4/4
Opinion (2)	0/2	0/2	New aspect (10)	8/2	3/7
Problem (4)	1/3	2/2	New perspective (7)	6/1	5/2
Joke (4)	0/4	1/3			
Sum:	5/32	22/15	Sum:	23/12	15/20

Note: The total number of inputs that interrupt or revitalize conversations are given in parentheses for each category. The number of attitude types, Open-Minded and Close-Minded (OM/CM), and syntactic codes, Elaborated and Restricted codes (Ec/Rc) for interrupting and revitalizing inputs respectively, are given for each category of input.

conspicuous pattern concerning *Morals*, *New perspective* and *New aspect.* Typically, *Morals* and *New perspective* are expressed using an Elaborated code, whereas *New aspect* predominantly is uttered using a Restricted code.

Attitudes

Compared to codes, the attitudes seem to have more impact on the fate of the conversation since Close-minded utterances typically interrupt conversations whereas Open-minded utterances typically revitalize them. A pattern where Close-minded utterances have the function of interrupting conversations is most obvious regarding *Solution, Opinion* and *Morals* (Table 3). In contrast, Open-minded utterances seem to revitalize conversations, as exemplified by *New aspect, New perspective* and *Solution* (when proposed in an Open-minded way).

In sum, conversations are typically re-vitalized when students introduce *New perspective* or *New aspect* in an Open-minded way, the former with an Elaborated code and the latter with a Restricted code. Conversely, conversations can be interrupted when students express *Morals* or *Opinion* in a Close-minded way, the former with an Elaborated code and the latter with a Restricted code. In general, an Open-minded attitude re-vitalizes, whereas a Close-minded attitude interrupts the SSI conversation. However, *Agitational talk* can re-vitalize conversations in spite of being expressed in a Close-minded way.

DISCUSSION

Methodological considerations

There are a number of methodological considerations concerning both the sample and the interpretations. First, the sample is limited to four student groups. Hence, the group dynamics, in other groups or in other contexts, could result in somewhat different patterns. Subsequently, there is a need for further investigation to give a more nuanced portrayal of students' conversations with regard to the function of the described input categories. Second, we analysed the conversation on only one SSI, which may not have stimulated all the students to engage in the conversation. Hence, another SSI could have given a more distinct pattern, especially for some inputs, i.e. those in small numbers (*Opinion*) and those with mixed attitudes and/or codes (*Questioning* and *Problem*). Third, since the study is made on a small sample of analysis units, i.e. utterances, the results must be interpreted with caution. This is especially important for understanding the function of *Questioning* in relation to the expression of attitudes and codes, which requires further investigation. As for reliability, we assume the coding procedure to be acceptable since the discrepancies in coding were small and could be agreed upon after listening to the audiotapes a second time. Although, only applied on a small sample in one context, we believe that our analysis can be considered as step towards a tool for formative investigations of students' small group discussions in a variety of contexts.

The impact of attitudes and language on the conversation

Our result indicates that the sociolinguistic codes seem to be of importance only when it comes to *New aspect, New perspective* and *Morals.* Although attitudes may be more strongly linked to the function of these inputs, the linguistic codes may give further information about the students' conversations. *New aspect* was predominantly expressed using Restricted code. These new aspects add to the precision of the topic by adding further details to clarify the on-going conversation. Since the students in this study had joint experiences of teaching and of small group discussions about the topic, we assume that the *New aspect* needed little explanation

or justification. Hence, a Restricted code would appear to be more efficient for fluent communication within a group where everybody is familiar with the topic (Bernstein, 1974). In contrast, when the discourse is to be enriched with something new and the social context is insufficient to support understanding the relevance of what is claimed, an Elaborated code is typically needed. This is also the case when a *New perspective* is presented, since it represents something which is not part of a present discourse and, thus, its relevance probably needs to be justified. Since the introduction of new perspectives is essential for students' reasoning on socio-scientific issues, Elaborated code appears to be crucial for the development of a multifaceted SSI discussion. This is in concordance with other studies (Zeidler et al., 2009; Zohar & Nemet, 2002), highlighting the importance of justifications in students' reasoning on SSI. Also, the utterances building on morals were expressed by Elaborated code. Elaborated code is possibly needed when morals are introduced as something new to consider and its relevance cannot be taken for granted (Bernstein, 1974). However, as opposed to *New perspective*, *Morals* had the function of interrupting the conversation. As moral perspectives represent an important part of the SSI framework, the finding that *Morals* can close a conversation will be further discussed separately in a section below.

