Jan Alexsis Nielsen

Science in Discussions

An investigation of the argumentative role of science in students' socio-scientific discussions

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Supervisor: Claus Michelsen Co-Supervisor: Kirsten Drotner

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Naturvidenskab i diskussioner:
En undersøgelse af de argumentative roller af naturvidenskab
i elevers socio-videnskabelige diskussioner

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To my father, Hans Kolbe – for being a wonderful discursive practitioner, and for sparking my interest in reflections about language use.

List of Publications

The papers included in this dissertation are marked with an asterisk (*)

Scientific Publications

* Nielsen, J.A., (forthcoming), Science in Discussions: An analysis of the use of science content in socio-scientific discussions. *Science Education.* Accepted with minor revisions September 21, 2011. Revised manuscript submitted September 22, 2011.
* Nielsen, J.A., (in press), Arguing from Nature: The role of 'nature' in students' argumentations on a socio-scientific issue. *International Journal of Science Education*.
* Nielsen, J.A., (in press), Dialectical Features of Students' Argumentation: A critical review of argumentation studies in science education. *Research in Science Education*
* Nielsen, J.A. (in press), Co-opting Science: A preliminary study of how students invoke science in value-laden discussions. *International Journal of Science Education*.

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Nielsen, J.A. (2010), Functional roles of science in socio-scientific discussions. In Ingo Eilks & Bernd Ralle (Eds.) *Contemporary Science Education – Implications from Science Education Research about Orientations, Strategies and Assessment* (pp. 83-96). Aachen: Shaker.

Nielsen, J.A. (2010), The uses and roles of Science in Socio-scientific Decision-making contexts. In Dolinšek, Slavko (Ed.) *Socio-cultural and Human Values in Science and Technology Education. Proceedings from the 14th Symposia of the International Organization for Science and Technology Education* (pp. 1436-38), Institute for Innovation and Development of University of Ljubljana.

Nielsen, J.A. (2010), Structuring Discursive Trajectories: Provisional Thoughts on Designing for Critical Discussions and Socio-scientific Decision-making. In Carl Winsløw & Bob Evans (Eds.) *Didactics as a Design Science - peer reviewed papers from a Ph.d.-course at the University of Copenhagen* (pp. 23-34). Copenhagen: Department of Science Education.

Michelsen, C. & Nielsen, J.A. (2010), Interdisciplinarity Through Processes of Modeling and Sociomathematical Decision Making. In Bharath Sriraman & Viktor Freiman (Eds.) *Interdisciplinarity for the Twenty-First Century: Proceedings of the Third International Symposium on Mathematics and Its Connections to Arts and Sciences* (pp. 173-191). Charlotte: Information Age Publishing

Nielsen, J.A. (2009), Structuring Students´ Critical Discussions Through Processes of Decision-Making on Socio-Scientific Controversies. *Revista de Estudos Universitários*, 35(2), 139-165.

Michelsen, C. & Nielsen, J.A. (2009), ScienceMath - developing mathematical literacy through interdisciplinarity and modelling, In Winsløw, Carl (Ed.) *Nordic Research on Mathematics Education: Proceedings from NORMA08* (pp. 375-376). Rotterdam: Sense Publishers.

The ScienceMath Group (2009), *The ScienceMath Project – Mathematical Literacy And Cross-Curricular-Competencies Through Interdisciplinarity, Mathematising and Modelling Science*. Hildesheim: Franzbecker Verlag.

Michelsen, C., Nielsen, J.A., & Petersen, M.R. (2008), Science and mathematics teachers of the future. *Interacções*, 4(9), 97-112.

Michelsen, C. & Nielsen, J.A. (2008), Between Teaching and Researching: Envisaging Ownership Benefits of Involving Teachers from an In-service Teacher Training Program in the PARSEL Project. *Science Education International*, 19(3), 2008. 315-324.

Lindner, M., Nielsen, J.A., & Michelsen, C. (2008) Science teacher professional development in new programmes in Germany and Denmark. In MacDonald, Allyson (Ed.) *Planning science instruction: From insight to learning to pedagogical practices: Proceedings of the 9th Nordic Research Symposium on Science Education* (pp. 264-269), University of Iceland, Reykjavik.

Nielsen, J.A., et al. (2008), Popularity and relevance of science education and scientific literacy: The PARSEL Project in Europe. In MacDonald, Allyson (Ed.) *Planning science instruction: From insight to learning to pedagogical practices: Proceedings of the 9th Nordic Research Symposium on Science Education* (pp. 183-184), University of Iceland, Reykjavik.

Andersen, B., Michelsen, C., Nielsen, J.A., & Stougaard, B. (2008), How do science centers perceive their role in science teaching - an inquiry into science centers in the Region of Southern Denmark. In Michelsen, Claus (Ed.) *Proceedings of the 4th Nordic Network of Researchers in Science Communication Symposium (pp. 4*-7). University of Southern Denmark, Odense.

Abstracts of Presentations

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Nielsen, J.A. (2011), *On the Different Functions of Science Content in Socio-scientific Discussions*. Paper presented at the Annual meeting of the National Association for Research in Science Teaching (NARST), April 3-6, Orlando, Florida.

Nielsen, J.A. (2011), *Når celler muterer selv, hvorfor kan mennesker så ikke også gøre det? - Gymnasieelevers brug af naturvidenskab i tværfaglige diskussioner*. Paper presented at INDsigt, March 17, University of Copenhagen

Nielsen, J.A. (2011), *A study of strategic usages of science in ethical decision-making*. Paper presented at the Third Ph.d. Colloquium, Department of Mathematics and Computer Science, February 10, University of Southern Denmark

Nielsen, J.A. (2010), *Strategic usages of science in discussions – On a problem concerning how to report qualitative studies on argumentation*. Paper presented at the Science Education Research Seminar, November 1, School of Education, Stanford University.

Petersen, M.R., Nielsen, J.A., & Michelsen, C. (2009), *Didaktisk rekonstruktion i naturfagsundervisningen*. Paper presented at the 2nd Nordic Subject Education Conference (NOFA), Middelfart, Denmark.

Beckmann, A., Zell, S., Nielsen, J.A., Höfer, T. (2009), *The European ScienceMath Project*. Presented at the 6th CERME conference, January 28 – February 1, Lyon, France.

Nielsen, J.A., Petersen, M.R., & Michelsen, C. (2009), *Teachers' Academic and Professional Development over Two Years as Master Students*. Poster presented at the 8th meeting of the European Science Education Research Association (ESERA), August 2009, Istanbul, Turkey.

Nielsen, J.A. (2009), *Students' discussions about mathematics and society*. Paper presented at Cooperation Between Mathematics And Sciences - From Research Towards Enhanced Teaching, August 26, St. Stanislav Institute, Lubljana, Slovenia.

Nielsen, J.A. (2008), *Udvikling af 'Mathematical Literacy' gennem tværfaglighed og modellering*. Paper presented at the regional meeting of the association of Danish mathematics teachers, November 19, Mulernes Legatskole, Odense.

Rannikmae, M., Holbrook, J., Tsaparlis, G., Nielsen, J.A., & Bolte, C. (2008), *Enhancing The Popularity And Relevance of Science Education For Scientific Literacy*. Paper presented at the 13th Symposia of the International Organization for Science and Technology Education, September 2008, Izmir, Turkey, 2008.

Graber, W., Blondner, R., Bolte, C., Galvao, C., Hofstein, A., Holbrook, J., Kipnis, M., Lindner, M., Michelsen, C., Mamlok-Naaman, R., Rannikmae, M, Nielsen, J.A., Reis, P., Szybek, P., & Tsaparlis, G. (2008), *The PARSEL Project in Europe*. Paper presented at the Annual Meeting of the National Association for the Research on Science Education (NARST), March 2008, Baltimore, USA.

Lindner, M., Nielsen, J.A., & Michelsen, C. (2008), *Popularity and Relevance of Science Education and Scientific Literacy*. Paper presented at the 4th Scandinavian Symposium for Research in Science Education, February 2008, Odense

Non-Peer Reviewed Publications

Nielsen, J.A. (2008), Den dydige innovation i og omkring de naturvidenskabelige fag: Om vigtigheden af naturfaglige og naturfagsdidaktiske projekter i University College Lillebælt. *Udvikling på tværs - Naturfag*, 1(1), 45-48.

Nielsen, J.A. (2003), Gradsforskelle i videnskabelig realisme hos Popper og Hacking: set som konsekvens af forskelle i deres epistemologiske positioner. *Semikolon*, 3(7). Pages 50-62.

Michelsen, C., Albrechtsen, T., Bangsgaard, K., Hansen, S.H., Nielsen, J.A., & Petersen, M.R. (2008), *Klonen: Et undervisningsmateriale til almen studieforberedelse*. Skriftserie for Center for Naturvidenskabernes og Matematikkens Didaktik, University of Southern Denmark, Odense, 2008.

Contents

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"Choice is not true or false"
Aristotle, *Eudemian Ethics*

Abstract

This dissertation thematises what it means to use science knowledge on societal issues from outside science. To this end, the dissertation, first, critically discusses how science education researchers could understand and analyse students' socio-scientific argumentation. It is argued that socio-scientific argumentation is a type of deliberation process in which arguers manage (potential) disagreement about what to *do* (not just what is true) by providing arguments and by engaging with the arguments of their interlocutors. This constrains how such discourse should be analysed. Second, the dissertation applies *normative pragmatics* in an analysis of students' use of science content in eight socio-scientific group discussions about human gene therapy. The specific focus of the study was on the argumentative role that invocations of science had in the dialectics of the discussions. The analysis suggests that science content occasionally played an informative role in attempts to establish the factual background of parts of the deliberations, but that speakers often invoked science content creatively and selectively in argumentative strategies that aligned with an attempt to frame the issue of the discussion in ways that were favourable for the speaker. The dissertation aims at explaining how such strategies worked pragmatically in the dialectical context of the discussions.

