Room for discussion?

Examining the role of discussions in students' work with socio-scientific issues

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Abstract

In this thesis the students' experiences of science classroom discussions are examined as well as the nature of their discussions and their ability to take different perspectives while working with socio-scientific issues (SSI). Student questionnaires concerning their attitudes towards school science and science in society, a paper-and-pencil test and focus group discussions have been analysed. The results show that students get to discuss during science lessons, and that they learn a lot from doing so. They also show that the SSI work has brought about a lot of discussions, to which students have a positive attitude. When investigating students' written and oral demonstrations few examples of argument-based discussions or of perspective-taking ability were found. Based on these results I argue that in-service teacher training should be carried out, focusing how to organise SSI discussions so that they support students' development of concepts and of generic skills.

Key words: *Secondary school science, science for citizenship, socio-scientific reasoning*

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1 Introduction

The relatively low student interest in studying or having a career in science is brought up in several studies (e.g. Osborne & Dillon, 2008; Schreiner & Sjøberg, 2006). Many students have a positive attitude towards science, though their attitudes towards other school subjects are even more positive (Lindahl, 2003; Schreiner & Sjøberg, 2006). Why is it so? One possible reason is that the nature of science lessons differs from the nature of other subject lessons. In a study by Lindahl (2003) lower secondary school students point out that discussions during science lessons are rare, compared to what the social science lessons are like. The students experience what they encounter in physics and chemistry lessons to be static, leaving no room for discussions. In a review of Austrian, English and Swedish students' views on science Lyons (2006) claims that in all three countries teacher-centred pedagogy, where unquestionable information is transferred to passive students, dominates science lessons. He argues that the characteristics of science teaching hinder students from engaging with the subjects. One student, quoted in the review, describes the nature of science education as follows:

> "It is like this, learn it because it is right, there is nothing to discuss." (Lyons, p.591)

Given these conditions, I find it interesting to investigate the role of discussions when students work with science in the context of a societal matter. I will examine the role of discussions in the science classroom from the students' point of view.

The aim of this thesis is to examine the role of discussions in science education, and more specifically, the role of discussions in student's working with socio-scientific issues (SSI).. The reason to emphasise the role of discussions is based on two main arguments: on one hand the need to develop skills that correspond to the citizenship-related objective of the compulsory school. The school should strive to ensure that all students should learn to form standpoints based on knowledge and ethical considerations. The students should also learn to discuss and use their knowledge to value statements (Skolverket, 2006a). On the other hand, it is based on the assumption that students' development of scientific concept knowledge is dependent of their participating in dialogue with others (Olander, 2010; Vygotskij, 1932; Wellington & Osborne, 2001). The concept knowledge argument as well as the citizenship argument will be further presented in the theoretical background.

A socio-scientific issue has it base in science, but is also influencing society (Ratcliff & Grace, 2003). The meaning of socio-scientific issues will be further examined in the theoretical background. Support for teaching SSI can be found in the compulsory school's aim to consider students as future citizens of a democracy (Skolverket, 2006a). Students' experiences of SSI discussions as well as the nature of their discussions during work with SSI will be examined in this thesis and the objective is thereby narrowed down, from regarding generic skills such as the ability of formulating personal arguments and criticising claims made by others to putting these skills in relation to citizenship.

Further, the focus is on how students' ability of taking different perspectives is demonstrated in their work with socio-scientific issues. The ability of perspective-taking is described by Sadler, Barab and Scott (2006) as one of four aspects of socio-scientific reasoning. According to the Swedish curriculum the compulsory school should offer a historical, an environmental, an ethical as well as an international perspective to education. The importance of students taking the perspective of other people is also stressed, formulated in the following goal: "The school should strive to ensure that all pupils can empathise with and understand the situation other people are in and also develop the will to act with their best interests at heart" (Skolverket, 2006a, p. 8).

1.1 Objective and research questions

The objective of this study is to examine the role of discussions in science education in general and in students' work with socio-scientific issues in particular. The focus is on students' discussions and their ability to take perspectives while working with socio-scientific issues. The research questions are:

1. How do students experience discussions in regular science lessons?

2. How do students experience discussions in their work with socio-scientific issues?

3. What is the nature of students' discussions about socio-scientific issues?

4. How is the students' ability of perspective-taking demonstrated in their work with socio-scientific issues?

2 Theoretical background

Is students' participating in discussions in science education important? Students' engagement in science might improve if the information presented in the classroom includes a negotiable dimension. In the following section the benefit of science classroom discussions will be presented. It is based on two main arguments: on one hand, the need to for students to develop certain skills preparing them for a future as decision-making citizens of a democratic society. On the other hand, the assumption that appropriation of scientific concepts is essential to learning science and that complete appropriation only can take place if students are given the opportunity of testing and re-accentuating new concepts in dialogue with others.

First the concept of discussions will be examined, followed by the concept knowledge argument and the citizenship argument for discussions in the classroom. Further the idea of the socio-scientific issues will be introduced, including its aspects of decision-making and perspectives. Finally the project Science in Social Context (SISC) will be presented, describing the general approach and the outline of the cases on which the teaching sessions studied in this thesis have been based.

2.1 Discussions

The central concept of this thesis is “discussion”. Though the concept has not been specifically explained to the students participating in the project I have had a certain meaning in mind when interpreting their statements about the role of discussions in the science classroom. In this thesis the meaning denoted to the word is based on a dictionary definition saying that a discussion is: “a dialogue (about a certain issue) in which the participants argue for their opinions and may influence each other” (Nationalencyklopedins ordbok, 1995, p.292, my translation, Swedish original text). The meaning of an argument is based on the same dictionary: ”a condition presented to support a certain opinion” (Nationalencyklopedins ordbok, 1995, p.55)

In the curriculum for the Swedish compulsory school system it is expressed that opportunities for discussions should be abundant in order to help students to develop their ability to communicate. Students should be able to critically examine facts and estimate the consequences of different decisions (Skolverket, 2006a).

2.2 Concept knowledge

The language dimension is present in all science education, from the early ages and throughout the school years. It is important for students to be able to take part in dialogues with a scientific content using scientific concepts and models (Skolverket, 2000). Below the development of concept knowledge is presented and put in relation to learning science and the interactions with others.

2.2.1 Scientific concept knowledge

Vygotskij (1934) claims that the development of a child's language and meaning of words is dynamic, and that a full concept comprehension of a new scientific concept can never occur right away. According to Vygotskij, scientific words can only be understood when being highly generalised, thus when they are localised in a system of interconnected concepts. Wellington and Osborne (2001) point out that highly abstract concepts such as ”work”, ”energy” and ”volume” represent the area where most learning difficulties are encountered. These concepts depend on prior understandings of other words why all of them could be seen as dependent parts of a network. If the prior understandings aren't sufficient the structure collapses. An additional problem is that many of the concepts have one denotation in students' everyday life and another one in a scientific context. For instance students already possess a personal conception of “work” and “energy” when entering school science education, where they are introduced to the scientific meaning of the same words.

Young people's development of, on one hand scientific concepts, and on the other hand everyday concepts is sometimes presented in contrast to each other. The scientific concepts are learned from a verbal definition via a system of interrelated concepts down to something concrete. The everyday concepts are rather learned outside of such concept systems, moving from personal experiences towards a generalisation (Mortimer & Scott, 2003; Vygotskij, 1934).

2.2.2 Dialogue and appropriation of words

In Iglands and Dysthes presentation of Mikhail Bakthins ”dialogue concept” the dialogue is described as a necessary condition for development of concept knowledge. A person can only appropriate, i.e. take something existing from the ”outside” and internalise it, by taking part in dialogue with texts or other people (Igland & Dysthe, 2003). When interacting with people or texts new ideas and concepts can be tested, re-accentuated and personally denoted, thereby giving the individual an opportunity to be comfortable with a new discourse or to get a clearer conceptual understanding than before (Igland & Dysthe, 2003; Newton et al., 1999, Zeidler, 1997).