An important role of Open-minded utterances is to overcome the challenges from close-minded utterances in an on-going conversation. Open-mindedness in conversations on socio-scientific issues has previously been described as a consideration of and respect for different viewpoints (Gustavsson & Öhman, 2013; Ratcliffe, 1997; Sadler et al., 2007). In the present study, the students' suggestions of *New perspective* and *New aspect* in an Open-minded way appear in light of the socio-scientific framework (Zeidler et al., 2009) as reasonable and important features of an SSI discussion. Our study contributes to previous research on SSI by bringing attention to the way in which an open-minded attitude can promote a multifaceted SSI discussion. A small fraction of the utterances bearing *New perspective* and *New aspect* were, however, presented in a Close-minded way, but they still had the effect of revitalizing the conversation. These few aberrations can possibly be explained by the fact that the added information could be used by the students to expand or specify their reasoning. This is in agreement with Ratcliffe (1997), who suggested that the quality of students' reasoning was related to the students' proneness to use available information.

To further exemplify the impact of an open-minded attitude, we want to draw the attention to the difference between *Solutions* expressed with Open-or Closed minded attitudes. *Solution* suggested with an Open-minded attitude, i.e. tentative and probing provides alternative ideas that promote further discussion, whereas a Close-minded *Solution* stalls the conversation. Conversations allowing alternative solutions have in other studies been shown to support successful SSI discussions (Evagorou & Osborne, 2013). The contribution of our study is that, it is not the mere suggestion of solution that promotes further conversation, but rather how the solution is presented, i.e. with an Open-minded attitude.

An unexpected finding in this study is that a Close-minded attitude, as conveyed with *Agitational talk*, can fuel group discussion. *Agitational talk* resembles "Disputational talk" (Evagorou & Osborne, 2013; Wegerif & Mercer, 1997) in the sense that it appears as if a student wants to win the discussion. It also includes what Mork (2006) calls "reasoned disputational" talk. The impact of *Agitational talk* raises the question of the role of attitudes and language in different types of organized classroom discussions on SSI. Such discussions can be carried out through, for example, consensus discussions, debates and dialogues aimed at understanding different viewpoints and developing participation skills (Kolstø & Ratcliffe, 2008). As also suggested by Kolstø and Ratcliffe (2008), these different ways of organizing classroom discussions are likely to produce different outcomes,

such as students' understanding of either their personal or others' perspectives and emotions, understanding concepts, as well as decision-making based on critical thinking. In our view, there is a problem concerning whether the desired outcome is decision-making as a personal matter or as a group matter, i.e. should the students develop their personal understanding as well as a more congruent view, or should they develop their skills to participate in a group's decision. To exemplify the problem, a student strongly engaged in a particular perspective, such as protecting the wolf, can with *Agitational talk* easily propel the discussion towards consensus, especially by using an Elaborated code. Thus, other students' perspectives are at risk of being excluded from the discussion. Since *Agitational talk* is Close-minded, fellow students probably need a strong engagement in the issue, or a developed habit to discuss different perspectives (Bernstein, 1974), in order to dispute such claims. Opposition may occur, but according to our findings, agitating students find new opportunities to re-actualize their line of arguments. In that case, the discussion may continue without being neither deepened nor broadened, preventing critical thinking in the sense that the consideration of multiple perspectives is hampered. In such cases, there are few possibilities to develop understanding for different perspectives.

The probably most important problem to consider regarding students' conversations on SSI is their use of *Morals* or *Opinion* as indisputable claims. Productive dialogues are not promoted by indisputable claims since rational reasoning becomes meaningless when views are presented as taken-for-granted facts, thus excluding further discussion. This is a problem when using SSI in science education since, at least, scientific facts are supposed to be considered as tentative and part of temporary agreements within the scientific community. It has been shown that students' critical thinking on scientific knowledge and understanding of the Nature of Science (NOS) are not prevalent among secondary school students (Klosterman & Sadler, 2010; Zeidler et al., 2009). However, the problem of dealing with morals and emotions in SSI discussions is still not addressed. In the present study, students were found to close the conversation when uttering *Opinion* and *Morals* since they were invariably expressed in a Close-minded way. These types of utterances create a potential risk of interrupting the exploration of the meaning of the presented claim as well as other perspectives, at least those related to the presented claim. Personal opinions, as well as morals, are supposed to be shared and discussed in relation to SSI (Sadler & Zeidler, 2005b), both for the development of moral identity and reflexive judgment (Zeidler & Sadler, 2008; Zeidler et al. 2009). Thus, a close-minded attitude among the students will prevent the desirable participation and sharing of meaning for a personal, as well as mutual, understanding. The lack of discussion on morals and its relevance for an SSI, as observed in the present study, indicate a serious problem for the students' development of critical thinking. Without explicit discussion, there are limited possibilities for the students to develop an understanding of others' as well as their own rational for the actualized morals.