Summary

Imagine that we ask a handful of upper secondary school biology students to discuss, for about an hour, whether human gene therapy should be allowed. How would these students use their science knowledge in the deliberation process? What could an individual student accomplish by presenting a science factual statements (for example, the statement that germ-line gene therapy has hereditary effects)? And how do such invocations of science affect the ensuing discussion? This dissertation addresses these questions in an overall attempt to investigate the argumentative role of science in socio-scientific discussions.

The dissertation consists of four papers. Each paper thematise aspects that pertain to what it means for students to deliberate about the controversial socio-scientific issue 'human gene therapy'. These papers are prefaced by a general introduction that discusses what type of discourse socio-scientific argumentation is, and how science education researchers could analyse such discourse. It is argued that socio-scientific argumentation is a type of deliberation process in which arguers manage (potential) disagreement about what to *do* (not just what is true) by providing arguments and by engaging with the arguments of their interlocutors. As such, socio-scientific argumentation will typically manifest rhetorical as well as dialectical features.

The first paper – *Dialectical Features of Students' Argumentation: A critical review of argumentation studies in science education* – presents a critical review of how science education researchers so far have analysed the dialectical features of dialogical argumentation (i.e. the features that are operative when arguers provide arguments *and* engage with the arguments of their peers). It is argued that while the standard analytical framework – the Toulmin model – cannot capture the dialectical features of such argumentation, information about the dialectical features is necessary for applying the Toulmin model. This paradox

suggests that the science education community needs other approaches to analysing argumentation – approaches that directly attend to the dialectical features.

Against this background, the general introduction argues that *normative pragmatics* is a viable lens, through which scholars can analyse socio-scientific argumentation as it unfolds in group discussions. In this approach, the analyst attempts to interpret the *practical significance* of certain argumentative acts. This leads to an identification of the argumentative *strategies* used by the speaker; and the aim is, subsequently, to *explain* how arguers can accomplish to influence the decision of others through using such strategies. The general introduction describes in detail how this framework was operationalized in a *four-step analysis procedure*.

In the empirical part of the study, normative pragmatics was used to analyse the discussions among eight groups of Danish upper secondary school biology students. Each group consisted of four to five students (age 16-19), who discussed (for 35 to 60 minutes) whether human gene therapy should be allowed. The last three papers present and discuss the interpretive findings of that study.

The second paper – *Co-opting Science: A preliminary study of how students invoke science in value-laden discussions* – was a preliminary application of normative pragmatics on a sample of three group discussions. It investigated how the students interwove science factual claims and evaluative statements in their socio-scientific deliberation. The analysis suggests that the students applied different strategies of interweaving factual and evaluative statements – for example in a number of occasions students would bootstrap a value statement onto a science factual statement in order to make it appear that the value statement was mandated by science. A general trend emerged: Often students would *co-opt* science in order to feather their own argumentative nests. Further, it was possible to identify a slight pattern in these strategies: The students would present a science factual statement *in conjunction* with a value-laden challenge to a standpoint or argumentation of their interlocutor. Pragmatically such moves could accomplish three things for the speaker: (i) She could blur the fact-value distinction in order to make it appear that her evaluation was, scientifically speaking, correct; (ii) she could make it appear that her way of *framing* the issue is, scientifically speaking, more correct than other ways of framing the issue; and (iii) the interweaving of science content into such value-laden challenges can make it appear that the framed issue has a determinate answer to which most should normally agree. Taken together, these pragmatic effects put the interlocutor in a potential bind of having to accept a *seemingly* unacceptable burden of proof.

The third paper – *Science in Discussions: An analysis of the use of science content in socio-scientific discussions* – analysed all eight discussions in an attempt to investigate the argumentative roles of invocations of science content, and of which pragmatic effects such invocations had on the dialectics of the discussion. The interpretive findings could elucidate the findings from the second paper. The analysis suggested that science content could play a purely *informative* role – in the sense that students *drew* on science knowledge in order to articulate and identify issues. In these cases, the pragmatic effect was that a series of possible issues or aspects could be identified as potentially relevant aspects. But at many points students used co-options strategies as presented in the second paper. In these cases, the invocation of science content had the pragmatic effect of scaffolding a particular way of framing the issue. The difference between these two general ways of invoking science is that while the first is informative in the sense that opens *a number* of potential aspects to consider in the decision-making process, the second closes in on a single aspect and effectively *clouds* that it could be relevant for the participants to discuss *which* aspects could be relevant. Further, the interpretive findings suggest that the socio-scientific discourse is very complex. Even sequences that at first appear to be exchanges in which science is used in a purely informative manner could later be co-opted by a speaker in order to feather her own argumentative nests.

The fourth paper – *Arguing from Nature: The role of 'nature' in students' argumentations on a socio-scientific issue* – analysed all eight discussions with the aim of investigating how the students invoked the concept of 'nature' or of 'what is natural', and further how they used science in those articulations. In the context of this dissertation, the fourth paper is also an attempt to vindicate that normative pragmatics is a versatile analytical framework in the science education context. The interpretive findings suggest that invocations of nature occurred at key places in the dialectics of the discussions. Typically, these invocations were uncritical appeals to nature as an ultimate arbiter of what is good and what is bad. These appeals often took place when a student had reached the end of her argumentative tethers; and when the interlocutors moved to confront such interlocutors, the speaker would *shift* the sense of nature instead of elaborating their previous line of argumentation by using science content.

These interpretive findings suggest that students are able to launch and execute complex argumentative strategies in which they use science content. A key practical outcome of such strategies is that the speaker can pragmatically scaffold and support their attempts frame the issue in a way that is favourable for her. This suggests that science education researchers have to reflect on what it means to ask of students that they use science on issues from outside science. In particular, these findings emphasise that science is not just used as *evidence* in socio-scientific deliberations, and that we, as science educators may have to accept that science has multifarious roles beyond providing certain evidence in the general discursive reality of society. Further, the interpretive findings identify very concrete challenges for those teachers who aspire to *assess* the way in which their students deliberate about real-life issues from society.

1

General Introduction

1.1 Introduction

One of the key aims of science education is to enable students to tackle societal, real-life issues by making decisions that are *informed by science* (EU-Commission, 2004; Millar & Osborne, 1998; OECD, 2006; Ryder, 2001). Policy-makers and researchers share, that is, the commitment that science teaching should foster the ability to use science knowledge on issues from *outside* science. This commitment is palpably represented in the executive order that defines the aim of biology teaching in the Danish upper secondary school system (STX, all levels of biology):

> Biology is a scientific discipline [...] [which] contributes to the human's understanding of it self as biological organism and as societal citizen – and which provides the disciplinary background for the development of responsibility, decision-making, and action with respect to present societal conditions with a biological content (Danish Ministry of Education, 2010, Appendix 12-4).

This commitment has nourished a substantial amount of work (theoretical as well as practically oriented) on *socio-scientific* teaching activities. Activities, that is, in which students thematise, and make decisions about, *socio-scientific issues* (i.e. societal, ethical, and/or political issues that relate to science) such as whether to allow human gene therapy, whether to encourage stem cell research and so on (Albe, 2008a; Kolstø, 2006; Levinson, 2006b; Sadler, 2004; Zeidler, Osborne, Erduran, Simon, & Monk, 2006).

The dominant rhetoric in the socio-scientific issue movement is that socio-scientific activities have the potential to allow students to operationalize their science knowledge in argumentation – for students are enabled to "formulate positions, and provide supporting evidence"

(Sadler, 2004, p. 515) – thus fostering the ability to use science as 'evidence' and on 'evidence-based' decisions on such issues (Sadler, 2006; Zeidler, Sadler, Simmons, & Howes, 2005). But it is not immediately clear what it means to use science, or scientific evidence, on issues from outside science.

From an *a priori* perspective, when we deliberate about, for example, whether human gene therapy should be allowed, we deliberate about what to *do*, not just what is *true*. In other words, socio-scientific argumentation is first and foremost *practical* argumentation (Kock, 2009); and this means that socio-scientific decisions are not simply derived from a range of certain scientific evidence. In short, you could not scientifically *prove* that gene therapy is acceptable. Socio-scientific decisions are essentially *political* products that do not fall under the purview of science – this is, at least, the *de facto* nature of socio-scientific decisions within the present bifurcation of society (Latour, 2004). In fact, it would not be logically incoherent to defend a standpoint on a socio-scientific issue *without* using the slightest science content (Dawson, 2000; Irwin & Wynne, 1996).

While these consideration may appear to be exercises made from an armchair perspective, they do have considerable consequences. Since it is not logically necessary for a person to draw on science when she tackles issues and problems from outside of science, we, as science educators, need to give alternative reasons for why this is still our aim. Further, if socio-scientific deliberation does not fall under the purview of science, then *science* teachers and *science* professionals may not naturally possess the repertoires needed for assessing students socio-scientific deliberations. Indeed, it is difficult to formulate a yardstick for gauging students' usage of science content in socio-scientific deliberations if we do not have a clear sense of what it means to use science content in such contexts.

To this end, the present study sought to thematise students' invocations of science content in small group discussions on human gene therapy. The study had the modest aim of coming to an initial understanding of what a speaker might accomplish by invoking science content; and – through that understanding – provide a new way for science education researchers to converse about the aim of enabling students to use science on issues from outside science.

1.1.1 Reading Guide

This dissertation consists of this general introduction, four individual papers (Sections 2 through 5), and, finally, a general discussion. The papers are essentially the core of this dissertation. Thus the general introduction and the general discussion are written so as to draw out red threads through the papers, and to bring out details that could not fit into the papers (for example about how the analysis was conducted). This means that there will be a certain number of reiterations here and there.

