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Students' Use of Open-Minded Attitude and Elaborate Talk in Group Discussion and Role-Playing Debate on Socioscientific Issues

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Abstract

Student-active science teaching that includes interactions among students is suggested to support students' reasoning skills. However, little is known about what are the beneficial modes of interaction to support learning. In the present study, we investigated how different types of classroom discussion on socioscientific issues can encourage students' reasoning skills as expressed in argumentative essays. Qualities of students' talk and reasoning skills were described in terms of attitudes, drawing on Dewey, and sociolinguistic codes, drawn from Bernstein. Qualitative data consisting of transcribed classroom discussions and student argumentative essays were analysed by means of statistical methods. The results describe how specific qualities in students' talk influence qualities of students' argumentative texts. The results indicate that teachers by promoting elaborate talk among students can stimulate more nuanced and elaborate student texts.

Keywords: elaborated code, group discussion, open-mindedness, role-playing debate, socioscientific issues, writing

INTRODUCTION

Student-active teaching has been an educational goal for decades, based on the assumption that it promotes learning (Howe & Abedin, 2013). Student-active teaching can include one or more elements of interactions among students, such as group or whole-class discussions (Arthurs & Kreager, 2017). Research on student-active approaches has focused on students' development of critical thinking and argumentation skills (Fung & Howe, 2012; Jiménez-Aleixandre et al., 2000; van Drie & van de Ven, 2017). In another vein, classroom interactions have been investigated to increase understanding of the characteristics of fruitful discussions (Wegerif & Mercer, 1997). Moreover, relationships between different forms of classroom interaction and students' learning outcomes have been explored. In science education research, students' learning outcomes have concerned, for example, the understanding of subject matter (Alexopoulou & Driver, 1996; Mercer et al., 2004), the development of argumentation skills (Agell et al., 2015; Belova et al., 2015; Simonneaux, 2001), and the ability to make informed decisions on complex socioscientific issues (Bayram-Jacobs et al., 2019; Zeidler & Schafer, 1984). However, few studies have assessed the quality of both students' interactions and students' learning outcomes. Although much research has been done on students' classroom discussions, the review by Howe and Abedin (2013) emphasizes the need for further understanding of group discussion in terms of the most beneficial modes of interaction among students to support learning.

In the present study we investigate if and how group discussions and role-playing debate promote different qualities of talk, and how such qualities can influence students' reasoning skills as expressed in writing. We analyze students' performance when they practice reasoning through classroom interactions on cross-curricular socioscientific issues and subsequently write individual argumentative essays. Specifically, we compare the outcome of explorative small group discussions with confrontational role-playing debate in a larger group. Our study builds on a previous study (Lindahl & Folkesson, 2016b) using a model for assessing students' talk, as well as their texts, to explore the

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Contribution to the literature

- The present study investigates if and how group discussions and role-playing debate promote different qualities of talk, and how such qualities influence students' reasoning skills as expressed in argumentative essays. Thereby, it provides knowledge about beneficial modes of interaction among students to support learning.
- The results show that qualities of group discussion and role-playing debate are different. Group discussions are beneficial for nuanced reasoning on a variety of perspectives, while role-playing debate promotes elaborate talk among students.
- Elaborate talk among students can promote their open-minded reasoning, as expressed in argumentative essays.

assumed relationship between student discussions and their performance in terms of reasoning skills.

BACKGROUND

Student-active teaching that involves interactions among students, and that is aimed at promoting reasoning skills and critical thinking, has attracted much interest, particularly in cross-curricular approaches to citizenship education (see Geboers et al., 2013). In the following two sections, research that addresses group and whole-class interactions in relation to students' development of reasoning skills is reviewed, to elicit current knowledge in this area. In the final section of the background, we present socioscientific issues that provide the context for teaching in this study.

Students' Development of Reasoning Skills through Group Discussions

In a review of research on classroom dialogue, Howe and Abedin (2013) conclude that students' group discussions are beneficial for learning but that little is known about what the most critical aspects are. In science education research, many studies have characterized students' reasoning using two theoretical models: Toulmin's Argumentation Patterns (TAP), which can describe structural qualities of arguments (Jiménez-Aleixandre et al., 2000; Toulmin, 1958), and 'Social modes of thinking', which describes how students interact during group talk (Mercer, 1996; Mercer et al., 2004).

Several studies have used TAP to assess the outcome of students' group discussions regarding students' skills in producing sound arguments in written post-tests (Tal & Kedmi, 2006; Zohar & Nemet, 2002) as well as in group discussions (Osborne et al., 2004). TAP can describe how a claim is supported by supplementary phrases or sentences providing data, warrants, rebuttals and backings. The popularity of using TAP for research purposes resists critiques regarding difficulties in defining warrants and data in classroom discussions (Jiménez-Aleixandre et al., 2000) and in capturing the dialectical features of interactions (Nielsen, 2013). Studies have shown that students' use of TAP as a framework for group discussions does promote the development of their argumentation skills (Jiménez-Aleixandre, 2002; Osborne et al., 2004; Zohar & Nemet, 2002). Typically, students are found to produce more sophisticated arguments in written post-tests (Grace, 2009; Tal & Kedmi, 2006; Zohar & Nemet, 2002) after having participated in group discussions on ethical issues. In the study by Zohar and Nemet (2002), the students improved their use of justifications for claims from one group discussion to another. The above-mentioned studies showed similar results in the sense that group discussions seemed to promote students' use of justifications and rebuttals, as well as their consideration of alternatives in arguments for their own decisions. Hence, students appear to develop their reasoning skills in terms of using explicit and elaborated manners to clarify their positions on ethical dilemmas by participating in group discussions.