2.2.3 Discussions for concept knowledge

Wellington and Osborne (2001) claim that students don't have a chance of understanding words of a high level of abstraction unless careful notice is taken to language in the science classroom. They stress that one can not be allowed to develop an individual meaning of scientific language, since the purpose is that knowledge and meaning should be shared. As a part of learning science it is important for pupils to explore their own views as well as those of others in order to develop their science language. Wellington and Osborne therefore suggest that pupils should be given opportunities to practise communicating and collaborating in school. Newton et al. (1999) argue that talk offers an opportunity for learners to challenge and doubt their conceptual understandings. When the students are forced to justify their views this can bring about clearer understanding of the concepts since other students will doubt and present alternatives to these views.

Olander (2010) examined students' talk during a teaching session focusing biological evolution. Seven peer groups were videotaped while discussing the alternatives of one multiple choice question concerning the origin of variation among living organism. Olander found that the students' negotiated and contrasted the meaning of some key notions with their opposites during the discussions. This talk was expressed in three types of social language: colloquial-, inter- and scientific language. The analysis of the peer group discussions showed that students' alternating between different social languages was favourable since it triggered them to refine their argumentation and since students' putting a colloquial term in scientific context helped them to make meaning of it.

2.3 Citizenship

The curriculum for the Swedish compulsory school system stresses that all school activities should be based on fundamental democratic values and that everyone working in school should act as role models by using democratic working methods in class. The main aim of the compulsory education is to prepare students to be future citizens of the democratic society (Skolverket, 2006a). In the following passage the citizenship aspect of education will be presented in relation to science education and the work with socio-scientific issues.

2.3.1 Science for citizenship

To participate fully in the society an understanding of science and technology is central (OECD, 2006). In the National Evaluation of the Swedish compulsory school, NU03, the scientific culture is emphasised as the foundation on which our society stands, referring to the need of maintaining and improving physical and social infrastructure and understanding the planet on which we all live (Skolverket, 2003).

The scientific areas of knowledge are increasingly specialised, bringing about a repertoire of specific concepts and methods which is unique for each area. For lay people to get a holistic view of science, or a holistic view of the society for that matter, is very difficult when knowledge is being fragmented and frontier science is known by only a few (Skolverket, 2003). Kolstø (2001) argues that the quality of the decisions made by lay people is of fundamental importance in democratic societies. Therefore lay people need knowledge of the science involved in the issues on which the decision will be made. They also need to know the characteristics of scientific knowledge in general. Bingle and Gaskell (1994) argue that citizens need the ability of making decisions in a world where it is often very difficult to distinguish between the different claims carried out in the debate. Further it is pointed out that those who are missing a basic understanding of the relation between science, technology and the socio-political environment could easily be disempowered and misled when exercising their democratic rights (Hodson, 2003; OECD, 2006).

2.3.2 Scientific literacy

Swedish students performed around the mean for OECD countries in the PISA 2006 assessment of 15-year-old students' scientific literacy. The Swedish students performed above average when it came to knowledge of scientific concepts and theories, and below average when it came to knowledge of the nature of science (Skolverket, 2006b). The concept “scientific literacy” defined in the PISA 2006 is closely related to the matter of education for citizenship (OECD, 2006). The question of what citizens ought to know about science and technology as well as of the students' values and abilities was central when the test was developed. In the framework for the PISA 2006 test “scientific literacy” refers to the individual's:

- Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
- Understanding of the characteristic features of science as a form of human knowledge and enquiry
- Awareness of how science and technology shape our material, intellectual, and cultural environments
- Willingness to engage in science-related issues and with the ideas of science, as a reflective citizen. (OECD, 2006, p. 23)

The concept represents a view on science as something which is urgent for every person to embrace, not only for those who aim for a career in science. The OECD definition emphasises not only the need to have scientific knowledge, but also the importance of knowing how to find out the things that you need to know about issues with a scientific content. Knowledge of the nature of science, an area on which Swedish students performed below the OECD average, is also stressed.

2.3.3 Socio-scientific issues

The science-related matters of everyday-life often include a web of different scientific disciplines in which also other aspects, such as economy and politics, are integrated (Skolverket, 2006b). According to Ratcliff and Grace (2003) a socio-scientific issue is one “which has a basis in science and has a potentially large impact on society” (p. 1). The following is suggested to describe the characteristics of a socio-scientific issue:

The nature of socio-scientific issues

- have a basis in science, frequently that at the frontiers of scientific knowledge
- involve forming opinions, making choices at a personal or societal level
- are frequently media-reported, with attendant issues of presentation based on the purposes of the communicator
- deal with incomplete information because of conflicting/incomplete scientific evidence, and inevitably incomplete reporting
- address local, national and global dimensions with attendant political and societal frameworks
- involve some cost-benefit analysis in which risk interacts with values
- may involve consideration of sustainable development
- may require some understanding of probability and risk
- are frequently topical with a transient life (Ratcliff & Grace, 2003, p. 2-3)

These criteria imply the complexity of the general socio-scientific issue. Bingle and Gaskell (1994) point out the several dimensions of conflict that lie within each socio-scientific issue. The nature of the issues is generally complex, including claims from what they refer to as "science-in-the-making". They explain that science-in-the-making is presently being done in laboratories and publicly debated. This kind of science differs in its nature from the stable school science that students encounter in class and in textbooks. It is also seen as an uncertain form of knowledge, and distinguishing claims based on this kind of science from mere opinions can not easily be done. Bingle and Gaskell argue that because of conflicts within the scientific community as well as in the society as a whole a person trying to form a standpoint in the matter must handle information from many different, often biased and incomplete, sources. According to the syllabus for lower secondary school science students should be able to do so, using their knowledge about science and scientific methods (Skolverket, 2000).

2.3.4 Decision-making

In the work with socio-scientific issues the goal is often to come to a decision on the matter being discussed. Bingle and Gaskell (1994) point out nuclear energy and global warming as common examples of what students need to be able to make decisions on. Kolstø (2001) argues that students should be able to identify underlying ideologies and biases in the arguments they are facing and that they should know when to ask for further evidence. There is rarely an absolute, "right" answer to how to solve the problem. Rather, several sources of information should be included and evaluated when forming the base for a decision:

> Because we have different wishes, values and beliefs, society is laded with these sort of conflicts. Such conflicts can not be solved by means of value-free evaluations or calculations, but have to be negotiated: therefore we need politics and discussions to *weigh values that in principle cannot be weighted.* (Kolstø 2001, p. 298)

When dealing with complex issues not only the weighing of different scientific facts influence the decision. Facts can often be overcome by a person's spontaneous emotion connected to the issue. Newton et al. (1999) stress that also scientific arguments can be subjective and that scientist can be influenced by personal values as well as by the culture of the society in which they live. Ekborg (2002) has, as part of a longitudinal study, interviewed Mathematics and Science teacher students in programmes oriented towards school year 1-7. Her aim was to examine how the students, during their teacher training, developed conceptual knowledge relevant for environmental education and ability to discuss complex environmental issues. She interviewed the students once in their first, second and fifth semester of teacher training. When asked to make comments on an article concerning whether the waste heat of a crematorium should be part of the system for district heating most students expressed a personal opinion. In most cases they answered in the same way throughout the three different interviews. Even though the arguments were more elaborate in the third interview, the students mainly used the same arguments as during the first interview. Several of them had by the time for the third interview visited a district heating plant as a part of a technology course. If having grasped the idea of what heat in general is and in of what the heating system suggested in the article is, Ekborg claims that one should realise that one would not get in contact with the dead in any way if the crematory contributed to the district heating. Some of those who had caught the idea of district heating did stay with their emotionally based answers, though they emphasised the contradiction between their science knowledge and their emotions. Many of the students expressed examples of personal "what-if" (e.g. what if it was my dead mother who was cremated and heating up my house?) in order to underpin their opinion.