I have collected the four papers in one lump, but this may complicate the reading of this dissertation. For Paper I is a theoretical exposition of what it means to study students' dialogical argumentation, and as such it belongs to the theoretical background of the empirical study. In contrast, Papers II through IV are empirical papers in the sense that they present and discuss the interpretive findings from the empirical part of this study. These papers are sandwiched, as it were, between this general introduction and the general discussion (Section 6).

The way in which this dissertation is collected offers the reader a choice between *two* ways of reading. On the one hand, the reader can read the dissertation from cover to cover in the order presented here. This could create a reading experience slightly similar to that created by traditional monograph-style dissertations. On the other hand, the reader can read the four papers first and then read the rest of this general introduction and the general discussion. This would give the reader an initial overview of the project and the results before delving into the finer details of the foundations of the project. (The main findings of the papers are reiterated in the beginning of the general discussion).

1.1.2 Overview of the General Introduction

Section 1.2 provides a sketch of the background for this study. This leads to a specification of the key concepts 'socio-scientific issues', 'argumentation' and 'socio-scientific argumentation'. Further, it is argued that there is a niche yet to be filled in research on socio-scientific issues – namely what it means, argumentatively speaking, when students do use science content in socio-scientific discussions. Section 1.3 outlines the general research questions of this dissertation along with three concrete research aims. Section 1.4 explores the framework of normative pragmatics (in more detail than the four papers do); this leads to the formulation of analytical questions that operationalize the general research questions. Section 1.5 presents the research design and the research process of the empirical study which is reported in Papers II through IV. Finally, Section 1.6 presents how the analysis procedure, which was used in this study, was constructed and it exemplifies some of the salient steps of that procedure.

1.2 Background & Specification

1.2.1 Specification of Socio-Scientific Issues

Let us initially define 'socio-scientific issues' as "*societal dilemmas with conceptual, procedural, or technological links to science*" – where this implies that such issues "are typically contentious in nature, can be considered from a variety of perspectives, do not possess simple conclusions, and frequently involve morality and ethics" (Sadler & Zeidler, 2003, p. 5; emphasis added).

The aspect of socio-scientific issues[1], which should be emphasised in this context, is that such issues are about *boundary objects* (Star & Griesemer, 1989) – objects that straddle the boundaries between multiple spheres of human life. Objects such as human gene therapy are "scientific objects" that, on the one hand, "inhabit several intersecting social worlds" in which they have different meanings; and, on the other hand, they have a "structure [which] is common enough to more than one world to make them recognizable, a means of translation" (Star & Griesemer, 1989, p. 393). In particular, human gene therapy straddles the boundaries between biomedicine, molecular biology, and the public sphere – for example in the form of patient organisations (Rémondet, 2009; Trompette & Vinck, 2009). The same could be argued for most other, if not all, objects in bioethical issues – such as the status of human embryos in stem cell research (Williams, Wainwright, Ehrich, & Michael, 2008).

[1] This dissertation's focus is necessarily too narrow, and too specific, to do proper justice to the complexity of the wealth of research on socio-scientific issues that has been produced over the last decade. A number of publications provide valuable and critical overviews of the rich and complex field of research on socio-scientific issues (Levinson, 2007; Pedretti & Nazir, 2011; Sadler, 2011). Further, Papers II through IV present and discuss some of the recent research findings concerning socio-scientific issues, in particular, in relation to argumentation.

So, while socio-scientific issues have ties to science, they extend beyond the purview of science: They arise *as issues* in the ethical, economic, or political spheres of human life. Consequently, it is, logically speaking, possible to make a decision about a socio-scientific issue without invoking science (C. Dawson, 2000; Irwin & Wynne, 1996). Clearly, however, if citizens' decision-making on socio-*scientific* issues is to be *informed*, then it must to some extent draw on the scientific information produced by experts. This point has been made adamantly clear by Kitcher (2010):

> [I]f citizens are to be able to express their views about things that matter most to them, they need informed views […] Serious democracy requires reliance on expert opinion (p. 1231).

But scientific information alone is not enough to render even an informed socio-scientific decision acceptable or not. *Science cannot be the sole arbiter* when it comes to issues such as whether human gene therapy should be allowed as a form of treatment. In other words, when we take a stance on such issues, we do so as *citizens* – not (just) as scientists – and we often do so in light of economical considerations, within a political context, with reference to specific ethical principles and so forth (Albe, 2008a; Fensham, 2002; Grace & Ratcliffe, 2002).

So when we contend – with Sadler and Zeidler (2003) – that socio-scientific issues "do not possess simple conclusions", we are not just stating that such issues tend to have tentative conclusions that future scientific advances may correct or validate, we are saying, rather, that such issues have no eternally right solutions that can be inferred from scientific information alone (Ekborg, Ideland, & Malmberg, 2009; Kock, 2009). This, then, is the key point: *When we discuss socio-scientific issues, we typically discuss what to do, not just what is true* (see Papers II through IV).

The upshot of the above is that a socio-scientific decision, such as the one captured in the statement

(S) Human gene therapy should be allowed as a treatment of life-threatening diseases,

has no provable determinate truth-value. Socio-scientific decisions, rather, can be *acceptable or not* in light of how *well reasoned* they are. Indeed, one of the main focal points in previous research has been on students' socio-scientific *argumentation* (e.g. Kolstø, 2001, 2006; Patronis, Potari, & Spiliotopoulou, 1999; Sadler, 2004; Zeidler, et al., 2006). Consequently, the central aspect of socio-scientific decision-making processes is that they (ideally) manifest a particular sort of *argumentative discourse about what to do, in which information, ideas, and (value) principles from multifarious spheres of human life – hereunder science – are interwoven.*

In particular, the process of socio-scientific decision-making should best be understood as a *deliberation* process. The term 'deliberation' lends itself naturally because, besides denoting a process of "long and careful consideration or discussion", it is derived from the Latin term '*librare*', which means to balance or *weigh* (Oxford Dictionary of English, Stevenson, 2010). In socio-scientific deliberation we balance or weigh information, ideas, and (value) principles from multifarious spheres of human life. It is this type of deliberation, and the involved argumentative discourse, which this dissertation thematises.

1.2.2 Preliminary Specification of (Socio-Scientific) Argumentation[2]

Let us now turn to consider argumentative discourse from a more general perspective. The term 'argument' will in the following denote a set of linguistic items of which one or more (the premises, or reasons) offer support for the acceptability of another (the conclusion, or standpoint). Arguments are authored and presented by arguers through the process of 'argumentation'. As such, arguments are the (static) *products* of the (dynamic) *process* of argumentation (O'Keefe, 1977; van

[2] Parts of this section overlap with the argumentation presented in Paper I

Eemeren & Grootendorst, 2004; Walton & Godden, 2007). Science education researchers have widely adopted this "product-process" distinction (e.g. Berland & Mcneill, 2010; Bricker & Bell, 2008; Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007; Osborne, Erduran, & Simon, 2004; Sampson & Clark, 2008; Zohar & Nemet, 2002).[3]

While it is debatable whether argumentative discourse has an intrinsic function beyond the broad sense in which all linguistic acts have a function (Goodwin, 2008), it will be assumed that argumentation, if nothing else, *enables* arguers to "manage [their perceived or potential] disagreement" (Wenzel, 1993, p. 1). And that, when persons manage their disagreement through argumentation (rather than through other means), they seek to *influence the decision of others through the use of language* (Binkley, 1995; Goodwin, 2001).[4] Indeed, cogent arguments seem to have a binding effect on *rational* agents:

> The arguer […] seeks to influence judgement by getting the audience to construct a reckoning supporting the desired judgement, and the arguer does this by supplying the audience with ingredients for such a reckoning. When I argue with you it is as if I should try to get you to make a

[3] Paper I delineates the benefits of distinguishing between two different kinds of products. The more specific meanings of the concepts of argument and argumentation continue to be objects of contention within the field of argumentation theory. This scholarly discussion involves issues such as what the *function* of argumentation is (Goodwin, 1999, 2008; van Eemeren & Grootendorst, 1989; Walton, 1998), whether *persuasion* is a necessary component of argumentation (Govier, 2010; van Eemeren & Houtlosser, 2002), and what it means for an argument to be *cogent* (Govier, 1980; Johnson, 2000). This dissertation will rarely do more than touch upon these esoteric issues.

[4] This generic understanding of argumentation leaves open whether the function of argumentation is to *resolve* disagreement. A number of argumentation scholars, such as the pragma-dialectical school, have argued that ideal "argumentative discourse is conceived as aimed at resolving a difference of opinion" (van Eemeren & Houtlosser, 2003, p. 387). But the notion that *all* episodes of argumentation should be evaluated *as if* they aim at resolution is controversial (Goodwin, 2008). Indeed, there could be "legitimate dissensus" – i.e. cogent and critical argumentation that does not lead to resolution – in, for example, political debates (Kock, 2007).

> cake by plying you with eggs, flour, sugar and baking powder: in the end, I hope, you will do the mixing and baking. This is why it is that, when your judgement has been influenced by someone's successful arguing, you have the feeling that not only that person, *but reason itself has persuaded you* (Binkley, 1995, p. 138; emphasis added).

This is the important force of arguments: Cogent arguments can lead persons to acknowledge a standpoint or conclusion as acceptable *in the face of Reason* – as opposed to, for example, in the face of coercion. At the same time this implies that argumentative discourse is subject to "a certain standard of reasonableness" (van Eemeren, 1990, p. 38) – a standard of what it means for an argument to be cogent. It is, of course, a perennial issue in argumentation theory to establish exactly what these standards of reasonableness are and where they come from (Goodwin, 2008; Govier, 1980; Johnson, 2000; van Eemeren & Grootendorst, 2004). While this dissertation will not go deeply into this issue, considerations about the normative aspect of argumentation analysis will be presented intermittently throughout.