Instead of describing students' formal reasoning skills, the characteristics of group discussions can be analyzed by means of 'Social modes of thinking' (Mercer, 1996; Wegerif & Mercer, 1997). Such studies provide information on how student-groups use three different forms of talk - disputational, cumulative and explorative - to share their thoughts. Disputational talk implies arguing against others and defending individual positions, and cumulative talk implies adding information in agreement with others, whereas explorative talk is used to introduce critical, alternative and constructive thoughts into the discussion. Studies have demonstrated a relationship between the quality of students' group discussions and students' development of reasoning skills (Mercer et al., 2004). They have shown that elaborate talk, cumulative as well as explorative, results in accentuated learning outcomes. In addition, explorative talk has been suggested to be particularly important for productive discussions on ethical issues in science education (Lewis & Leach, 2006). In a small case study (Evagorou & Osborne, 2013), two pairs of students characterized as high-achievers and low-achievers were compared in terms of argumentation skills and interaction (social modes of thinking). The high achievers used explorative talk and were shown to improve how they constructed arguments in their

discussion. The low achievers used cumulative talk during the lessons and did not improve their arguments. Analysis of written pre- and post-tests showed that the pair using more explorative talk and a more elaborate manner of discussion developed their argumentation skills, whereas the pair using cumulative talk showed no improvement after four lessons.

Thus, research has shown that group discussions can be beneficial to students' development of reasoning skills. However, there are also studies indicating that group discussions do not necessarily promote students' learning outcomes (Bungum et al., 2018; Grace, 2009; Kuhn, 2015). In a study on group discussions on cross-curricular socioscientific issues, Lindahl and Folkesson (2016b) were able to demonstrate that group discussions displaying few turns with elaborate talk resulted in a low quality of subsequent argumentative essays. Consequently, there is a need for further research to enhance our understanding of the relationship between group discussions and students' learning outcomes. Studies on students' learning outcomes in terms of reasoning skills expressed in argumentative essays are still scarce.

Benefits of Engaging in Whole-Class Discussion, Role-Playing and Debate

In addition to group discussions, research on student-active approaches has focused on whole-class discussions, debates and role-plays as tools for promoting students' reasoning and critical thinking skills. In whole-class settings, discussions or debates can be more or less guided by the teacher, whereas role-plays are directed by a formal situation with given contrasting roles (Akerman & Neale, 2011). Role-plays are often followed up by whole-class discussions to specify, summarize or negotiate to reach consensus.

Studies have shown that open-ended classroom discussions can promote critical thinking (Anagnostopoulos et al., 2008) and the quality of students' talk in terms of elaborate utterances and arguments (Sedlacek & Sedova, 2017). Debates and role-plays, for example, on issues related to climate change (Belova et al., 2015) and animal transgenetics (Simonneaux, 2001), have been shown to promote students' development of reasoning skills and critical thinking. Similarly, students who have participated in whole-class debates tend to demonstrate enhanced awareness of different perspectives as well as more nuanced opinions in written post-tests (Agell et al., 2015; Simonneaux, 2001). In line with these results, Mezuk et al. (2010) showed strong evidence that the inclusion of debates in high school education promotes students' development of reasoning skills, although in general related to the subjects that provide contexts for debate issues.

Thus, studies on outcomes of whole-class discussions, debates and role-plays show that such interactions among students can stimulate critical thinking and reasoning skills. However, little is known regarding the particular qualities in the classroom discourse that have an effect on students' learning outcomes.

Socioscientific Issues as Contexts for Developing Reasoning Skills

The use of socioscientific issues in science education is a prominent example of cross-curricular approaches to citizenship education. Some examples of socioscientific issues include issues related to sustainable development and applications of gene technology. Typically, such issues are open-ended, unsettled problems that cannot be resolved by science alone, because they are cross-disciplinary and often involve contradictory interests. This means that, alongside scientific evidence, social, political, economic and ethical considerations may be involved in the negotiation of socioscientific issues (Ratcliffe & Grace, 2003; Sadler et al., 2007). Consequently, the use of socioscientific issues as contexts for teaching can provide opportunities for students to engage in complex decision-making processes. It challenges students to choose appropriately between sources of knowledge and manners of reasoning in the science classroom (Aikenhead, 2006; Whitty, 2010). Socioscientific issues also encourage students' perspective-taking and development of critical thinking (Kahn & Zeidler, 2017; Lindahl et al., 2019) and reasoning skills (Sadler & Zeidler, 2004; Zeidler et al., 2009).