2.3.5 Perspectives

By practising to take different perspectives the students may become better at making logical and scientific decisions on socio-scientific issues (Zeidler, Walker, Ackett & Simmons, 2002). The importance of openness to different ideas is emphasised in the curriculum for the Swedish compulsory school system. Education should demonstrate a wide range of different approaches and give room for pupils to form their own standpoints (Skolverket, 2006a).

> It is important that education provides general perspectives. An historical perspective enables pupils to prepare for the future and develop their ability to think in dynamic terms. An environmental perspective provides them with opportunities not only to take responsibility for the environment in areas where they themselves can have a direct influence, but also to form a personal position with respect to global environmental issues.(Skolverket 2006a, p. 6)

If students are trained in socio-scientific reasoning it should improve their ability to analyse complex issues from different perspectives (Sadler et al., 2006). From a study of 14-year-old students' dialogues, Kolstø and Ratcliff (2008) argue that secondary school student opinions are self-centred, requiring much evidence for them to change into a more balanced view point. In the longitudinal study referred to above, Ekborg (2002) describes the news paper article as possibly engaging many groups of interest. The obvious, Ekborg writes, is the conflict between the politician who wants to include the crematorium in the community district heating system and the priest who does not approve of the idea. Further the citizens of the municipality can be thought of as a group of interest. Though the conflict between science and emotions where mentioned by several, very few of the teacher students brought up the conflict of interests presented in the article.

2.3.6 Discussions for decision-making

The ability of examining different perspectives is important when forming a base for decision about socio-scientific issues. In the SSI a consensus is seldom recognised, thereby it is not possible to find an objective "right" or "wrong" to base the decision on (Bingle & Gaskell, 1994). Science education is argued to be an important area for students to practise the ability to understand and evaluate the arguments of the parties involved in a SSI conflict, and to form arguments and draw conclusions of their own (Newton et al., 1999). Zeidler (1997) claim that discussions are important for students when it comes to practising argumentation since discussions force the students to adapt their internal reasoning to the reasoning presented by other individuals. In small group discussions students are also forced to justify the reason for their claims, if the work form is used in an effective way (Wellington & Osborne, 2001).

2.3.7 The project Science in Social Context

The researchers of the Science in Social Context (SISC) project group aim at studying students' development of interest, knowledge and self-efficacy in their work with socio-scientific issues. They are also interested in what knowledge teachers develop while teaching SSI-based science. In order to do so they have constructed six cases with content that qualifies them as socio-scientific issues according to the definition made by Ratcliff and Grace (2003). The cases were presented in a guide handed out to the teachers participating in the project. All cases contained a starting point inspired by an excerpt from some kind of media (e.g. a news paper article or an internet blog). The teachers were supposed to work with the project for at least five lessons and to plan for small group discussions at some point of the teaching session. In the teacher's guide some examples of questions to work with were presented. Apart from the starting point, the small group discussions and a minimum of five lessons the teachers were free to organise the project teaching as they found suitable (Ekborg, Ideland & Malmberg, 2009).

Ekborg et al. (2009) suggest a framework to analyse and construct SSI cases for the secondary school. In the description they include the six cases of the project referred to above. The six cases had been chosen so that they include different aspects of science and technology, which science components are specified in the table below. Further, the nature of the scientific knowledge base, the social content and for what the scientific knowledge should be used, is presented as important components when analysing and constructing SSI cases. The level of conflict which lies within the socio-scientific is also included.

Table 1. Conceptual framework with six components. The table also shows how the components can vary in six examples of SSI-cases. (Ekborg et al., 2009, p.42-43)

Component	**Case**					
	1. You are what you eat?	2. Laser treat-ment and short sightedness	3. To hear or not to hear?	4. Me, my family and global warming	5. Are mobiles hazardous?	6. Climate-friendly food in school?
1. Starting point	TV-programme	Personal homepage	Excerpt from novel	Family situation	Newspaper articles	School canteen
2. School science subject	Biology and chemistry	Biology and physics Technology	Biology and physics Technology	Chemistry and physics Technology	Biology and physics Technology	Chemistry and physics Technology
3 Nature of scientific knowledge base	Well-known, but information is often misleading and science is used incorrectly.	Well known and the scientific content is often correctly presented.	Well known and the scientific content is often correctly presented.	Well known and the scientific content is often correctly presented. Difficult to judge.	Not agreed upon.	Difficult to judge.
4. Social content	Media power Economy Personal responsibility	Identity Economy Politics	Identity Values Economy	Personal responsibility Economy Politics	Media power Economy Personal responsibility	Personal responsibility Economy Politics
5. Use of scientific knowledge for	Critical thinking Scrutinize information	Decision – making Clarifying Risk assessment	Investigation and clarification Cost-benefit	Decision –making	Decision-making Cost benefit Risk assessment Scrutinize info Critical thinking	Act to make a change Cost-benefit
6. Type of conflict	Individual level	Individual level Priorities in society	Individual level Groups of individuals	Individual and structural level Family, Priorities in society Regional and international	Individual level Who benefits from what information?	Individual and structural level Family, Priorities in society Regional and international

In the passage describing the methodology of this thesis one example of the cases, “Me, my family and global warming” is further presented.

3 Methodology

The thesis is based on data from the SISC project. For the thesis I could dispose two questionnaires filled-in by all students participating in the project as well as the data from one classroom study. When the research questions were formulated I knew what data that was at my disposal, though I had not read or listened to any of it. My research questions were discussed with one of the SISC researchers before I continued with the study. In order to encircle students' opinions on the role of discussions in the science classroom in general and in their working with socio-scientific issues in particular the student responses to certain statements chosen from two questionnaires has been in focus. In addition to this, recordings from three focus group interviews have been transcribed in verbatim, focusing the students' claims regarding discussions in the science classroom in general as well as their claims regarding discussions during their working with the SSI project. Analysing the transcripts of the focus group interview attention has also been drawn to the nature of the students' discussions and to their ability to take different perspectives. To investigate students' ability of perspective-taking their responses to a paper-and-pencil test task has also been the item for analysis. The process of data collection and analysis is described below.

3.1 Sample

The SISC group found 70 teachers and their classes in lower secondary school volunteering to participate. It was done by the SISC research group getting in contact with head teachers and visiting schools of one northern and one southern region of Sweden. Altogether 1500 student from grade 7 to grade 9 participated. Big city schools as well as village schools are represented in the data material. The teachers could choose from six cases in a teacher's guide which one to work with. A case study was performed in an eighth grade at a lower secondary school, situated in a small community in the northern region of Sweden. For the case study the SISC group followed this teacher during her project teaching, observing the lessons and making field notes, recording classroom work, handing out a paper-and-pencil test, interviewing teachers and interviewing focus groups. There class consisted of 29 students, aged 14. The teacher had chosen the SSI case “Me, my family and global warming” which will be described below. For the classroom study the teacher and her class were chosen by convenience-sampling: the teacher had agreed to participate in a classroom study as well as the students and their parents. Further the time for the teacher's project teaching was convenient for the SISC group. Altogether fifteen of the students from the classroom study participated in three focus group interviews (Ottander, 2010, personal contact).