This dissertation distinguishes between *monological* and *dialogical* argumentation. Following Goldman (1999), this distinction can be drawn at the minimal level of the *context* of the argumentation: while "*monological* argumentation [is] a stretch of argumentation with a single speaker […] *dialogical* argumentation [is a stretch of argumentation] in which two or more speakers discourse with one another" (p. 131). Beyond the difference in context, it has been argued that there (at least potentially) is a qualitative difference between monological and dialogical argumentation (van Eemeren, Grootendorst, & Kruiger, 1987; Walton & Godden, 2007).

It seems intuitive that an arguer's discourse will be shaped by the anticipation of, and reaction to, what her interlocutor says and does. This intuition can be tentatively grounded in Schlegoff's (1988) empirical finding that talk turns in even rudimentary conversations are products of what has been said so far and of what the speaker anticipates will happen next. Since the empirical part of this dissertation focuses on the argumentative discourse in student groups, the term 'argumentation' will exclusively refer to dialogical argumentation, unless stated otherwise.

The majority of science education studies on argumentation have focused on students' dialogic argumentation. *But by 'dialogic argumentation' science education scholars have typically meant more than just the context of argumentation*. For example, Duschl and Osborne (2002) defined dialogic argumentation as a "social and collaborative process necessary to solve problems and advance knowledge" (p. 41). Similarly, Clark and Sampson (2008) have held that "dialogic argumentation stresses collaboration over competition" (p. 296); and Erduran, Simon, and Osborne (2004) emphasized that "the goals in promoting argumentation in science lessons is to engage learners in dialogical conversation where they can not only substantiate their claims but also refute others' with evidence" (p. 927). These definitions do not just mention a dialogic context, they also involve a collaborative aspect of back-and-forth argumentation. Numerous scholars in the argumentation strand have offered equivalent definitions of dialogical argumentation (e.g. Driver, Newton, & Osborne, 2000, p. 291; Erduran, 2007, p. 65; Garcia-Mila & Andersen, 2007, p. 32; Hofstein, Kipnis, & Kind, 2008, p. 73; Jiménez-Aleixandre, 2007, p. 103; Jiménez-Aleixandre & Pereiro-Muñoz, 2005, p. 420; G.J. Kelly & Chen, 1999, p. 885; Kolstø & Ratcliffe, 2007, p. 120; Munneke, van Amelsvoort, & Andriessen, 2003, p. 116; Naylor, Keogh, & Downing, 2007, p. 17; Skoumios, 2008, p. 382; Zeidler, et al., 2006, pp. 99-101; Zohar, 2007, p. 261). Thus it has been standard in science education research to parse dialogic argumentation as a *specialized way* of arguing in which the participants not just defend own claims, but also engage constructively with the argumentation of their peers. From the perspective of argumentation theory that specialized way of arguing is typically referred to as *dialectical argumentation*.

Since Aristotle's *Topics* (1997), dialectical arguments have typically been defined as arguments in which the conclusion cannot be inferred from the premises (e.g. Blair & Johnson, 1987; van Eemeren & Grootendorst, 1982). For Aristotle, the special situation in which premises cannot be (or, at least, are not) known to be true necessitates a specialized form of public arguing: *Dialectical argumentation in which two (or more) arguers elicit arguments for and against a point of view* (cf. van Eemeren, et al., 1987). So while inferences are certain and valid arguments with conclusions that "can be reached without accounting for others' arguments", dialectical arguments "arise out of the heterogeneity of other arguments" (Beard, 2003, p. 255; see also R. H. Johnson, 2002; van Eemeren & Grootendorst, 2004; Walton, 2000). Most notably, arguers who engage in dialectical argumentation interact through a register of dialectical *moves* such as questioning, elaborating, requesting justification, anticipating future reactions, and retracting standpoints in light of convincing counter arguments (e.g. Johnson, 2002; van Eemeren, et al., 1987).

In the following it will be assumed that dialogical *argumentation can embody dialectical features in the sense that arguers can opt to manage (potential) disagreement by providing arguments and engaging critically with the arguments provided by others* (Paper I addresses these features more directly).

While dialectic is traditionally conceived as the study of how arguers publically and collaboratively *deliberate* and mutually resolve disagreements, rhetoric is traditionally conceived as the study of how speakers *persuade* their audience. Indeed, today we often think of the classical conception of rhetoric as the "civic art of public speaking", and the *rhetor* as "the worker of persuasion" (Kennedy, 1999, p. 1). As such, even among scholars it is possible find a strong bifurcation: Namely, the "strict separation between dialectic and rhetoric, rhetoric being devoted exclusively to style, and dialectic being incorporated into logic" (van Eemeren & Houtlosser, 2000, p. 296). The traditional bifurcation into dialectic and rhetoric has, of course, had palpable effects on how people have valued these two forms of argumentation:

> The upshot […] [has been] to conceive of dialectic as a rather pure and theoretically sound method aimed at a cooperative search for cognitive truth, and of rhetoric as a seriously tainted and practically compromised knack serving a competitive quest for persuasive success (Hohmann, 2000, p. 223).

But rhetoric and dialectic may not be completely incompatible. Generally speaking, *all* argumentative discourse is rhetorical in the sense that such discourse concerns *issues* that "need to be named and framed" (van Eemeren & Houtlosser, 1999, p. 494; see also Simons, 1990). This was evident even for Aristotle: Hohmann (2000), for example, found evidence that Aristotle treated rhetoric and dialectic as interdependent: Public dialectical reasoning requires that the audience accepts the premises, and for rhetorical oratory to be effective, opposing standpoints need to be included and treated in the oratory. Indeed, the 'dialectian' (the technically versed arguer) and the 'sophist' (the one who misuses her technical argumentative skills to mislead and groundlessly persuade) are both 'rhetors' in Aristotle's *Rhetoric* (Aristotle, 1954, p. 1355b). Further, traditional dialectic scholars such as van Eemeren and Houtlosser (1999, 2000, 2002, 2007) have recently argued that all argumentation manifests 'strategic manoeuvring' to varying degrees of legitimacy. There is, indeed, a general call for new ways in conceptualising the different strengths of, and possible overlaps between, dialectical and rhetorical approaches to argumentation (Eemeren & Houtlosser, 2002; Goodwin, 2000a; Jacobs, 2000).

Recently, Kock (2009) found evidence that Aristotle in many passages described rhetorical argumentation as deliberation (not mere persuasion) about *practical* decisions about what to do (pp. 67ff.). In particular, Aristotle treated rhetorical argumentation as a type of public deliberation needed in situations where the issues are "matters of choice": In such situations, "none of the arguers will necessarily be forced to retract his standpoint" in light of counter argumentation (as would be the case in traditional conceptions of dialectical argumentation), and none of the arguers will necessarily have to "conclusively 'prove' his standpoint" (Kock, 2009, p. 77) – for, as Aristotle argued in the *Eudemian Ethics* (1981), "choice is not true or false" (1226a).

In many cases we are faced with, what Raz (1999) has called "incommensurate" reasons – reasons that do "not defeat" each other and that are of "equal strength or stringency" (p. 102-3). According to Kock (2003, 2006), we are often in argumentative situations where opposing sides of a dispute "both […] have arguments that carry *some* weight" (2006, p. 251), and he continues:

> what that means is […] that there is no necessary, deductive and certain algorithm telling us what is required when a moral or practical choice has grounds that argue for different actions and invoke different warrants or values. However, the existence of incommensurability and optional choices does not mean that we do not weigh alternatives and make choices. We do make choices, and we do so because we have debated reasons and weighed them against each other. Only we do not have a common measure or umpire that will render an indisputable, algorithmic verdict, in the way that a pair of scales renders an objective, physical verdict as to which scale has most weight on it (p. 253).

So according to Kock (2006), rhetorical argumentation (i.e. practical argumentation about what to do) involves a degree of "weighing" fundamentally "incommensurable" information, ideas, and principles often from multiple spheres of human life – even though there could be no objective scale for us to weigh these aspects up against. This can be directly applied on the notion of socio-scientific deliberation. For example, when one wants to make a choice about whether human gene therapy should be allowed, one could include knowledge about the hereditary effects of germ-line gene therapy, information about severely ill patients' living conditions, general information about parents decision-making in pre-natal contexts, one's personal ethical principles and so on. Each of these factors may at some point in the deliberation provide individual reasons for a given action to be taken. *But such multifarious consideration rarely point in the same direction, and it does not seem possible to measure the relative strength of such reasons from a detached vantage point.* Socio-scientific deliberation thus, to a large extend, will involve argumentation about the relative weight of incommensurate reasons and why they should be given this particular weight.

Against the background of these considerations, socio-scientific argumentation could be seen as a form of discourse that embodies features from both dialectic and rhetoric. Socio-scientific argumentation necessarily draws on premises from multiple fields or spheres of human life. Many premises such as ideological or ethical (value) principles cannot be known to be either true or false. In many socio-scientific issues the relevant scientific information is tentative and not presently known to be correct (Millar, 1997). Consequently, socio-scientific decision-making should manifest dialectical argumentation in which decisions emerge from the participants' pro and contra argumentation. At the same time, however, socio-scientific argumentation is typically about a choice of what to do (e.g. should we choose to allow human gene therapy?); and while such choices can be more or less informed or more or less reasoned, such choices are not true or false. So socio-scientific argumentation will typically also embody rhetorical features.