Insights into the manners by which students engage in classroom discussions are of particular interest for the design and enactment of cross-curricular approaches to teaching. In particular, information on the outcomes of students' participation in the classroom discourse is necessary for a purposeful design of cross-curricular themes (Zeidler et al., 2009).

THEORETICAL FRAMEWORK

Discussions on socioscientific issues provide opportunities to develop critical thinking while aiming at well-informed decision-making. Critical thinking has been described in several ways, using definitions similar to Dewey's notion of reflective thinking (Zeidler & Sadler, 2008). Hence, for the purpose of this study, "reflective thinking" and "critical thinking" will be used interchangeably.

Since the socioscientific issues framework is grounded in Dewey's pedagogy, we will build the theoretical framework for our analysis on Dewey's assumption that reflective thinking is favored by certain attitudes, namely open-mindedness, whole-heartedness, and responsibility (Dewey, 1933). In this study, we focus

on open-mindedness, as it appears to be particularly important for discussions aimed at exploring perspectives related to socioscientific issues. Open-mindedness is an attitude that favors students' interest for new ways of seeing and understanding, their readiness to consider different perspectives, as well as their willingness to change their opinions and stance. Bernstein (1974) also indicated the importance of an open attitude, denoted as open communication code, for acknowledging different perspectives. An open communication code affords many alternative views and fosters the habit of expressing specialized meanings and coping with ambiguities. When using an open communication code, nothing is taken for granted and, therefore, all statements call for justifications and explicit ways of talking. The opposite, a closed communication code, that is, a closed attitude, means that the expression of general and unequivocal meanings predominates in the discussion. Discussion of meanings is superfluous since they are taken for granted. In a science classroom dealing with socioscientific issues, the willingness to consider scientific and other funds of knowledge can be regarded as crucial for participating in a constructive manner as well as for making an informed decision. Hence, the occurrence of open-mindedness can be regarded as an indication of how productive the classroom discussion is.

To describe these different habits of talking, Bernstein uses 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 manner of talking, characterized by a lack of explanations and motives. In contrast, the elaborated code is explicit and typically includes explanations and justifications. Bernstein indicates that sociolinguistic behavior is not to be understood as a capacity, but rather as a linguistic habit that is related to context. In a classroom discussion on socioscientific issues, the introduction of knowledge from different sources, as well as the scrutiny of such knowledge, will require the use of elaborated code to ensure that all participants can engage with and consider proposed standpoints in a constructive manner. Hence, the occurrence of elaborated code can be regarded as an indication of how productive the classroom discussion is.

AIMS AND RESEARCH QUESTIONS

In the present study we will explore the assumed relationship between student discussions and their performance in terms of reasoning skills. Based on pedagogical philosophy (Dewey, 1933) and sociolinguistic theory (Bernstein, 1974) our aim is to investigate if and how group discussions and role-playing debate promote different qualities of talk, and how the different types of interaction can influence students' reasoning skills as expressed in texts. The qualities of students' reasoning in talk and texts will be described in terms of attitudes, that is, communication code and sociolinguistic codes. An additional aim is to further the understanding of how qualities of students' group discussions and debate can be understood in relation to the purposes of the two forms of discussion. Our investigation is informed by the following research questions:

(1) What are the similarities and differences between students' group discussions and debate?

(2) What relationships can be found between attitude and sociolinguistic code in talk and texts between the two conditions?

METHODS

In this study, we use quantitative methods to analyze qualitative data. Our qualitative data comprise students' texts and transcriptions of students' talk. The data are naturalistic in the sense that there is no pre-test that focuses the students' attention on certain aspects of what is investigated here.

Participants

The participating students were 15-16 years old and enrolled in the "Social Science Programme" (preparatory for higher education) at a public upper secondary school with approximately 900 students in a small Swedish city. They participated in "Science Studies", which is a course that is compulsory for all non-science students in upper secondary school in Sweden. The course covers aspects of sustainable development, human sexuality and relationships, individual health and lifestyle, and biotechnology and its implications. Twenty-two students, eight boys and 14 girls, participated in the group discussion condition. Thirteen students, four boys and nine girls, participated in the debate condition. 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 homogeneous groups based on their use of elaborated language, that is, explanatory justifications, in their first argumentative text on a socioscientific issue.

The two participating teachers hold teaching degrees in the natural sciences. The teacher teaching his class in the role-playing condition had 10 years of teaching experience. The teacher teaching his class in the group-discussion condition had three years of teaching experience. The teachers and their classes were chosen because the teachers had participated in a university course for practicing teachers on the use of socioscientific issues in science teaching. During the school year

preceding this study, the teachers had implemented the use of socioscientific issues in "Science Studies" throughout the academic year (approximately 90 hours of instructional time). The teachers' participation in the study was voluntary and motivated by their personal interest in the use of socioscientific issues in science teaching.

Ethics

The students were given information regarding the project, data collection and data handling. They were given the opportunity to decline from participating with the aid of a written description of the project's purpose and data collection to be discussed with their parents. The form was then returned to school signed by the student and a parent, with or without their consent to be a participant.