To get empirical material that could answer the research questions I selected the two student questionnaires, the three focus group interviews and the paper-and-pencil-test from the existing data. The students of the classroom study were anonymous to me, apart from my knowing the first names of those participating in the focus groups. The first questionnaire has been answered by 1459 students. The missing responses are about 10% for each statement. In the second questionnaire 1137 students have responded. The missing responses for each statement are about 24%, since the initial number of 1459 students still is counted as the whole group. The increased loss can mainly be explained by the fact that the responses of whole classes never were sent in to the research group after the project had ended. The paper-and-pencil test was answered by 20 out of 29 students (68%) in the classroom study. The test was distributed on the last project lesson, when a few students were absent due to illness and one was away on an internship. A few students were granted an extra day to answer the test, but the SISC researchers did not receive all of those late tests when returning to the school the day after (Ottander, 2010, personal contact).

3.1.1 Me, my family and global warming

In the case study, students' experiences of the SSI project work as well as their discussions and a perspective-taking ability has been in focus. This group has worked with the case “Me, my family and global warming”. Ekborg et al. (2009) describe this particular case as oriented towards students taking action and changing their ways of living. The case is constructed to concern the students at a personal level. The task is to make a realistic plan on how the family can decrease their carbon dioxide emission by investigating what their current situation is like and what they could change. Different alternatives, to for instance transportation, should be investigated and ecological, scientific, economical aspects should be taken in consideration. In the teacher's guide the following is presented (my translation, Swedish original text):

> **Mission**
> You will give a suggestion to how you and your family or how your municipality can help to decrease the emissions of carbon dioxide. To do so you must investigate what the situation is like today.
> – How do you in your family travel?
> – What vehicles do you use in your everyday lives and in your spare time?
> – What kind of fuel is used for the vehicles?
> – What other alternatives are there to get to the places you travel to? Are there other solutions? Do the alternatives imply that the carbon dioxide emissions will decrease?
> Show how much you can decrease your emissions by choosing other alternatives and explain as thoroughly as possible what you need to do. Discuss what is possible for your family to do and what you find important. What more do you need to learn in order to succeed in dealing with the mission? Where can you read about this? Who can you ask? You will show your results and compare it with the results of others. This is done either for a group or for the whole class. It is especially interesting to talk about the things you do not agree on. Try to explain why you do not agree. (SISC project group, n.d., p.25)

The teacher's effectuation of the project teaching were in line with what was purposed in the guide (Ottander, 2010, personal contact).

3.1.2 Questionnaires

The first student questionnaire was filled in before the students had taken part in the project teachings. The aim, formulated by the SISC research group, was to describe the work forms that the students were used to as well as their personal attitudes towards school science and science in society, their self-efficacy and beliefs about learning. The second questionnaire was distributed immediately after the project had ended. The aim was to measure the characteristics of the SSI work and its outcomes. Altogether the questionnaires consisted of 144 statements (Ottander, Ekborg & Rehn 2009). From these statements I selected those that corresponded to my research questions. The selection was based on the statements' connection to discussions, reasoning or perspectives. I extracted the sought-for data from an SPSS™ file to which all students' responses had been transferred by researchers of the SISC project. The extraction was made based on the case study group in particular as well as on the group consisting of all the students participating in the project. From the first questionnaire the students' responses to the following statements were extracted:

1. We get to discuss during science lessons.
2. I learn a lot from discussing during science lessons.
3. During science lessons my teacher talks a larger part of the time.
4. We discuss too much during science lessons.

These statements were chosen since they were estimated to give an indication on how students experience discussions in the regular science classroom**.** From the second questionnaire the students' responses to the following statements were chosen since they were estimated to give an indication of how students experienced discussions in the SSI project work:

5. We discussed a lot in the group.
6. It was fun to discuss the questions of the task
7. My friends found my view points important.
8. I can argue for my opinion.

The students could respond to each statement by ticking one of five boxes of a Likert scale, with disagreeing on one end and fully agreeing to the current statement on the other end. In this case, a student's ticking box denoted 1 stand for fully agreeing, while ticking box 5 implies disagreeing to the statement. In the analysis of the data, a student's ticking box 1 or 2 has been interpreted as an agreement while choosing box 4 or 5 is seen as the student not agreeing to the current statement. A ticked-for box 3 is read as the student's being indifferent to the statement, not fully understanding the statement or answering that they neither agree nor disagree. In the result presentation, number 3 responses are presented in a separate group named "neither-nor" to facilitate the interpretation of whether the statements apply to the students' views or not.

3.1.3 Focus group interviews

In the case study three focus group interviews have been performed by three researchers from the SISC project group, one per interview. The idea of a focus group interview is that the respondents are the ones who should talk. The interviewer's task is to guide the discussions so that the subjects being ventilated are of interest to the researchers. I knew the interview outline before I listened to the recordings. From this I judged that there was a possible opening for students' claims coinciding with the objective and research questions. The emphasis of the interview was on how the students had experienced the SSI work and how they responded to a task similar to the ones they had worked with during the project. Other areas of interest were how students handled criticism of the sources and if the project had influenced them or their families to change their habits.

When describing students' ability of taking different perspectives in their working with socio-scientific issues the guide has been the distinction of four aspects of socio-scientific reasoning, i.e. complexity, perspectives, inquiry and scepticism described by Sadler et al. (2006). They have distinguished four levels of perspective-taking ability and from their work with students negotiating socio-scientific issues exemplar quotes has been given to each one of them. As indicated in the table below, the student must present some kind of argument for his or her opinion in order to demonstrate an ability corresponding to level 2 or higher.

Table 2. Levels of complexity in ability to take perspectives, which is one aspect of socio-scientific reasoning (Sadler et al., 2006, p. 380).

	Level 1	Level 2	Level 3	Level 4
Perspectives	Fails to carefully examine the question.	Assesses the issue from a single perspective.	Can examine a unique perspective when asked to do so.	Assesses the issue from multiple perspectives.
Exemplar quote	P: I'd stick with that [nuclear power] I: Why would you think that would be the right decision? P: I have no clue.	P: They should add some more fish and cut the boating... it's the right decision and it's the only option they have. They don't have anything else to work with.	P: If the city doesn't have enough money, the coal would be better... I: Why might someone disagree with your solution? P: They might live colers to it [coal plant] and be affected more...	If you build a nuclear power plant, the city's environmental health could be destroyed... but it could be better using nuclear power but there is a risk if there are accidents...

The interviews were transcribed in verbatim. I transcribed all parts of the recordings equally thoroughly. When analysing the data the focus was on students' claims regarding discussions in science lessons in general and in their working with SSI in particular. I was also interested in the nature of the discussions, and particularly how the students demonstrated the ability of taking different perspectives while talking. In the interviews I have listened for examples similar to those Sadler et al. (2006) present. I was looking for sections in the interview where the students spontaneously gave examples of their ability to take perspectives, as well as examples when the interviewer had asked them specifically to do so.

3.1.4 Paper-and-pencil-test

The students of the case study group had taken a paper-and-pencil test after having finished the SSI project ”Me, my family and global warming”. The test consisted of tasks that covered factual knowledge as well as students' ability of formulating questions, taking different perspectives and keeping a critical approach to the information which was being presented to them. I made copies of the students' responses to task 8 and 9 of the test taken by the case study group. The focus for the analysis was on the students' ability of taking different perspectives in their formulated questions to a politician and to a climate researcher. Again, the levels of perspectives distinguished by Sadler et al. (2006) were my source of categorisation when analysing the data. In contrast to the focus group interviews, where the students' different claims possibly could be examples of all four levels, this analysis only determined whether the students could examine a unique perspective when asked to do so (representing level 3 in Table 1 above). In the paper-and-pencil test, the students' responses to the following tasks have been analysed:

8. Ask a politician. Assume you meet a politician in your home town. Which three questions would you ask him/her about the climate?
9. Ask a scientist. Assume you meet a climate researcher. Which three questions would you ask him/her about the climate?