1.2.3 Socio-Scientific Argumentation in Science Education

Since the science content in many socio-scientific contexts is so complex (Ryder, 2001) and tentative (Millar, 1997), many have argued that socio-scientific activities are best implemented through a focus on informal argumentation, allowing students to "formulate positions, and provide supporting evidence" (Sadler, 2004, p. 515). Corresponding to this manner of implementation, scholars have predominantly investigated students' socio-scientific discussions through the lens of (informal) argumentation (e.g. Kolstø, 2001, 2006; Patronis, et al., 1999; Sadler, 2004; Zeidler, et al., 2006). This dissertation follows suit. But it will thematise socio-scientific argumentation in a new way – both in terms of *what the focus is* and in terms of *how argumentation is analysed*.

Against the background of the conceptual specifications in the previous parts of this section, it is possible to identify some general themes in science education research on socio-scientific argumentation. This carves out a niche in the research, which this dissertation aims to fill. (All three themes are explored in the papers, but the first theme is explored in more detail here).

1.2.3.1 *Theme 1: Science Content as Evidence*

The first general theme in research on socio-scientific argumentation concerns *the interesting tendency of scholars to focus on scientific information as evidence in socio-scientific deliberations*. Indeed, numerous studies have aimed at investigating how students manage scientific information as *evidence* in socio-scientific decision-making and to which extent such decision are *evidence-based* (e.g. Acar, Turkmen, & Roychoudhury, 2010; V. Dawson & Venville, 2009; Eastwood, Schlegel, & Cook, 2011; Evagorou, 2011; Fowler, Zeidler, & Sadler, 2009; Halverson, Siegel, & Freyermuth, 2009; Kolstø, 2001, 2006; Kolstø, et al., 2006; Levinson, 2006a; Ratcliffe, 1997; Sadler & Zeidler, 2005b; Simon & Amos, 2011; Wu & Tsai, 2007). The tendency to immediately parse the use of science content in terms of 'evidence' could be rooted in a more general tendency among those science education scholars who study student argumentation. One of the most persistent topics in argumentation studies in science education is how students handle the epistemological game of providing and asking for *evidence for science knowledge claims* (e.g. Aufschnaiter, Erduran, Osborne, & Simon, 2008; Clark & Sampson, 2007; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000; G.J. Kelly, Druker, & Chen, 1998; Patronis, et al., 1999; Simon, 2008; Zohar & Nemet, 2002).

But while 'evidence' is a clearly visible factor in scientific argumentation, it can seem strangely elusive in *socio*-scientific argumentation.

Clearly, 'evidence' is a type of reason for adopting a standpoint. *But not all reasons are evidence*. For example, the possibility of talking to friends and colleagues across the Atlantic could be a reason for me to attend a conference in the US, but that possibility is not evidence. The same is true about the scientific fact that germ-line gene therapy has hereditary effects; it could be a reason for someone to hold that germ-line gene therapy should not be allowed, but it is not evidence for holding that position. As Walton (2002) argued, evidence is used in *inferences* – evidence, that is, is a set of propositions on the basis of which an "*inference is drawn to support some claim or conclusion*" (p. 225; emphases added). But, as has been argued above, a decision on a socio-scientific issue (or, more generally a political decision) is rarely a conclusion that can simply be inferred from a range of evidentially true premises. So from a formal perspective, it is fundamentally unclear what it means to base one's socio-scientific decision on (scientific) evidence. Of course, arguers *can* cite evidence intermittently during a socio-scientific deliberation, but it is in no way given what effects such citations could have. (Indeed, this dissertation aims to shed light on this issue – even if it is just a sliver of light).

On the face of it, we are often used to link policy making with evidence-based decision-making. It is a well-known episode of modernity to emphasise the need for reason-driven policy making. Davies, Nutley, and Smith (1999) have argued that modernity's outlook on policy making is largely "post-ideological" in the sense that "evidence would take the centre stage in the decision making process" (p. 3). Sanderson (2002) elaborated this point: Within the grasp of this rationalistic "promise" of "effective government action informed by reason" we habitually "assume that reliable knowledge provides a sound basis for effective action; it is explanatory and theoretical, providing an understanding of how policies work" (Sanderson, 2002, p. 3).

But, the rhetoric of evidence-based policy-making is hardly matched by practice. For example, Kogan (1999) argued on the basis of a number of case studies that this rhetoric may be used by policy-makers to support their decisions, but in actual practice policy-makers will tend to only use evidence which is in "accord with current policy directions" (p. 12). In other words, rather than speaking of evidence-based policies, we could be speaking of policy-based selection of evidence.[5]

Further, the modernistic vision of policy-making became subject to much criticism near the end of the last millennium (Colebatch, 1998). As Funtowicz and Ravetz (1990) have argued:

> There is a long tradition in public affairs which assumes that solutions to policy issues should, and can, be determined by 'the facts' expressed in quantitative form. But such quantitative information […] is itself becoming increasingly problematic and afflicted by severe uncertainty. Previously it was assumed that Science provided 'hard facts' in numerical form, in contrast to the 'soft', interest-driven, value-laden determinants of politics. Now, policy-makers increasingly need to make 'hard' decisions, choosing between conflicting options, using scientific information that is irremediably 'soft' (p. 1).

In other words, modernity's call for evidence-based decision-making belongs to different era. In the era of "post-normal science", uncertain scientific information is a normality; and this questions the overall cogency of the notion of evidence-based decision-making (e.g. Funtowicz & Ravetz, 1993; Nowotny, 1990; Ravetz, 1987). But policy-makers *still* need to make decision; and they will have to deliberate in a complex landscape of competing values, even if the information they can get their hands on is tentative at best.

[5] This is resonant with the concurrent discussion in psychology about "confirmation bias" on the level of the individual (Mercier & Sperber, 2011; Nickerson, 1998). This is discussed in Paper III.

Such lines of criticism have been flanked by a competing model for policy-making – a "constructivist perspective" (Sanderson, 2002, p. 6) that focuses on *argumentation*:

> The argumentative turn, in policy and planning no less, seeks to overturn objectivist and instrumental notions of judgement and actions in the name of *practical reasoning*. The essence of judgement and decision becomes not the automatic application of rules or algorithms but a of *deliberation which weighs beliefs, principles and actions* under conditions of multiple frames for the interpretation and evaluation of the world (Dryzek, 1993, p. 214; emphasis added)

From this perspective, then, evidence (in the traditional sense) does not necessarily have a privileged role in the immensely complex process of political deliberation: They central question is no longer *which* evidence a decision is based on, but *how* policy makers *argumentatively deliberated* on the basis of a plethora of factors – possibly including science factual evidence. Correspondingly, any investigation of such deliberations should not in the first place be overly concerned about citations of evidence. It should, rather, "evaluate the [policy makers'] arguments not only for their truth or falsity but also for their partiality, their selective framing of the issues at hand […] their [argument's] symbolic significance, and more" (Fischer & Forester, 1993, p. 2).

This argumentative model is roughly in accord with the picture of socio-scientific deliberation which was presented in Subsections 1.2.1 and 1.2.2. In particular, this model shares the contention that socio-scientific deliberations have rhetorical features in the sense that such deliberations concern *choices*, which can only be made by weighing incommensurate information, factors, and ideas from multiple spheres of human life; and the model appears to share the conviction that socio-scientific deliberations have dialectical features in the sense that the proper medium for addressing such choices is through the argumentative processes in which the assumptions behind the decisions are questioned.

Thus there are ample indications in social and political science research that it is fundamentally unclear what the role of (scientific) evidence for policy making (hereunder socio-scientific deliberation) is or should be. In particular, these considerations should persuade us to postpone our commitments to focus on science content as evidence in students' socio-scientific deliberations.

Correspondingly, the present study aims to adopt an explorative approach vis á vis the role of science content in socio-scientific deliberations: The focus will be on how students invoke science content in the process of negotiating non-scientific standpoints about what society should do about human gene therapy. In particular, the approach of the present study follows Fischer and Forester's (1993) suggestion to investigate the "selective framing of the issues at hand" and the "symbolic significance" of argumentative moves in students' socio-scientific argumentation. This not only leaves open what role science content has in such deliberations, it also allows the possibility that science content could have multiple roles and even be used selectively.

1.2.3.2 *Theme 2: Science Content in Socio-Scientific Argumentation*[6]

The focus on science content in students' deliberation about socio-scientific issues is by no means a novel focus. Roughly put, studies of science content in socio-scientific deliberations fall into one of two classes. First, one class of studies has focussed on the presence and quality of science content in socio-scientific deliberations (e.g. Albe, 2007; V. Dawson & Taylor, 1999; Fleming, 1986; Grace & Ratcliffe, 2002; Levinson, 2004; Ratcliffe, 1997; Sadler & Donnelly, 2006; Sadler & Fowler, 2006; Sadler & Zeidler, 2003; Simon & Amos, 2011). Such studies have tended to record students' socio-scientific

[6] Parts of this section overlap with the argumentation presented in Paper III

discourse (in various contexts) and subsequently investigate the degree to which, or the quality with which, students applied scientific information in their argumentation. On the basis of these studies, it appears that *students tend to rely on other factors than scientific information in their socio-scientific deliberation, and that the scientific content – which student do use – is of a relatively poor quality.*

Second, another class of studies has focussed on the extent to which science knowledge, or knowledge about science, determines the quality of socio-scientific deliberations (e.g. Bell & Lederman, 2003; Lewis & Leach, 2006; Ryder, 2001; Sadler & Fowler, 2006; Sadler & Zeidler, 2005b). Such studies resemble more general attempts to investigate whether a students' construction of an appropriate understanding of a scientific concept influences how that student articulates or manages that concept in various activities (e.g. Hogan, 2002; Tytler, 2001; Zeidler & Schafer, 1984). Often such studies begin with a measure of the sample students' understanding of science concepts or of other aspects of science; then the quality of the sample students' socio-scientific deliberations is investigated with the aim of finding correlates between the goings-on in the deliberation and the measure of understanding (see e.g. Sadler & Zeidler, 2005b). This line of research is still very diverse, so more work is needed. But the general indication appears to be that *content knowledge, knowledge of the epistemology of science, and generic transfer schemas may predetermine the quality of socio-scientific decision-making.* Lewis and Leach's (2006) study is particularly interesting: They found that students who had not constructed an understanding of the difference between germ-line and somatic gene therapy would not have access to a wide range of potential issues concern gene therapy. This point will be critically discussed in Papers II and III, as well as in the general discussion (Section 6).