Setting

In Sweden, the syllabi are goal-oriented with broad descriptions of core content. Consequently, teachers have a great deal of freedom to specify content and organize classroom work, as long as the course objectives can be reached. The classrooms of the two teachers in our study can be described as more student-centered than teacher-centered. The teachers followed their instructional designs without intervention from the researchers and the students' texts were part of the examination process planned by the teachers.

The task in the group discussion condition was to explore the viewpoints conveyed by different stakeholders regarding proposed solutions to the problem of the inbred Swedish wolf population. The task was introduced to the students through a five-minute presentation focusing on the inbreeding of this population (population size 350 wolves). The introduction briefly covered several conflicting perspectives present in the public debate. After the teacher's introduction, the students were given two newspaper articles presenting the views of different stakeholders. Their task was to discuss the articles in groups to share understandings and personal standpoints to facilitate the writing of an individual argumentative text as a homework task.

The task in the debate condition was to participate in a debate on the use of genetic modification techniques to produce genetically modified organisms (GMOs) to increase crop yields for the benefit of a growing population. The teacher introduced the project by giving a short overview of the progress of science from Aristotle to Craig Venter. The purpose was to engage the students in thinking about possible dilemmas as a result of further scientific progress. The students were divided into seven groups, and each given the role of a stakeholder in an international debate on GMOs. The groups prepared for the debate during four lessons (approximately four hours). They searched for information on the Internet regarding different perspectives on the problem and prepared arguments and counterarguments. The students were to learn from their group work and the debate to be able to write argumentative texts on the use of GMOs to be assessed by their teacher. The students started writing their texts during a 60-minute lesson shortly after the debate and the texts were then to be completed at home.

Data

Data from student talk in the group discussion condition were collected during two 60-minute lessons on two consecutive days. The 22 students were divided into four groups during the two classroom discussions (lasting 20 and 23 minutes respectively) that were audio-recorded. Transcripts for analysis consisted of 5136 words. The students' texts were submitted to the teacher approximately two weeks after the introduction of the task. The texts, in total 13926 words, used for analysis had a word count of M = 633 (SE = 74; Min = 126; Max = 1463).

Data from the debate condition were collected during one lesson in which two students from each group acted together as stakeholders in a debate. The teacher acted as moderator, initially giving each of the seven groups two minutes to pose their stands. At the end of the debate, each group was given two minutes to conclude their stand on the subject. The debate lasted 49 minutes and was video- and audio-recorded. Transcripts for analysis consisted of 9644 words. The students' texts were submitted to the teacher three weeks after the debate. Since one student did not produce a text, analysis is based on 13 texts. The texts, in total 7618 words, used for analysis had a word count of M = 586 (SE = 67; Min = 136; Max = 886).

The teachers' grading of the texts, from both conditions, used the A-F scale. For statistical calculations, grades were given numerical values from 5 to 1 for A to E, that is, A=5 and E=1. No F-grade was given by the teachers.

Analysis of Students' Talk

The students' talk was analyzed in terms of attitude and sociolinguistic code by interpreting and identifying the occurrence of the concepts Open-mindedness, Close-mindedness, Elaborated code and Restricted code (Lindahl & Folkesson, 2016a). These concepts were based on the work of Dewey (1933) and Bernstein (1974) as described in the theoretical framework. Transcribed talk from each group was divided into conversation parts. A conversation part was considered to have ended when it appeared to be exhausted as it faded into murmur or took a noticeable pause. Typically, a new conversation part started with a new angle on the task. Conversation turns containing inputs, that is, utterances

Table 1. Examples of Attitude and Sociolinguistic Code in Students' Talk and Text

Code	Talk	Text
OM	*"It could be possible in a more controlled way [keeping a healthy wolf population], 'cause those who actually are affected don't want to, can't live a normal life, like they don't dare to let their kids like go to the bus and such, but sort of, I mean if you can do it in a more controlled way."*	*"I think we should increase the number of wolves to be in the range of 400–500. If we should import or move our wolves, I think we should place them in an area where there are no reindeer or Sami people. We could invest in fences, but there is a risk that we would fence in the wolves together with reindeer and that would be a disaster. If we can't put up fences, then we may need to increase the number of reindeer."*
CM	*"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."*	*"I think the EU's proposition concerning protective hunting is very good! It sounds like a good solution for keeping our wolf population healthy and as safe as possible."*
Ec	*"Why can't we just let it be? I mean nature has like made it work, it's us making those problems."*	*"Today there are many more reindeer than wolves. And I think that if we increase the number of wolves and reindeer, then the Sami people would be happy because they get more reindeer."*
Rc	*"That's sooo awesome!"* [after students had discussed when a wolf was seen in the region].	*"I think the wolf has a right to live here in Sweden."*

OM = Open-minded attitude; CM = Close-minded attitude; Ec = Elaborated code; Rc = Restricted code

that added something new to the conversation (as opposed to simple agreements and clarifications of facts) were coded in terms of Open-minded (OM) or Close-minded (CM) attitude, and Elaborated (Ec) or Restricted (Rc) sociolinguistic code. The concepts, as used in this study, are described below and examples, translated into English, are given in Table 1.