To determine if the students demonstrate an ability of taking perspectives corresponding to level 3 in the table above I have formulated three criteria. If not meeting the criteria the student response can belong to level 1 or 2, but to tell which one of these lies out of reach for this study. The criteria were determined after I had read the students' test responses.

1. The students must have addressed at least one question each to the two fictive characters.
2. The students' questions to the politician should not be the same as the questions to the scientist.
3. The questions should be formulated in consideration of the certain areas of expertise and influence which is related to the two fictive characters. It should be possible for a reader, if all questions were renumbered and scrabbled, to determine to which character the question is addressed. Such distinguishing should be possible for at least one “politician question” and one “scientist question” per student.

It is obvious, that if a student fails in meeting criterion 1, neither one of the following criteria can be met. The case is similar regarding criterion 2, since it is not possible to meet criterion 3, hence to distinguish between questions, if the same are asked to the politician as to the scientist. Given the way the criteria are formulated, there is a possibility of one or two of the questions being identical for both characters, while the second, or the second and third question addressed to each character is distinguishable. I order to determine to which character the questions are addressed I have paid attention to the following:

Politician questions: Is the question posed in regard to what the politician should have certain knowledge of (e.g. statistics and information about the municipality)? Is the question addressing the politician's certain area of influence (e.g. the prices or accessibility of public transport, plans for improving the environment)? If so, the question is regarded as “distinguishable”. *Scientist questions:* Does the question concern what the scientist could be supposed to have certain knowledge of (e.g. climate statistics, what fuel to prefer concerning what is best for the environment, questions about the Greenhouse effect and polar ices melting)? If so, the question is regarded as “distinguishable”. Personal questions with clear connections to the characters' occupations (e.g. do you enjoy being a researcher?) are also regarded as “distinguishable” in the matter of students demonstrating ability of perspective-taking.

After I had formulated the criteria I renumbered the questions and cut them apart. Using the criteria I then matched each isolated question to one of the headlines: “Politician”, “Scientist” and “Not distinguishable”. This procedure make up what I from now on will refer to as my analyse tool. Two peer students have used the analyse tool to perform the distinguishing procedure, in order to test its reliability (Appendix A).

4 Results

The results of the study will be presented in accordance to the order of the research questions: i.e. first the result regarding science classroom discussions, followed by results regarding discussions in SSI work and finally the results regarding students perspective-taking ability.

4.1 Discussions in the science classroom

The results are shown in tables and diagrams in which I have translated the Swedish original questionnaire text. In the analysis of the data, a student’s ticking box 1 or 2 has been interpreted as an agreement while choosing box 4 or 5 is seen as the student not agreeing to the current statement. A ticked-for box 3 is interpreted as a “Neither-Nor”-response in the tables and diagrams. If not otherwise described, the distribution of responses for the whole student group resembles that of the case study group.

Table 3. Distribution of questionnaire responses for the whole student group (N=1330.Missing=130). The questionnaire was filled-in prior to students' participation in the SSI project work. The distribution of the case study group's responses are written in italic letters (N=29 Missing=0).

Statement	**Percentage of the group's responses**		
	Agree (%)	**Neither-Nor (%)**	**Disagree (%)**
We get to discuss during science lessons.	55,5	27,3	17,1
I learn a lot from discussing during science lessons.	52,2	29,4	18,5
We discuss too much during science lessons.	19,7	28,5	51,8
During science lessons my teacher talks a larger part of the time.	39,6	36,1	24,3
Case study group: During science lessons my teacher talks a larger part of the time.	*24,1*	*34,5*	*41,3*

A majority of the students claim that they get to discuss during science lessons and that they learn a lot from doing so. Almost as many disagree to the statement that classroom discussions being too common. When it comes to the distribution of the spoken word, about two fifths of the whole student group claim that their teacher talks during a larger part of the lessons. In the case study group a much smaller share claim so. It should be noted that the response distribution in table 3 represent the students opinions of their own teachers, meaning the diagram implicate a mean value of the views on 55 different teachers. In the case study group only one teacher's talk is referred to, and therefore the whole group's responses and the case study group's are not completely comparable.

4.2 Discussions in the SSI work

In the second questionnaire the questions regarded how students had experienced working with the SSI project and what they had learnt during the project work. The students had worked with six different cases. The case study group had worked with the case "Me, my family and global warming". Given the openness of the teacher's guide formulated by the SISC project researchers, the teaching can not be assumed to closely resemble that of the other classes experiencing the same case. Regarding these conditions, the responses of only the case study group has been extracted from the SPSS™ file in order to investigate whether the responses are remarkably different from the whole student group or not. If not otherwise described, the case study group's responses resemble those of the whole group.

Table 4. Distribution of questionnaire responses for the whole student group (N=1120 Missing=340). The questionnaire was filled-in after the SSI project teaching had ended. The distribution of the case study group's responses are written in italic letters (N=25 Missing=4).

Statement	**Percentage of the group's responses**		
	Agree (%)	**Neither-Nor (%)**	**Disagree (%)**
I can argue for my opinion.	64,6	24,3	11,2
My friends found my view points important.	55,4	31,1	13,4
We discussed a lot in the group.	54,8	23,8	21,4
It was fun to discuss the questions of the task.	46,4	27,7	25,9
Case study: It was fun to discuss the questions of the task.	*28*	*48*	*24*

A majority of the students agreed to the statement saying that they discussed a lot during the group work and that their peers found their opinions important. Noteworthy is further the large share of the whole student group claiming that they can argue for their opinions. Nearly half of the students claimed that it was fun to discuss the questions of the task. A much smaller share of the case study group claimed that it was fun to discuss the questions, compared to the responses of the whole student group. Given that the questions differs depending on what case the students have worked with, it is of interest to extract also the responses from all students who have worked with the same case as the case study group, i.e. "Me, my family and global warming". The distribution is shown in diagram 1 below.

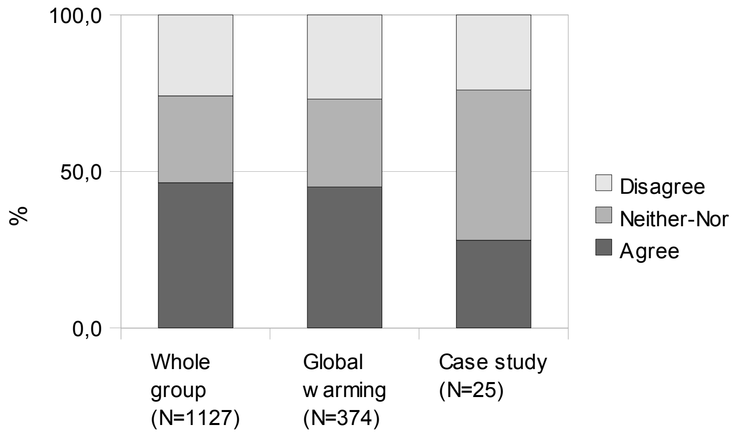

Diagram 1. Distribution of students responses to the statement "It was fun to discuss the questions of the task".

The students who had worked with "Me, my family and global warming" responded similar to the responses of the whole student group when it came to the questions about being fun to discuss.

When looking for the students' comments on the role of discussion in the regular science classroom compared to what the working methods had been like during the SSI project, I found a few sections of interest in the focus group interviews. Only once was the word discussions explicitly used in the interviews, but in order to encircle students opinions on the role of discussions in the SSI work all of the passages including talk about group work are presented below. In one of the interviews the interviewer wanted to know what working methods the students usually experience during science lessons (my translation from my Swedish transcriptions):

Interviewer:	Have this work been similar to how you usually work?
John, Eric:	No.
Interviwer:	What is the difference?
Eric:	You get to work I groups, you are allowed to speak during lessons.
Interviewer:	Aren't you allowed to do so normally?
Peter:	No.
Others:	Yes, sometimes.