To summarise, the first class of studies has focussed on *whether* students use science content in socio-scientific deliberations; the second class of studies has focussed on whether students *knowledge* influences the quality (according to some standard) of socio-scientific deliberations. But neither class of studies involve the question of *why* a particular science content was invoked at a particular point in the deliberations. In other words, neither class of studies has thematised the meaning of a given invocation of science content in the context of the deliberations. Thus these two classes of studies carve out a niche, which is yet to be explored in detail: When students *do* use scientific content, what roles do such usages have *in the dialectical process* of socio-scientific deliberations?

A similar issue has recently been broached by Orlander Arvola and Lundegård (2011). The authors found that while there was a paucity of science in classroom discussions about abortion, students *did* occasionally use science content, and *when* they did, they did so because they deemed it necessary to "clarify their own standpoint" (p. 21). This indicates that while students may not use much science in socio-scientific argumentation, they *can* engage in socio-scientific argumentation in ways that are meaningful for them and they *can* use science in specific ways that suits their argumentative goals. This finding is resonant with the preliminary findings of the present study (see Nielsen, 2010a; this is also documented in Papers II and III).

But a general investigation of the dialectical role of science in socio-scientific deliberation is needed. In particular, Orlander Arvola and Lundgård's (2011) study was addressed *classroom interactions*. This leaves open the question of how students invoke science content when they attempt to *autonomously* manage their (potential) disagreement on socio-scientific issues. Thus Orlander Arvola and Lundgård's (2011) study needs to be paralleled with investigations of socio-scientific deliberations in small group discussions.

1.2.3.3 *Theme 3: Analysing Students' Socio-Scientific Argumentation*[7]

The third general theme in research on socio-scientific argumentation concerns *how* scholars have conceptualised and analysed socio-scientific argumentation. Until recently, most studies have applied adjustments

[7] Parts of this section overlap with the argumentation presented in Paper I

of Toulmin's (1958) framework for arguments (e.g. Kolstø, 2006; Osborne, et al., 2004; Sadler, 2004; Sadler & Donnelly, 2006; Sadler & Zeidler, 2005a; Shea, Duncan, & Stephenson, 2011; Simon & Amos, 2011; Wishart, Green, Joubert, & Triggs, 2011) – drawing on applications of Toulmin's model within psychology (Kuhn, 1991; Pontecorvo & Girardet, 1993).

Toulmin (1958) famously took issue with traditional formal logic: He proposed that argument are contextually embedded in specific fields of inquiry, and that arguments ideally manifest a certain "pattern [or] shape […] that has been presented in a series of steps" (p. 40) – such as making a *claim*, presenting *data*, drawing on *warrants*, making *rebuttals* – where each item in the pattern, or step, has a unique *logical function* (p. 92). The label 'the Toulmin model' denotes this idea of a pattern of items with different logical functions.

From Toulmin's (1958) perspective, argumentation is about the construction of "justificatory arguments" (p. 12). He was, that is, not concerned with the practical process through which persons reach conclusions, make decisions, or resolve disagreements; he was, rather, concerned with how "arguments sentence by sentence" *justify* such conclusions, decisions, or resolutions (Toulmin, 1958, p. 88). Consequently, in Toulminian analysis or evaluation of argumentation is concerned with the *layout* of arguments: The analyst scrutinizes the "manner" with which arguers are "laying [their arguments] out" in order to justify claims (Toulmin, 1958, p. 88).

The tendency to use a Toulminian approach on socio-scientific argumentation is firmly rooted in the overwhelming number of studies in science education, in general, that have used the Toulmin model to analyse student argumentation (including conference proceedings, the number of Toulminian studies must be counted in hundreds; a compilation of the most influential as well as the most recent studies would include the following: Aufschnaiter, Erduran, Osborne, & Simon, 2007; Aufschnaiter, et al., 2008; Chin & Osborne, 2010; Clark & Sampson, 2007, 2008; V. Dawson & Venville, 2009; Erduran, et al., 2004; Gott & Duggan, 2007; Jiménez-Aleixandre, et al., 2000; G.J. Kelly, et al., 1998; Maloney & Simon, 2006; Molinatti, Girault, & Hammond, 2010; Okada & Shum, 2008; Osborne, 2005; Osborne, et al., 2004; Ravenscroft & Mcalister, 2008; Sadler & Donnelly, 2006; Sadler & Fowler, 2006; Shea, et al., 2011; Simon, 2008; Simon & Johnson, 2008; Skoumios, 2008; Wishart, et al., 2011; Wu & Tsai, 2007; Zeidler, et al., 2006).

In accord with the tenets of the Toulmin model, these studies have, at their base, had the following analytical approach in common: (i) The Toulmin model provides a list and a description of items with different logical functions (claim, data, warrant, etc.); (ii) according to this list, the analyst looks through a piece of recorded argumentation in order to find talk units that could fit one of the items; (iii) the analyst *extrapolates* the talk units that are deemed to fit the logical functions determined in the Toulmin model; (iv) the analyst rearranges the extrapolated talk units in order to *reconstruct* the layout of the argument; (v) finally the analyst either critically discusses this particular layout or collects information about the layouts of multiple arguments in the corpus or other corpuses with the aim concluding something general. An archetypical example is found in Osborne, Erduran, and Simon's (2004) influential paper in which students' argumentative discursive was analysed with the aim of classifying individual arguments on the basis of which Toulminian items (claim, data, warrant, rebuttal) they comprise, and the on the basis of the quality with which these items figure in the layout.

But the Toulmin model faces a number of serious problems – technical as well as theoretical. In particular, some science education scholars have recently voiced the concern that interesting discursive aspects may become *lost in translation* because the Toulmin model essentially reduces the dialogic nature of students' argumentation into passive patterns of arguments (e.g. Hofstein, et al., 2008; Naylor, et al., 2007; Nielsen, 2010a; Walker & Zeidler, 2007). Since Paper I presents a detailed argument for why the Toulmin model is ill-equipped for thematising *dialectical argumentation*, this subsection merely reiterates the primary points of concern regarding that model.

Numerous scholars in argumentation theory have argued that the Toulmin model – as an analytical framework – cannot sufficiently guide an analyst to determine which logical function a given talk unit has (e.g Bermejo-Luque, 2006; Castaneda, 1960; Chambliss, 1995; Cooley, 1959; Freeman, 2005, 2009; Gross, 1984; Hample, 1992; Johnson, 1981a, 1981b; Keith & Beard, 2008; Newman & Marshall, 1991; Reed & Rowe, 2005; Trent, 1968; Verheij, 2005; Willard, 1976). For example, Cowan (1964) and van Eemeren, Grootendorst, and Kruiger (1987) have pointed out that talk units that may be extrapolated as data in one case can be extrapolated as a warrant in others and vice versa. According to Hample (1992) it is “hopeless” to distinguish between the different items in practice “except for the case of someone who actually says 'I have found that' and 'We may take it that,'” and so on (p. 229). Thus the analyst is forced to “engage in considerable translation to see how the argument fits” (Fulkerson, 1996, p. 24). The problem is not just that the Toulmin model does not offer an appropriate guide, it explicitly precludes the analyst from taking into account other aspects than the logical function – so the analyst will have to disregard aspects such as the expressive qualities of spoken language (cf. Toulmin, 1958, p. 87; p. 91). This line of criticism has largely been acknowledged in science education – even by some of the scholars who have applied the Toulmin model (e.g. Duschl, 2007; Erduran, 2007; Erduran, et al., 2004; Jiménez-Aleixandre, et al., 2000; G.J. Kelly, et al., 1998; Walker & Zeidler, 2007).

Another, and potentially more serious, line of criticism of the Toulmin model is the concern that the Toulmin model exclusively affords a monological view of argumentation; and that it, in consequence, cannot meaningfully be applied the complex dialogic dynamics of everyday argumentation (e.g. Fulkerson, 1996; Habermas, 1984; Johnson, 1981a, 2002; Lynch, 1982; Primatarova-Miltscheva, 1987; van Eemeren, et al., 1987; Willard, 1976; Wohlrapp, 1987). Indeed, the Toulminian analyst *reduces* dialogical argumentation to static monological argument layouts. So though the Toulminian analyst may intend to investigate dialogic argumentation, her direct object of study is *monologic* – it is dialogic only in terms of the distant dialogic context in which the object of study was recorded.

This puts to the question the *a priori* consistency of the Toulmin model. Indeed, the key tenet of the discursive paradigm that emerged within the social sciences and philosophy in the 20th century is that no talk unit or part of a dialogue can be categorized or extrapolated *as anything at all* without attending to its relation parts of the dialogue (e.g. Habermas, 1984; Schlegoff, 1988). So the fundamental problem is that the Toulmin model simply does not include the conceptual tools that are needed in order to understand and thematise the dialogic context it presupposes for everyday non-analytical argumentation (Smith, 1995). In other words, the quest for thematising *dialectical features* of dialogic argumentation "cannot be accommodated, at least straightforwardly" in approaches such as the Toulmin model (Walton & Godden, 2007, p. 10).

Against this background, it is clear that *if* socio-scientific argumentation involves dialectical features, and *if* the aim is to analyse socio-scientific argumentation as such, *then* other analytical frameworks are needed. This, then, forms another corner of the niche which this dissertation aims to fill: The socio-scientific argumentation will be analysed from a perspective that explicitly addresses the dialectical features of the argumentation.