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

Close-minded talk. This attitude is the opposite of open-mindedness in talk. 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.

Elaborated code. A statement that is supplemented with an explicit precision, explanation, or causal justification was considered to be one using Elaborated code. Claims are made with an adjacent explanatory justification for being relevant to the context, that is, the students appear to assume that the meaning and relevance of claims need to be made explicit to other students in order to be understood in the intended manner. Claims expressed with Elaborated code can also have an apparent relationship with previous utterances by the student who is talking or by any of the students in the group, that is, there is an explicit relationship with the context of the conversation.

Restricted code. Simple statements *without* explicit precision, explanation, or causal justification were considered to be using Restricted code. Claims expressed with Restricted code lack adjacent explanatory justification for being relevant, that is, the students appear to assume that the meaning and relevance of claims are unambiguous and obvious to everyone. Claims expressed with Restricted code are uttered without apparent reference to previous utterances by any of the students in the group.

Two researchers analyzed the data. This resulted in 89% (group discussion condition) and 88% (debate condition) agreement between the researchers' analyses. After comparing and discussing the results, the researchers reached a 100% agreement on the results. The number of each of the different codes used by each student was counted in order to be used for statistical analysis.

Analysis of Students' Texts

Two researchers analyzed the students' texts to determine the occurrence of the concepts Open-mindedness, Close-mindedness, Elaborated code and Restricted code (Lindahl & Folkesson, 2016b). These concepts were based on the work of Dewey (1933) and Bernstein (1974) as described in the theoretical framework. The texts were divided into paragraphs, if necessary. Many of the students had already made paragraphs so that the paragraphs contained their reasoning beginning from one perspective or suggested solution. Paragraphs containing more than one, apparently disconnected, focus of reasoning were divided. Parts of the texts that were mere repetitions of given facts without being clear parts of any reasoning were omitted from the analysis.

A sentence or group of sentences describing a problem or a solution were labeled "problem" or "solution". To be assigned the problem label, a description of the "why" or "how" something can be a problem was required to be expressed. The solution label was given where descriptions of how to solve or reduce a problem were presented. The relations between problems and solutions and the complexities of such

relations were analyzed according to the definitions given below in order to distinguish between different types of attitude. After a discussion on the definitions (as seen below) while re-examining parts of the texts, a 100% agreement was reached. The concepts, as used in this study, are described below and examples, translated into English, are given in Table 1.

Close-minded text. Close-minded texts describe a problem from one perspective only, with or without a solution to that problem. They may also describe or reject the presented solution without consideration of any other stakeholders' interests.

Semi open-minded text. Semi open-minded texts describe the essence of two or more problems but consider the problem from only one perspective in the suggested solutions.

Open-minded text. Open-minded texts describe the essence of two or more problems and consider two or more of the perspectives, either by suggesting solutions or by describing an unsolvable dilemma.

The texts were also analyzed with respect to sociolinguistic code using the definitions below.

Elaborated code. A statement that is supplemented with an explicit precision, explanation, or causal justification was considered to be written in an elaborated manner.

Restricted code. Simple statements *without* explicit precision, explanation, or causal justification were considered to be written in a restricted manner.

It should be noted that the demands regarding Elaborated code are higher for students' texts than students' talk, since written language is expected. In their writing, students are expected to use correct punctuation. Hence, a justification or other elaborations added in a new sentence in their writing is considered to be oral language, which will be considered to be Restricted code in our analysis. This is in contrast to students' talk, in which students can elaborate together on their own as well as others' inputs by adding justifications, explanations, etc.

Only parts of the texts concerning perspectives relevant to the task were included, that is, factual descriptions without explicit reference to the described statements were omitted. Two researchers analyzed the data. This resulted in 77% agreement (both conditions) between the researchers' analyses. A 100% agreement was reached after discussing the students' claims that were coded differently. The number of each of the different codes used by each student was counted in order to be used for statistical analysis.

Statistical Analyses

The Semi open-mindedness and the Open-mindedness variables from the texts were computed into one variable (hereafter called Open-mindedness) since texts were found that could contain instances of either Semi open-mindedness or Open-mindedness. This was done in order to make calculations more robust by preventing exclusion or unnecessary influence of mean.

An independent t-test was performed to estimate any differences between the performance variables for the two conditions. To avoid any possible impact of the length of students' texts on the number of Elaborated and Restricted codes, the quotient Elaborated/Restricted code was also included as a variable.

Stepwise linear regression calculations were performed using Close-minded text, Open-minded text, Elaborated code (text), Restricted code (text), Elaborated/Restricted code quotient (text) as variables. It should be noted that when using Elaborated/Restricted code quotient (text) as a dependent variable, Elaborated code (text) and Restricted code (text) were omitted as independent variables since these variables are included in the quotient. Linear regressions were made for the purpose of estimating any causal relationship between students' texts and students' talk. Initial calculations made use of four independent variables. However, due to the low number of participants, each calculation was repeated with only three predictor variables to avoid multicollinearity.