In the focus group the students expressed that they wanted to be more active in the classroom, especially to do laboratory work, and that they had appreciated the group work element of the SSI case. Among the reasons for why group work was preferable the students mentioned that it implied less individual work as well as variation from normal classroom activities. The following was heard when the interviewer wanted to examine the concept "fun" in relation to learning:

Interviewer:	You said that if it is fun then you learn. What makes things fun?
Sara:	That you don't just sit down writing during every lesson.
David:	Yes.
Maria:	That you get to do something.
Victor:	To discuss.

Noteworthy is that this passage represents the only one, all three focus group interviews included, where the word "discuss" occurs. Since the students do not talk specifically about the discussion element of the SSI work during the interview I can not judge what meaning they denote to the word "discussion". The in verbatim transcriptions give implications on what students' discussions look like. The excerpt below represents a typical passage in the data material concerning the students talk about the news paper advertisement:

Interviewer:	Do you think a lot of that, what kind of car you should have?
Oliver:	Have a diesel.
Emma:	Is it a diesel?
Isaac:	No, it is a clean vehicle. It is probably a hybrid-stuff.
Emma:	Isn't that a quite cheap car?
Interviewer:	Is that something wrong? Or is it good?
Emma:	It is good.
Nina:	Though sometimes it can be bad that they are cheap.
Anna:	Bad quality.
Interviewer:	What do you mean by "quality"?
Oliver:	Emits 120 grammes per kilometre.
Anna:	How the seats are, if they are soft.
Emma:	How it looks.

Regarding how the student dialogue is carried out in the interview it appears that the students' communication consisted of a line of short statements. The focus group students' talk was scarcely formulated. I found that it was very rare that a student utterance consisted of more than one sentence at a time. The students seldom questioned each other's statements and did very rarely present any arguments for their opinions.

4.3 Perspectives

The characteristics of the focus group dialogue was that the students' comments were short and though sometimes attempting to take different perspectives (in those cases often economical or environmental) their argumentation was absent or scarce. In the news paper advertisement presented to the focus group one can read that the "clean vehicle" is run by diesel. When the interviewer wanted to examine what fuel the students connected to the word "clean vehicle" the following dialogue took place:

Interviewer:	The first thought when it says "clean vehicle": Then you think about....
Jenny:	Ethanol
Sara:	No, I believe I think about diesel.
Interviewer:	You think about diesel. Why did you think about ethanol?
Jenny:	No idea. Because we have talked about it, that it is best, so I just thought...

Here the student did not give any arguments to support her idea of which fuel she connects to the concept "clean vehicle". The interviewer continued to ask the students why ethanol could be seen as an environmental-friendly fuel, opening up for them to take different perspectives in order to form arguments:

Interviewer:	How can you say that [ethanol is the best fuel]?
Tom:	Cheapest.
Victor:	But you have to look at it this way: you get less energy out of ethanol than you get out of diesel, so it will almost be as expensive.
Interviewer:	Yes, so when you look at the cost it will end up being the same, but still you all quite agreed on ethanol implying "clean vehicle".
Victor:	It depends on how it is made, the ethanol.
Sara:	Yes, that is true.
Victor:	Yes, people in America use fossil fuel in order to make it and that only destroys the environment more than if you would buy petrol, which we do now. So actually they should not make ethanol and buy petrol instead, that would be better.

This passage serve as an example of a student assessing the issue from different perspectives, i.e. level 4 of the framework constructed by Sadler et al. (2006). Firstly, the student criticised his peer's statement of ethanol being the cheapest fuel by emphasising the difference in how much energy you can get out of the two fuel types. This can be said to represent the economical and the scientific perspective of the issue. Secondly, the student stressed that the way that the ethanol is produced affects how environment-friendly the fuel is, giving an example of how the production of ethanol takes more fossil fuel at use than it would if petrol was the fuel chosen. This can be said to represent an environmental perspective of the issue. Noteworthy is that this is the only example found in the interviews where a student demonstrated an ability representing any the two higher levels of perspective-taking described by Sadler et al. Altogether fifteen students took part in the focus group interviews.

From the interviews it appeared that the student had a difficult time when it came to formulating questions to certain fictive persons. This tendency is here exemplified by three similar situations: In the first interview the students did not say anything for a long time when the interviewer asked them what questions they would pose to a “clean vehicle” expert. The interviewer then asked if it was hard and the students said yes, but still no questions were asked. In the second interview the students were asked to pose questions to the people who had made the news paper advertisement, and then two of the six students came up with one question each. In the third interview the students were asked to pose questions in relation to the advertisement picture. One student then said that all that what he need to know he could read in the advertisement text and no further questions were posed by any of the students.

In the paper-and-pencil test tasks 8 and 9 the students were asked to write down three questions to each character, hence to formulate six questions altogether. Not all students wrote something in this part of the test. A missing response has also been included in the analysis and interpreted as the student failing in demonstrating ability of taking different perspectives. Four students left this part of the test blank (no answer), eight students wrote more than zero but less than six questions (partial answer), and eight students wrote six questions (complete answer). The criteria determining whether the students demonstrate the ability of examining a unique perspective are:

1. The students must have addressed at least one question each to the two fictive characters.
2. The students' questions to the politician should not be the same as the questions to the scientist.
3. The questions should be formulated in consideration of the certain areas of expertise and influence which is related to the two fictive characters. It should be possible for a reader, if all questions were renumbered and scrabbled, to determine to which character the question is addressed. Such distinguishing should be possible for at least one “politician question” and one “scientist question” per student.

According to these criteria six of twenty students demonstrated the ability of taking different perspectives in their asking questions to people of different areas of expertise.

Table 3. The distribution of students responses to the paper-and-pencil-test with regards to the completeness of their answers and whether they succeed in taking different perspectives or not.

	Succeeds in taking different perspectives	Fails in taking different perspectives	N
Complete answer	5	3	8
Partial answer	1	7	8
No answer	0	4	4
TOTAL	6	13	20

Following is an example of a student response meeting all the criteria above (my translation from the students' responses in Swedish). In all tables “you” is bold if it refers to second person singular. If not bold, it refers to second person plural.

Table 4. Example of a student's responses meeting all the criteria.

Ask a politician. Assume you meet a politician in your home town. Which three question will you then ask him/her about the climate?	**Ask a scientist.** Assume you meet a climate scientist. Which three question will you then ask him/her about the climate?
What do you do to improve the environment?	*How much has the average temperature increased during the last 100 years?*
Can't you lower the bus prices?	*Will the Greenhouse effect make it more difficult for human beings?*
How much petrol is sold in the municipality?	*Are **you** sure that **you** are right?*

Analysis: 1. The student has addressed at least one question each to the two fictive characters.
2. The students' questions to the politician are not the same as the questions to the scientist. 3. It is possible to determine to which character four of the questions are addressed. The question regarding bus prices addresses the politician's area of influence, the amount of petrol sold in the municipality has to do with politician's area of expertise. The questions concerning the average temperature and the Greenhouse effect addresses the scientist's area of expertise. Two of the questions: “What do you do to improve the environment?” and “Are you sure that you are right?” can not be directly connected to a certain area of expertise or influence.
Altogether the student succeeds in demonstrating ability of perspective-taking.

Following is an example of a student response not meeting the criteria in a sufficient way:

Table 5: Example of a student's responses not meeting all of the criteria.