Pedagogical implications and future research

The main contribution of our study is that Close-minded attitude hampers fruitful SSI-discussions. Close-minded attitude can support both premature decision-making and the inclusion of morals as taken-for-granted facts. Furthermore, the use of sociolinguistic code will be given special attention since it seem to be important for critical inputs such as Morals and New Perspective, and because Restricted code in general could be detrimental to explorative discussions. Below, we will present pedagogical implications of our results and suggestions for further research. In particular, we will suggest that teachers' development of sensitivity to students' use

of sociolinguistic code and attitude provides opportunities for the promotion of fruitful SSI-discussions.

Much attention has been given to students' use of justifications in socio-scientific conversations (Erduran, Simon & Osborne, 2004; Jiménez-Aleixandre, Rodriguez & Duschl 2000). Our results indicate that an Elaborated code, i.e. the use of explanatory justifications, is important for revitalizing conversations. This is typically observed in relation to introducing new perspectives. Hence, a teachers' prompting students to use more elaborate language (Evagorou & Osborne, 2013; Ratcliffe, 1997) is further confirmed by our results.

Subsequently, previous endeavours to promote students' argumentations skills would seem to be honourable. However, our results also show that Elaborated code is more frequent among the interruptive inputs. Thus, teacher's unreflective focus on justifications can be precarious. The reason being that an Elaborated code can be used to prevent students' development of a multifaceted discussion. This is emphasized by the finding that Morals, which in particular is supposed to enrich the discussion on SSI, can interrupt the conversation when expressed using an Elaborated code in conjunction with a Close-minded attitude. The problem of students' expressing of Close-minded attitude can to some degree be related to the finding that cumulative talk coincides with less developed dialogue (cf. Evagorou & Osborne, 2013). Thus, it seems necessary for teachers to promote the use of Elaborate while maintaining an Open-minded attitude. If students successfully are made aware of the need to make their contributions relevant for the present issue, by making information available to peers for further elaboration, then a multifaceted SSI discussion can be promoted.

Close-minded attitude seem to make discussion unnecessary in different ways. Hence, it is important to give students guidance to avoid using justifications in conjunction with Close-minded attitude in their conversations. Thus, it may be just as important to focus on attitudes as on argumentation skills to enhance critical thinking through discussion on SSI. Subsequently we suggest that the development of teachers' sensitivity to students' use of sociolinguistic code and attitude could enhance their ability to support the development of fruitful SSI-discussions in the classroom. Thus, their possibilities to help students to build an awareness of and to scrutinize their taken-for-granted views are facilitated. Such awareness seems to be especially important when it comes to morals and personal opinions, since these views are necessary ingredients in a fruitful SSI discussion (Ratcliffe, 1997; Zeidler & Sadler, 2008). Untutored student groups are at risk of interrupting the conversation towards a deeper understanding if morals and personal opinions repeatedly are used in a close-minded way. To promote the development of students critical thinking it seems crucial for teachers to formulate learning goals focussing the understanding morals and opinions related to a multitude of perspectives. This can be accomplished if the students are explicitly encouraged to engage in an open-minded explorative conversation. Furthermore, the teacher needs to instruct students to avoid arguing for and to prematurely decide on "the right solution", a problem also shown by others (Evagorou & Osborne, 2013). A focus on decision-making can be detrimental to the conversation. Hence, the explorative phase of the discussion may need to be emphasized. Close-minded attitudes, especially in the form of Agitational talk, should be avoided if the purpose of the discussion is to develop critical thinking. The reason being that a Close-minded attitude prevents students from developing a deeper understanding of their personal view as well as that of others. Agitational talk may be difficult to discern without a developed sensitivity to both sociolinguistic code and attitude since students engaged in Agitational talk appear to be active and perhaps even proficient in using desirable argument patterns.

Our results suggests that further research is needed on student interactions in group discussion, especially with regard to the problems and possibilities concerning students' possibilities to participate in an explorative discussion as a preamble to informed decision-making regarding scientific problems in general and socio-scientific issues in particular. However, at this point little is known regarding the impact of a "fruitful SSI-discussion" on students' abilities to present an informed decision on a socio-scientific issue in naturalistic settings. Subsequently and in order to further explore the value of group discussions on SSI, future research on the outcome of group discussions on group level is suggested.

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