RESULTS

Independent t-test

Differences were estimated between students' performances in the two conditions with regard to talk, subsequent written texts and students' grades (see Table 2). Significant differences between the group discussion condition and the debate condition with regard to students' manner of talking were observed. In the debate condition, utterances with Open-minded attitude ($t(32.87)=16.53$, $p<.001$) were less frequent compared to the group discussion condition. There were no significant differences between the groups with regard to Close-minded talk. Hence, the number of Open-minded utterances can be used to designate the type of classroom discussion.

Another significant difference between the two conditions was the frequency of Restricted code used. Restricted code ($t(33)=5.19$, $p<.001$) was less frequent in the debate condition compared to the group discussion condition, whereas the use of Elaborated code did not differ. The apparent resemblance between the two conditions with regard to Elaborated code is unexpected, since Elaborated code is expected to be required for negotiating boundaries to produce new meanings. Yet, when the difference between the two conditions with regard to Elaborate/Restricted code quotient was estimated, it was found to be significantly higher ($t(13.60)=3.45$, $p<.001$) for the debating students. Hence,

Table 2. Comparison of Talk, Text and Grades for Students in Group Discussion and Debate Conditions

	Discussion groups		Debate groups		t	df	p
	M	SD	M	SD			
Open-minded talk	23.73	4.50	3.38	2.79	16.53	32.87	<.001
Close-minded talk	21.91	3.61	26.85	20.09	-.88	12.46	.397
Elaborated code (talk)	19.91	6.45	19.46	11.10	.13	16.88	.896
Restricted code (talk)	25.73	7.57	10.77	9.28	5.19	33	<.001
Elaborated/Restricted code quotient (talk)	.93	.61	2.71	1.81	-3.45	13.60	.004
Open-minded text	3.09	1.97	2.54	1.85	.82	33	.419
Close-minded text	2.09	1.34	3.46	2.70	-1.71	15.58	.107
Elaborated code text	12.68	7.37	10.77	4.57	.84	33	.406
Restricted code text	9.09	5.18	10.23	5.91	-.60	33	.555
Elaborated/Restricted code quotient (text)	1.63	.96	1.19	.50	1.74	32.69	.091
Students' grades	2.09	1.34	2.38	1.12	0.66	33	.512

Table 3. Standardized weights from linear regression analysis with Open-minded text as dependent variable

Predictor variables	Standardized beta (β)
Elaborated code (talk)	.49***
Restricted code (talk)	-.57***
Open-minded talk	.48**

***p<.001, **p<.01

Open-minded talk, Elaborated code (talk), Restricted code (talk) were used as predictor variables. Close-minded talk was not included to prevent multicollinearity.

Restricted code was more frequent in the group discussion condition, and the relative number of utterances with Elaborated code was higher in the debate condition.

When the students' texts from the two conditions were compared, no significant differences were found. This indicates that the type of classroom discussion appears to have little impact on attitude and sociolinguistic code in students' subsequent texts. Although differences were not significant, it was noted that the mean for Close-minded texts was somewhat higher for the debating students and the mean for Elaborated/Restricted code quotient was somewhat higher for the students performing group discussions.

Regression Analysis

The effects of the qualities of talk on students' texts and grades, as well as the effects of text qualities on students' grades, were estimated. Linear regressions were performed to explore the possibility of using qualities of classroom talk to predict qualities of students' text. It was found that Open-minded attitude in students' texts can be predicted by Elaborated code (talk) and Open-minded talk, but counter predicted by Restricted code (talk) (see Table 3).

The model explained a significant proportion of variance in Open-minded attitude in texts [$F(1,31)=9.37$, $p=.005$; adjusted $R^2=.45$]. Hence, although there was no significant difference between the two conditions regarding attitude and sociolinguistic code in students' text (see Table 2), qualities of classroom discussions seem to have an impact on students' use of Open-minded attitude in the subsequent writing of texts. In order to predict Close-minded attitude in students' texts, we used Open-minded talk, Close-minded talk and Restricted code (talk) as predictor variables. Elaborated code (talk) was omitted from the calculation to prevent multicollinearity. It was found that Close-minded text was counter predicted by Open-minded talk, $\beta=-.34$, $t(33)=-2.06$, $p=.047$. Restricted code (talk) and Close-minded talk were excluded in the calculation. Hence, Open-minded talk could, to a limited extent (adjusted $R^2=.09$), explain the variance in Close-minded text [$F(1,33)=4.24$; $p=.047$]. Consequently, the use of Open-minded talk in classroom discussion has little impact on reducing Close-minded attitudes in students' texts.

Elaborated code (text) was found to be predicted by Elaborated code (talk), $\beta=.48$, $t(33)=3.10$, $p=.004$. Close-minded talk was omitted from the calculation to prevent multicollinearity. Apparently, Elaborated code (talk) could to some extent (adjusted $R^2=.20$) explain the variance in Elaborated text [$F(1,33)=9.64$; $p=.004$]. Hence, the frequency of Elaborated code in classroom discussions seems to promote students' use of Elaborated code in their texts. The use of Open-minded attitude in students' texts was also found, although with limited effect, to predict students' grades, $\beta=.36$, $t(33)=2.24$, $p=0.032$. Elaborated/Restricted code quotient (text) and Close-minded text were excluded from the calculation. Open-minded attitude explained to a limited degree the variance (adjusted $R^2=.11$) in students' grades [$F(1,33)=5.02$; $p=.032$].