1.3 General Research Questions and Aims

The ground covered so far has resulted in (i) a specification of the type of argumentative discourse which this dissertation has set out to investigate, and (ii) a niche among previous investigations which this dissertation aims to fill. It has been argued that socio-scientific discussions typically involve practical argumentation – about what to do, not just what is true – and that this argumentation among students should be understood as manifesting both *rhetorical* and *dialectical* features. Further, it has been argued that there are several reasons for why there is a need for new studies on students' socio-scientific argumentation. First, the *type* of argumentation that scholars should expect to find socio-scientific decision-making calls for *new* analytical approaches in science education – namely, approaches that directly attends to the dialectical features of dialogical argumentation. Second, there is reason to assume that the traditional focus of students' ability to cite *evidence* in socio-scientific decision-making is too narrow – because it is no longer intuitive that evidence-giving is the primary factor in socio-scientific decision-making. Third, while some studies have investigated the amount of science content in students argumentation, and while some studies have investigated whether science knowledge (or knowledge of science) have an impact on socio-scientific decision-making skills, there is a genuine need for investigations of what students can accomplish, in terms of argumentative outcomes, by invoking science content in socio-scientific discussions.

Against this background the general research questions of the present dissertation are the following:

(RQ 1) What argumentative roles do invocations of science content have in students' group discussions about a socio-scientific issue?

(RQ 2) What can students accomplish – in terms of affecting the dialectics of the discussion – by invoking science content?

Now, in relation to the issues raised in the previous section, these questions immediately entails another question:

(RQ 0) How can scholars investigate the particular type of argumentation, which is involved in socio-scientific discussions?

In other words, the first step would be to envisage a cogent analytical framework for investigating the rhetorical and dialectical features of socio-scientific argumentation. This step is addressed in detail in the next section, in which normative pragmatics is introduced as an analytical perspective that affords attention to both rhetorical and dialectical features of argumentation. In Section 1.6 this framework is operationalized for the science education context.

While the two general research questions (RQ 1 and 2) did guide the overall project, only Paper III addresses them directly. Paper II addresses a more specific version of the primary research questions by asking '*How and for what purpose do students interweave factual and evaluative statements in group discussions about a controversial socio-scientific issue?*' So the focus in Paper II is on invocations of science content *in relation to evaluative statements*. Similarly, Paper IV investigates the relation between invocations of science content and invocations of nature, by asking '*What argumentative roles do students' arguments from nature have in the context of small-group discussions about human gene therapy; and to what extent do students invoke science content in their articulations of nature?*'

1.3.1 Research Aims

The general research questions are complemented by three research aims. First, it aims to *review the relevant literature in order to establish a* *foundation for a viable framework for analysing students' socio-scientific argumentation.* The ground covered in the previous sections and the review and arguments presented in Paper I is an attempt to (a) indicate the need for a new framework in science education that is sensitive to the dialectical features of students' arguments and (b) to vindicate the theoretical viability in this respect of normative pragmatics. The primary presentation of the normative pragmatics perspective, however, will be given in the next section.

Second, the dissertation aims to *conduct a suitable empirical study that can be used to elaborate on the general research questions* (RQ 1 and 2). This empirical study will be described in detail in the following sections; the individual findings will be presented and discussed in Papers II through IV; and a general discussion of these interpretative findings and their implications will be presented in Section 6.

Third, the dissertation aims to *indicate the empirical applicability of normative pragmatics*. This aim is modestly sought achieved through the application of normative pragmatics on *different kinds of research questions*. The specific research questions in Papers II and IV differ slightly. This will be used to argue that, within limits (see Section 6), normative pragmatics may be a framework that is suitable for elaborating a variety of issues in science education.

1.3.2 Matching of Expectations

The methodological considerations that arise for studies like the present one are discussed in detail in section 6.3. Nevertheless, it is relevant, at this point, to emphasise that the empirical part of this study did *not* aim to catalogue every single invocation of science, *nor* did this study aim at presenting *all* different types of argumentative roles that science content could have in socio-scientific discussions; and it certainly did *not* aim to count frequencies of such different usages of science, should such differences exist. Rather, the aim was to investigate whether it makes sense to speak of different argumentative roles of science, and, if so, to come to an understanding of students can accomplish to bring about argumentative effects by some representation of science content.

1.4 Normative Pragmatics

Normative pragmatics is a generic approach to the study of argumentation. It was originally proposed as an attempt to construct "a coherent paradigmatic framework in which all relevant aspects of the study of argumentation are systematically taken into account" (van Eemeren, 1990, p. 37). During the last twenty years, the label 'normative pragmatics' has been invoked in a number of different ways (see e.g. Blair, 2006). Consequently, while normative pragmatics can be specified in terms of some *generic* tenets, the different branches of normative pragmatics can be specified in terms of more committing *specific* tenets.

Normative pragmatics draws its main inspiration from linguistic pragmatics, which is defined, traditionally, as "the study of the relation of signs to interpreters" (Morris, 1938, p. 6) – or, more recently, as the study of how *performances* (such as uttering some words) allow language users to *convey meanings* and to *bring about consequences* (B. Fraser, 1996; Horn & Ward, 2005; Mey, 1993). The key idea is that linguistic performances have *practical significance* in the sense that any message implies a meaning and could achieve some outcome (much like when a bicyclist stretches her arm out to the right, her performance signals her intention to turn to the right and she can, in specific contexts, influence the actions of her fellow road users).

The fundamental tenet of normative pragmatics is that (i) "argumentative discourse should be studied as a specimen of normal verbal communication and interaction" (van Eemeren, 1990, p. 38), and (ii) that argumentative discourse is a complex activity in which arguers *use language* (as opposed to e.g. physical coercion) *to influence the decisions of their interlocutors* (cf. Goodwin, 2001).

Normative pragmatics, in its most general form, aims at studying the "norms presupposed by and operating in [argumentative] language use" (Blair, 2006, p. 13; see also Brandom, 1994). Some branches, such as the influential *pragma-dialectical* school, attempt to reach this aim by deriving an *ideal model* of argumentation, which defines how critical argumentation *ought* to proceed; and on that basis, stretches of actual argumentation are reconstructed in order to gauge to which extent that stretch conforms to the ideal model (cf. van Eemeren & Grootendorst, 1989, 2003, 2004; van Eemeren & Houtlosser, 2007). This dissertation, however, adopts a different focus. Pragma-dialectics, understood as a *species* of normative pragmatics (Blair, 2006), involves the additional commitment that the ideal aim of argumentation is to "resolve a difference of opinion" (Eemeren & Grootendorst, 1992, p. 10). In particular, in the case of *practical deliberation* about what to do, it seems that there should be room for "legitimate dissensus" (Kock, 2007, 2008).

Further, pragma-dialectical analysis involves a significant amount of *reconstruction*: Actual stretches of argumentation are charitably reformulated so as to represent them in the form that is most appropriate vis à vis the ideal model. In other words, passages that, *according to the ideal model*, do not contribute to the argumentation are deleted; unexpressed premises that, *according to the ideal model*, have to be there are added; and unclear passages are reformulated under the principle of charity (Eemeren, 1993; Eemeren & Grootendorst, 1992; van Eemeren, Grootendorst, & Snoeck Henkemans, 2002). But Jacobs (2000), who adopts a different species of normative pragmatics, has argued that such reconstructions often have an "ironic" side effect:

> What follows from this method of representation [e.g. the pragma-dialectical reconstruction] is not a charitable interpretation, but an ironic puzzle. The product is what could have been said, but wasn't. The puzzle is, why wasn't it said that way in the first place? (p. 265)

Jacobs' (2000) point is that *the way arguers express themselves* is an important feature of argumentative discourse, and that by abstracting from such information, the analyst may "overlook strategic technique[s]" (p. 265). While this dissertation applies a number of insights from pragma-dialectics (such as empirically based knowledge about the pragmatics of 'argumentative indicators'; see Section 1.6), this dissertation follows Jacobs' (2000) and Kock's (2007) critique of the pragma-dialectical approach and the stipulation of the aim of resolving a difference of opinion.

The species of normative pragmatics which is adopted in this dissertation draws on the (roughly similar) approaches of Jacobs (2000) and Goodwin (2001). Jacobs (2000) offers a particularly helpful overview:

> One of the basic assumptions of a normative pragmatic approach to argument is that arguments invite assent (or not) by virtue of what gets communicated as a message (p. 263).

Consequently the overall focal point for this dissertation is what students communicate as messages. In other words, this dissertation aims to reflect on the *practical significance* of what students *say* in socio-scientific discussions. The aim of the normative pragmatics approach of this dissertation is explorative: The aim is to ask which "changes" arguing students "make in the world" (in the form of utterances) that could assist them to influence the decisions of their interlocutors (compare Goodwin, 2003, p. 4).

The normative pragmatics approach adopted in this dissertation considers (argumentative) messages from several perspectives. Messages have specific *contents* (i.e. that which is being said), they have specific *designs* (i.e. how that which is being said is said)[8], and they have a

[8] The distinction between a message's content and its design corresponds roughly to Searle's (1969) distinction between the propositional content of an utterance and the act in which that content is elicited (Jackson & Jacobs, 1980). Argumentation from this perspective is a speech act complex. The argumentation of a speaker must have the illocutionary effect of bringing about that the interlocutor realizes that the speaker is presenting argumentation, and argumentation always involves the speaker's attempt

specific *dialectical situatedness* (i.e. who said what to whom, at which point):

> [W]hat gets communicated as a message is a complex inferential construction based not just on what was said, but also on the *way* it was said, *when* it was said, *who* it was said *to, by whom* (Jacobs, 2000, p. 263).