Ask a politician. Assume you meet a politician in your home town. Which three questions would you ask him/her about the climate?	**Ask a scientist.** Assume you meet a climate scientist. Which three questions would you ask him/her about the climate?
*What do **you** do to decrease the carbon dioxide emissions?*	*If we go on as we do, how long will it take before the earth goes under?*
*How do **you** get to work?*	*What should we think about in order to decrease the carbon dioxide emissions?*
*What do **you** think all families should do to decrease the carbon dioxide emissions?*	*How do **you** get to work?*

Analysis: 1. The student has addressed at least one question each to the two fictive characters.
2. The question regarding how to get to work is posed to both the politician and the scientist. Two of the students' questions addressed to the politician, are similar to one to one of the questions addressed to the scientist, since all three questions concerning what to do in order to decrease the carbon dioxide emissions. 3. The question about the earth going under is addressing the scientist's area of expertise. Thus, only one question passes as distinguishable and the student fails in demonstrating ability of taking different perspectives.

I find that many of the questions focus on the characters' life styles, with no immediate connection to their occupations. The lifestyle questions mostly involve how the person gets to work, as exemplified in Table 5. There are several examples when student have addressed the questions to second person plural (one can tell by the Swedish text). In the test context, where the questions were written directly under the specific task, it was possible to assume that this meant “you politicians" or "you scientists", but when the questions had been cut apart and scrabbled such assumptions could no longer be done.

As mentioned, six of the 20 students demonstrated the ability to take perspectives in this test. Since 20 students were asked to write six questions each there were in total 120 possibilities to demonstrate the ability of taking perspectives. Noteworthy is that less than a third of those (38) were regarded as "distinguishable". Out of the 120 possibilities altogether 44 of the lines were left blank by the students. That meant I had 76 written-down answers to analyse. Out of the written down attempts half of them were "distinguishable".

4.4 Summary

Students claim that they get to discuss during science lessons and that they learn a lot from doing so. The whole student group claimed the SSI task questions fun to discuss, while the case group's responses indicated a less positive attitude towards them. This can not be because the particular case included less fun questions, since the group of all students working with "Me, my family and global warming" agreed to the statement to the same extent as the whole group of students. The questionnaire responses also imply that the SSI work has brought with it a lot of discussions and that the students had a positive attitude towards the discussions that took place. Students agreed to the discussions being fun and to that their view point had been seen as important. In the case study group a majority of the students disagreed to the statement: "during science lessons my teacher talks a larger part of the time", but in the interview recordings a different picture emerged. The impression from the interviews was that the focus group found their regular science lessons to be teacher-dominated, mainly consisting of the teacher's talking and writing notes on the board and the students copying the notes.

The interviews were transcribed in verbatim and by the excerpts it appears that the students' communication consisted of a line of short statements. In the focus group discussions students' talk was scarcely formulated. The students did not challenge each other's statements and it was rare that they presented arguments for their opinions. In the interviews only one of altogether fifteen students demonstrated the ability of perspective-taking representing level 2 or higher in the framework suggested by Sadler et al. (2006). The other students either did not say enough for me to analyse their talk or they demonstrated that they were examples of level 1 in the Sadler et al. hierarchy of perspective-taking ability, i.e. that they failed to carefully examine the questions they were facing.

The students' argumentation ability is of no specific focus in this study, but it is notable that though such a large share of the whole student group claimed they could argue for their opinions this ability was not demonstrated in the focus group interviews.

5 Discussion

When I interpreted the data I alternated between the large group of all students participating in the project and the small group of the case study. In the following two passages I will discuss the views expressed by the whole student group in relation to what was said and demonstrated by the students of the classroom study. In the passage concerning students' perspective-taking ability only the classroom study is discussed.

5.1 Discussions in the science classroom

Regarding the whole group's responses to the first questionnaire there seems to be room for discussion in science class. When I investigated this further in the case study group the students' comments gave that the conditions in the case study group's science lessons were not ideal for discussions to take place. This is based on the students' wish to be active in the classroom, which they expressed in contrast to the passive situation they mostly seemed to find themselves in. The focus group students' descriptions are in line with a study of Norwegian secondary school science where the time devoted to different classroom activities were counted (Ødegaard & Arnesen, 2010). The analysis of altogether 1765 minutes of videotaped lessons gave that students spent more than 50% of the time “following the teacher” by listening, answering questions or taking notes.

The results from the classroom study imply that the students need training to develop their argument-based discussion skills. The importance of students practising to discuss is stressed by several researchers (Newton et al., 1999; Sadler et al., 2006; Wellington & Osborne 2001; Zeidler, 1997). It is also important that teachers get to practise how to organise classroom discussions and that they are skilled when it comes to helping students to improve their reasoning (Zeidler, 1997; Zeidler et al., 2002). Given the difference between students' view on their own argumentation ability and the case study group's performances I suggest that the teacher pays careful notice to the argumentation element when organising classrooms discussion.

5.2 Discussions in the SSI work

The whole group of students had experienced the SSI project discussions as abundant and positive, and that a large part of the whole student group claimed in the second questionnaire that they could argue for their opinions. The same goes for the students in the case study. What students demonstrated in the classroom study does not support neither the whole student group's views nor the case study groups views. It rather resembles what Kolstø & Ratcliff (2008) conclude from a study of 14-year-old students' decision-making dialogue, hence that it was incomplete and simplistic. Why is it that the focus group interviews demonstrate such poor discussion skills if discussions has been common during the SSI work? This may, to some extent, be explained by the fact that a smaller share of the case study group claimed that it was fun to discuss the questions in the project task compared to what the whole group claimed. This could imply that they did not engage much with the discussions and thereby did not argue for their opinions or challenged the opinions of their peers. Regardless, the findings from this study raise the question of how discussions are carried out in the classroom.

Classroom discussions are regarded, by English science teachers, as difficult because of the conflict between the work form and the nature of regular school science. In school science there is often a “right” and a “wrong”, which does not open for discussions (Newton et al., 1999). Another difficulty when trying to organise discussions which include scientific-based arguments is that the student often stick to their core beliefs, no matter what science imply (Kolstø & Ratcliff, 2008;

Ekborg, 2002; Zeidler, 1997). Do these difficulties apply to the teachers involved in this study? Seven of the teachers that had participated in the project have been interviewed by the SISC researchers. These teachers expressed that they had been comfortable with teaching the cases. Ekborg & Ottander (2010) interpret, from the teacher interviews, that the project lessons have been inefficient when it comes to training students' generic abilities. They argue that the students had not been properly facilitated by the teacher during the group discussions and stress the need for teachers to develop teaching strategies in relation to this. Based on a study of students working with a decision-making task Kølsto and Ratcliff (2008) raise the question of how the task design influence the nature of the student dialogue. They suggest that higher demand on students to justify their statements could improve their skills. Accordingly, I argue that the teacher plays an important role regarding the outcomes of SSI-based teaching. In an overview of humanistic approaches to science Aikenhead (2006) presents a number of conditions which lead to improved integration of science and humanistic science in the classroom. Among these are the teachers' willingness to deal with a level of uncertainty in the classrooms; teachers' involvement in creating classroom materials and an in-service program coordinated with student teaching. Based on the findings of this study I argue that in-service training should be carried out to secondary school science teachers. When forming such a programme the characteristics of socio-scientific issues should serve as a base. The teachers should particularly practise how to organise discussions so that the students improve their generic skills.