DISCUSSION

The aim of the study was to investigate how different types of classroom interactions can encourage students' reasoning skills. Below we start by discussing the limitations and strengths of the study, followed by a discussion on differences as well as similarities regarding students' talk in group discussions and debate. We proceed by discussing how qualities in students' talk can affect the outcome in terms of written argumentative essays. The discussion section ends with our conclusions.

Limitations and Strengths of the Study

Our sample is limited with regard to participants; 35 students from two classes were formed into 11 student groups. This could result in the differences with regard to the use of Restricted and Elaborated codes in students' talk, due to group dynamics, in the two conditions being more or less apparent. Nevertheless, we consider the estimated differences to be interesting and relevant for describing the two conditions, since they can be explained by the different demands tied to the different conditions in light of Bernstein's theory on the use of sociolinguistic code (Bernstein, 1974). The results may have a limited external generalizability for another reason. Although the students from the two classes were not exceptional in any sense, their teachers were trained to have a practical and conceptual knowledge of the use of socioscientific issues in teaching. Socioscientific issues are not explicitly promoted in Swedish syllabi, but there is an emphasis on critical thinking that supports the idea of including socioscientific issues in science teaching. However, like all teachers in Sweden, the two teachers in our study had a great degree of freedom when it came to specifying content and organizing classroom work, and their classrooms could be described as student-centered. Although not unique for the specific context, the participating students may therefore have been more encouraged to use an Open-minded attitude and Elaborated code than most students.

The limited sample resulted in much written data (transcripts and students' texts), which is considered as a strength, especially since the texts were analyzed on an individual level (35 students). The analysis of talk as well as text can be assumed to fairly represent students' oral and written performance. We assume the coding procedure to be acceptable since the discrepancies were small and could be agreed upon after discussion.

Regression analysis was done while taking the limited number of participants into consideration to avoid multicollinearity. The model for predicting the degree of Open-minded attitude in students' text resulted in a high adjusted R^2-value, which is high for studies on human behavior. All three independent variables have a moderate effect on the dependent variable. In addition, regression analysis - although limited in terms of predicting variables - provided an acceptable model, indicating a moderate effect of Elaborated code (talk) on the use of Elaborated code in texts. The other two models show weak effects and can explain the variance only to a small extent.

Explorative Discussions and Debates - Classroom Talk with Different Goals

Student-active learning involving interactions among students can be a way of promoting students' reasoning skills. Studies suggest that both group discussions and debates promote critical thinking (Akerman & Neale, 2011; Grace, 2009; Simonneaux, 2001) and consideration of different perspectives (Lindahl et al., 2019; Kahn & Zeidler, 2017), as well as argumentation skills in the sense that students develop their ability to justify their positions (Jiménez-Aleixandre et al., 2000; Osborne et al., 2004). However, little is still known about how different forms of interactions, such as group discussions and role-playing debates, provide opportunities for students to develop their reasoning skills (see Howe & Abedin, 2013).

In the present study, the group discussions typically allowed more Open-minded attitude than the debate. This is not surprising, since an open-minded attitude was implied in the instructions for the discussion. An explorative discussion that serves to prepare students for informed decisions on controversial and cross-curricular subjects, such as socioscientific issues, needs to be open-minded in the sense that all the different perspectives, for example, scientific, moral, political and personal, have to be scrutinized and considered (Kahn & Zeidler, 2017; Lindahl et al., 2019). In that process, students can engage in reflective thinking (Zeidler & Sadler, 2008), which in turn is dependent on open-mindedness (Dewey, 1933). The significant difference regarding Open-mindedness between the two conditions is also logical since debates can be confrontational (Belova et al., 2015), which is unlikely to encourage an Open-minded attitude. This was the case in the present study, since the teaching design set the focus on competition. Hence, a Close-minded attitude was expected to be more frequent in the debate since debate can be considered to have the function of persuading others as to the most favorable decision. But, in our limited study, there was no significant difference between the two conditions with respect to Close-minded attitude. We can only suggest that the relative difference between the two attitudes, within each condition studied, indicates that a Close-minded attitude has some kind of importance for both forms of interactions. Hence, we suggest that an Open-minded attitude, but not a Close-minded attitude, can be considered *typical* for explorative discussions. Possibly, a Close-minded attitude serves the purpose of reaching a logical and conclusive point in a discussion.