5.3 Perspectives

Regarding to the framework suggested by Sadler et al. (2006) the students need to present an argument for their opinion in order to demonstrate a perspective ability higher than level 1. The characteristics of the communication in the focus group gave that the students' did not use the room for arguments. Thus few examples of a perspective-taking ability were demonstrated. The communication did not imply that students explored each other's views or that they were forced to justify their opinions which is stressed that students should do in order to develop their scientific concept knowledge (Newton et al., 1999; Wellington & Osborne, 2001) The criteria which the students had to meet in order to demonstrate a perspective-taking ability in the paper-and-pencil-test was rather generously formulated. Since only one question per character needed to be "distinguishable" for the students to pass the examination I find it remarkable that only six of twenty students passed. It is also remarkable that less than a third of the possibilities ended up with a question of "distinguishable" perspective, and that only half of the written attempts did so. From the classroom study I detect a need for students to practise to take different perspectives. This corresponds to the curriculum emphasis on presenting different perspectives in school so that students can form their standpoint in relation to these (Skolverket, 2006a). When practising such skills Zeidler et al. (2002) point out the socio-scientific issue as a suitable context since it involves many different aspects and the science involved is not as stable as school science. They argue that teachers therefore need to be able to address social and ethical dimensions of the issues discussed order to organise SSI. There is a need to challenge students' views and the arguments they present to support it (Kølsto & Ratcliff, 2008), which indicates that the teacher should be skilled in organising discussions and knowing when to interfere with questions or statements that forces students to practise different aspects of reasoning.

5.4 Generalisability

Since the questionnaires were answered by about 1459 secondary students aged 13 to 16 years the data is regarded to be representative for Swedish students of this group of age. When it comes to the studies of one group's (N=20) responses to a paper-and-pencil-test and the focus group interviews (N=15) the data is too limited to be applicable on a larger group. Instead, the case study group serves as an example of how 14-year-old students experience science classroom discussions, what their SSI discussions look like, and how their perspective-taking abilities are demonstrated in their SSI work.

5.5 Reliability

The result of the focus group interviews is dependent of my subjective analysis. The physical appearance of the in verbatim transcriptions suggests that also other people would draw the same conclusions when it comes to the perspective-taking, hence that the scarce nature of the students' communication could not include students presenting argument enough to show perspective-taking ability.

Two peer students have tried my analyse tool on the questions written by students in the paper-and-pencil test. The test gave a 98,6% and an 85,5% consistency when the peer analysis were compared to my analysis. Based on this I find the perspective analyse tool sufficiently reliable. The procedure of the reliability test is described in Appendix A.

5.6 Validity

In the paper-and-pencil-test the students were asked to examine the unique perspectives of the politician and the scientist by posing three questions to each character. Having listened to the focus group interviews I can assume that formulating questions is something that students find difficult in it self. From this point of view, the task could also be said to test students' ability to formulate questions. In this particular case I have estimated the ability of asking a question to a person of certain expertise so closely related to the ability of taking different perspectives that the abilities overlap.

The analyse tool implies that all the students questions of the paper-and-pencil test should be regarded in isolation. What is tested given this method is therefore if the students can examine a unique perspective when asked to, which is described by Sadler et al (2006) for the level 3 perspective aspect. Further, the isolation element of this method implies that it should be possible to say which unique perspective the student is examining without knowing in advance. Even though my criteria suggest a stricter approach to the answers than implied in the framework, this is not estimated to affect the number of students judged as having demonstrated level 3 perspective-taking abilities.

5.7 Implications for teachers

Based on the scarce student dialogue and the poor perspective-taking abilities that were demonstrated in the case study I argue that there is need for opportunities to practise discussions. Regarding the necessary conditions for students to appropriate scientific concepts the nature of the focus groups' communication does not support concept knowledge. This since it lacks the argumentation and questioning elements as well as the exploration of other people's views that researchers claim is essential to internalising new words (Newton et al., 1999; Olander, 2010; Wellington & Osborne, 2001). The case study group's demonstrated abilities are too poor when it comes to the skills that researchers emphasise as urgent for decision-making on complex socio-scientific issues (Bingle & Gaskell, 1994; Kolstø, 2001; Ratcliff & Grace, 2003; Sadler et al., 2006; Zeidler et al., 2002). Further I argue that teachers need training in order to organise classroom activities where students are pushed to develop their discussion skills. This is in line with the need to develop science education in order to improve students' engagement, expressed by Osborne and Collins (2008). They stress that long-term solutions to students' decreasing interest in science should be carried out, including the development of pedagogy and teachers' skills. Given the differences between what the whole group students claimed and the abilities demonstrated in the classroom study I suggest that teachers emphasises what characterises a discussion and the need to examine different perspectives when arguing for an opinion.

5.8 Further research

I would find it interesting to study how Swedish science teachers perceive classroom discussions: how do they motivate the use of discussions as a classroom work form? In such a study the emphasis on concept knowledge and citizenship in relation to discussions would be of certain interest. I would also find it interesting to investigate and compare the meaning that teachers and secondary school students respectively denote to ”discussions” and ”to argue”.

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Appendix A: Reliability test

In order to test the analyse tool I have asked two peer students to perform the distinguishing procedure purposed in the paper-and-pencil test criterion 3, i.e. that it should be possible to determine to which character the question is addressed if all questions were de-numbered and scrabbled. I printed all students' questions, cut each one out and scrabbled them. The test persons was supported by the additional description saying that the questions should address the characters special area of expertise or influence, or be connected to their occupation. Then the test persons were asked to individually match the questions to one of the three rubrics: “Politician”, “Scientist” and “Not distinguishable”. I presented the task to them and they were able to ask questions to me before starting. I emphasised that the questions should be regarded in isolation, hence that questions consisting of the word “you” could not be assumed to imply “you politicians” or “you scientists”. Further I stressed that questions that referred to other questions, and therefore were incomprehensible in isolation, should be regarded in isolation. I then compared the test persons' matchings to my analysis. The first test person and I differed in only one of 76 matches. The second test person I differed in nine of 76 matches. The questions that we did not judge equally are presented below:

Table A. The questions which were differently classified by the two test persons and me. The students' intention as well as our classifications are marked. O marks “not distinguishable”. Note that among the questions including “you” the bold first person plural and the rest to second person plural.

Question	Students intention	Analysis		
		Me	Person 1	Person 2
1. What do you do to improve the environment?	Politician	o	o	Politician
*2. Which kind of petrol do **you** think is best for the environment?*	Scientist	o	o	Scientist
3. What is the big environmental rogue (miljöbov)?	Scientist	o	o	Scientist
4. What do you do to improve the environment?	Politician	o	o	Politician
*5. Are **you** sure that **you** are right?*	Scientist	o	o	Scientist
6. How do you think we should decrease the Greenhouse effect?	Politician	o	o	Scientist
7. How should we improve the environment?	Politician	o	Scientist	Scienctist
8. How do you do to improve the environment?	Politician	o	o	Politician
9. What do you do about the Greenhouse effect?	Politician	o	o	Politician

The tendency is that when there are differences, I have found the question undistinguishable, while the test persons interpreted it as addressing one of the characters. Out of these questions number 1, 4 and 8 are almost identical and addressing what a group of people do in order to improve the environment. Also question number 9 refer to what the group of people do about an issue. When I spoke to test person 2 after he had done the matching he explained that he had focused on the orientation towards action that he found was demonstrated by the phrasing “what do you do”. He had in mind, while analysing these questions, that the people most expected to take responsibility for actions in such matters are the group of politicians.

If test person 1 would have done the analysis of the paper-and-pencil test the same questions would have been regarded as “distinguishable” as when I did it. If test person 2 would have done it, seven additional questions would have been regarded as “distinguishable”. The analysis made by person 2 would have resulted in one more student meeting all the criteria for level 3 perspective-taking.

Appendix B: Student questionnaires

Student questionnaire 1
Available: http://www.sisc.se/Enkater/ELEVENK%C4T1.pdf (2010-06-08)

Student questionnaire 2
Available: http://www.sisc.se/Enkater/ELEVENK%C4T2.pdf (2010-06-08)