Another significant difference noted between the two conditions was that Restricted code was more common in the explorative group discussion. Restricted code is likely to occur in situations when knowledge and values are supposed to be known and shared by all involved (Lindahl & Folkesson, 2016a). Restricted code will serve to maintain a smooth dialogue (Bernstein, 1974), and this could explain why, particularly in explorative discussions, the group members do not need to explain every claim they make, since they have acquired shared knowledge, for example, scientific knowledge in a specific context, through previous science lessons and reading assignments. Restricted code allows more time

for the students to deal with, for example, different views and explanations. However, if much is taken for granted, different perspectives can remain hidden, thus hampering critical reasoning (Lindahl & Folkesson, 2016a). In contrast to Restricted code, Elaborated code is necessary to clarify what is not supposed to be "common knowledge". This could mean the necessity of presenting developed arguments based on scientific or other funds of knowledge. In the present study, Elaborated code was found to occur as frequently in the group discussions as in the debate. However, the *relative amount* of Elaborated code was significantly higher in the debate. This suggests that Elaborated code, at least in the form of justified claims, is encouraged in both group discussions and role-playing debates, but more so in debates. Although necessary for explaining and clarifying in explorative discussions (Lindahl & Folkesson, 2016a), Elaborated code is crucial in a debate situation since it cannot be taken for granted that opponents understand presented claims and arguments in the intended manner. Hence, the higher relative amount of Elaborated code in the debate situation can be viewed as typical for debates. This conclusion can be understood in the light of other studies, wherein persuasive arguments are obviously advantageous in confrontational debates on socioscientific issues (see Belova et al., 2015) and, consequently, students are likely to use Elaborated code.

Attitudes and Sociolinguistic Codes in Classroom Talk Impact on Students' Written Texts

In spite of there being much research on classroom discussion, in particular group discussions (Howe & Abedin, 2013), little is known about the relationship between features of classroom discussions and students' learning outcomes. The problem of capturing the dialectical features of discussion in qualitative studies using TAP (Nielsen, 2013) implies that other methods are needed to more adequately analyze outcomes, particularly in terms of students' written texts. Studies on the outcomes of debates or group discussions show that such interactions can stimulate argumentation, critical thinking and reasoning skills, as displayed in written texts, but little is known about what qualities in the classroom discourse have an effect on students' writing.

In the present study, group discussions and debate did not result in any significant difference with regard to attitude or sociolinguistic code in students' written texts. The qualitative similarities were also supported by the teachers' grading of the texts. The similarities were taken as a motive for trying to estimate what possible impact students' talk, regardless of situation, could have on their texts. It should be noted that the writing tasks for both groups were similar in that they can be described as argumentative texts, wherein a personal decision should be clarified and discussed, considering multiple perspectives. Hence, both tasks implied the use of Open-mindedness to stress the consideration of many perspectives in students' reasoning while presenting their path towards a personal decision on the issue at hand. By using regression analysis, we were able to describe how specific qualities in group discussions and debate can have an effect on the outcome in terms of students' argumentative texts. The use of Open-mindedness in students' texts showed no significant difference between the two conditions in our study. But regression analysis showed that Open-minded talk, to some extent, could reduce students' use of Close-mindedness in text. The effect of Open-minded talk can be explained by the suggestion that many perspectives need to be considered to reach a well-informed decision (Kahn & Zeidler, 2017; Lindahl et al., 2019; Sadler et al., 2007), something that would be appreciated as an important quality of argumentative texts concerning socioscientific issues. Our calculations also resulted in a model for predicting students' use of Open-mindedness in the texts, which indicates that Open-minded and Elaborated talk encourage the use of Open-mindedness in students' texts, whereas Restricted talk discourages it.

The negative impact of Restricted talk logically supports this model, but also implies that Restricted talk in the science classroom could constrain students' writing of reflective texts since information is presented as being taken for granted and lacking complexity (Lindahl & Folkesson, 2016a, 2016b). The most important conclusion is that the prediction of Open-minded attitude in texts clearly shows how important the use of elaborate talk in group discussion, as well as in debate, is for the quality of students' reasoning in the writing task. The quality of arguments, as sometimes described by TAP (Osborne et al., 2004) in an oral debate does not have to be high, since opposing roles played by students are likely to provide elaborate counterarguments. However, the encounter between elaborate arguments and counterarguments, described in our study as Elaborated code, in both the group discussions and the debate, has a positive effect on students' writing. This implies that the type of interaction (see Belova et al., 2015; Grace, 2009; Wegerif & Mercer, 1997) seems to be less important than the use of language for developing skills for writing argumentative texts. The pedagogical implication here is that teachers have an important role to play in stimulating students to explicitly and meticulously justify their claims in group discussions as well as in role-playing debates.

CONCLUSION AND IMPLICATIONS

When students deal with controversial and cross-curricular issues, such as socioscientific issues, group discussions seem to provide more opportunities for including nuanced reasoning on a variety of perspectives, for example, scientific, moral, political and

personal, as compared to role-playing debate. It is important to note that debate still allows such open-mindedness and that in this respect there is no difference in outcome between group discussions and debate in terms of written argumentative texts. Role-playing debate appears to be more beneficial in promoting elaborate talk. Although elaborate talk encourages students to use precision and justifications in their texts, its most important contribution is to encourage students to write open-minded reasoning texts. Our results indicate that teachers, by promoting elaborate talk and perhaps mitigating restricted talk in their classroom discourse, can stimulate students towards writing more nuanced and elaborate texts on controversial and complex socioscientific issues.

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