A comprehensive understanding of argumentative messages requires all that these aspects are taken into account. Purely dialectical approaches have tended to disregard the design-aspects of argumentative messages (Goodwin, 2000b; Jacobs, 2000). But a speaker's design-choices *are* potent argumentative devices and as such they should fall under purview of any theory of argumentation (Innocenti, 2006; Jacobs, 1999). Consider, for example, the following two utterances with roughly similar content:

(1) Well you wouldn't say that merely being predisposed of being, like, really, really fat should simply be dealt with using gene therapy do you?

(2) Being predisposed of being overweight is not a condition that should fall under the purview of gene therapy treatments

The design aspects of these two utterances are very different. Not only does (1) contain strong evaluative – even emotive – adjectives, it is also formed as a question, which indicates that it would play a different role than (2) in an argumentation situation. For example, utterance (1), in contrast to utterance (2), indicates more explicitly a shift in the burden of proof (van Eemeren, Houtlosser, & Snoeck Henkemans, 2007), and the emotive adjectives in utterance (1) can often steer the

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to bring about the perlocutionary effect of convincing her interlocutor (van Eemeren & Grootendorst, 1982).

argumentation in specific directions (Gilbert, 1997). Further, in order to appropriate gauge what is going on, one would need to know the dialectical context in which the utterance was produced – who was the speaker, what was she reacting to at that time, and how did her interlocutor react to her utterance? Section 1.6 delineates in more detail how these multiple perspectives are operationalized in a regimented analysis procedure.

The adoption of these multiple perspectives, Jacobs (2000) argued, transcends the traditional distinction between rhetoric and dialectic. While dialectic has traditionally been occupied with the study of "opposition" and the propositional *contents* that arguers elicit when they "undertake to reach a consensus" – as well as the norms of reasonableness that govern such undertakings (Jacobs, 2000, p. 261), rhetoric has traditionally been occupied with the study of "manifest design for persuasion" and a given orator's "*strategic design* of [her] messages" (p. 263; emphasis added). Through a focus on design as well as content, normative pragmatics attempts to "synthesize the differences between dialectical and rhetorical theory in a way that saves the central insights of both" (Jacobs, 2000, p. 262).

The aim of this dissertation can be further specified through the notion of *argumentative strategies*. Consider Goodwin's (2001) comparison between argumentative discourse and the activity of "walking through some crowded event, like a state fair":

> Everyone walking is trying to achieve his or her own projects in an environment filled with other people. For anyone to succeed, some degree of coordination is required; otherwise everyone will always be bumping into each other. There are some strategies for getting through the crowd – things like conspicuously turning one's body to indicate the direction one is planning to go, or warning someone who's not looking where he's going to watch out. A theory of walking would collect such strategies, dissect them, and explain how they work (p. 10).

Goodwin's (2001) point is that walkers can perform acts – such "as turning one's body" – and that these acts have practical significance within a context – for example, the practical significance of communicating where "one is planning to go". The individual walker, thus, resorts to *strategies* that assist her in influencing the decisions of other walkers – for example, the decision to not occupy a particular space in the road.

Similarly, *arguers* can utter words and thereby elicit *messages*. Such performances have practical significance within a specific context. In that sense, arguers also resort to strategies – such as providing reasons for a claim – through which they seek to influence the decision of their interlocutors – for example, the decision to acknowledge that a claim is adequately supported. A theory of arguing would collect and dissect the conspicuous strategies that arguers use, and explain how these strategies work (cf. Goodwin, 2001; Jacobs, 2000). Consequently, *this dissertation attempts to analyse students' argumentative strategies that feature science content, and explain how such strategies work.*

In this context, the term 'strategy' does *not* denote argumentative moves or performances that are necessarily misleading or even outright insidious. An argumentative strategy is purely a general term for the *means* through which arguers attempt influence each others' decisions when they manage (potential) disagreement (Goodwin, 2001; compare van Eemeren & Houtlosser, 1999, 2002). Strategies are necessary plainly from the fact that every arguer faces a number of "practical difficulties": Not only do many situations call for arguers to "exert some (communicative) force" in order to influence the decisions of their interlocutors; most situations also have a "tight deadline" in which arguers simply do not have "time for infinite regresses where [their] premises are secured by further arguments" (Goodwin, 2005, p. 100). In other words, arguers adopt strategies not just because they seek to mislead or subvert, but because they must attempt to accomplish their goals in an efficient and expedient fashion.

Some strategies are straightforward. Citing reasons for one's standpoint is a strategy which could have the practical significance of making it explicit to an interlocutor that one has adequately justified a standpoint (Brandom, 1994; van Eemeren & Houtlosser, 2002). Other strategies involve a bit more work. For example, an arguer could (indeed, *should*) be concerned with "inventing (that is, discovering or creating) […] the unchallengeably adequate premises she needs" to justify her standpoint (Goodwin, 2005, p. 100). In that situation it is not enough to merely cite reasons – one would also need to *show* or *teach* one's interlocutor that the cited reasons are unchallengeable and that they adequately support a given standpoint. Finally, some strategies work in complex ways. The strategy of *accusing*, for example, brings about both that accused is requested to explain her position, and the implication that her position is wrong or morally contestable (Kauffeld, 1998).

The key is that arguers can adopt strategies that create *pragmatic reasons* in the sense that it is the very act of eliciting the message that creates a reason for the interlocutor to do something (e.g. acknowledge the adequacy of a premise) (Innocenti, 2006). Reasons – traditionally conceived – support, for example, a claim due to a particular relation between the content of the elicited reason and the content of the claim. In contrast, *pragmatic* reasons do not offer support merely in terms of content, they support at face value in terms of a specific act. For example, when a fellow scholar tells you at a conference presentation that Vygotsky defended some sort of abstract rationality and cites some scholarly source – lets say Wertsch (1996) – your decision of whether to acknowledge that claim will potentially be influenced by the speaker's *act* of making a citation.

One of the focal points in recent research on 'strategic manoeuvring' within argumentation theory is how arguers *frame* or *design* the issue they are arguing about (Groarke, 2011; Tindale, 2004; van Eemeren & Houtlosser, 2002). Now, the issues – or the objects of contention – that arguers argue about are not merely found: Issues are "something we *raise*, *take*, *put in*, *press*, *force*, *join*, or *frame* [– in short that an] issue arises when we *make an issue of* it" (Goodwin, 2002, p. 86). The notion of *designing* or *framing* the issue is commonly defined as a speaker's attempt to

> select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described (Entman, 1993, p. 52).

The abortion debate is a well-known case in which the original issue of whether to allow abortion has been framed either as whether to be pro-life or as whether to be pro-choice (Craig & Tracy, 2005). Framing issues in such ways can have argumentative effects on the decisions of one's interlocutors – "(often small) changes in the presentation of an issue or an event produce (sometimes large) changes of opinion" (Chong & Druckman, 2007, p. 104).

1.4.1 Research Questions Revisited

Against the background of normative pragmatics, the general research questions can be operationalized in a more specific fashion. To recall, the general research questions were:

(RQ 1) What argumentative roles do invocations of science content have in students' group discussions about a socio-scientific issue?

(RQ 2) What can students accomplish – in terms of affecting the dialectics of the discussion – by invoking science content?

Using the conceptual apparatus of normative pragmatics as a foil we could operationalize the questions into analytical questions: (i) Do students adopt different types of argumentative *strategies*, in which invocation of science content, when they discuss socio-scientific issues; (ii) how do these argumentative strategies work – i.e. how can such strategies be *compelling*; and (iii) how can the invocation of science content assist a student arguer in an attempt to *steer* the discussion or to *frame* the issue? It is essentially these questions that the analysis of the data aims to answer in the first place.

1.5 Research Design and Context

This section presents the final research design (see Figure 1 and Section 1.5.1). Further, it describes how this design originated and evolved, and it presents the written material that structured the discussion activities and the general considerations that were behind placing students in groups in order to discuss a controversial socio-scientific issue.

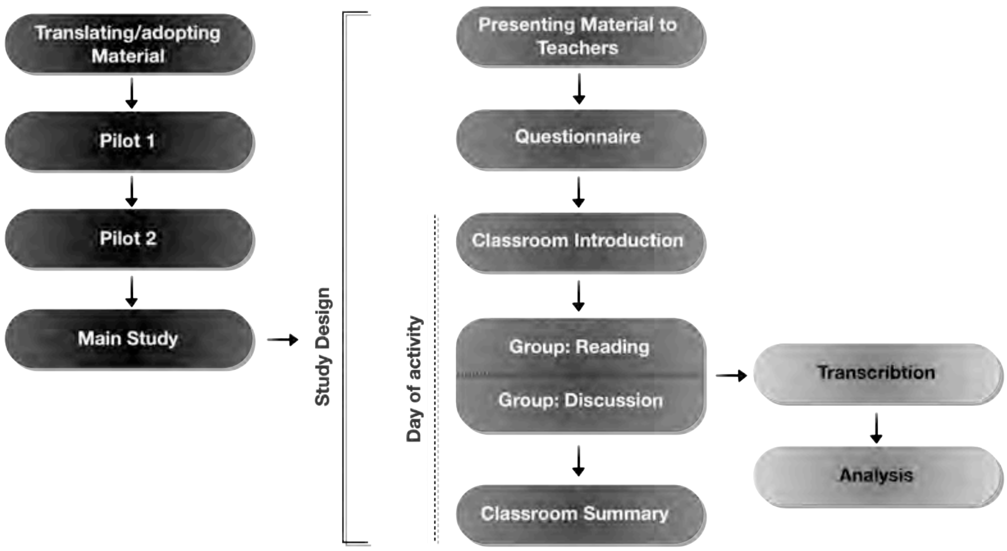

Figure 1: A graphical representation of the research process, and the research design of the main study.

1.5.1 Overview

Figure 1 represents the overall research design. The empirical data consisted solely of transcribed discussions. The data set comprised eight small-group discussions among four to five Danish upper-secondary school students (age 16 to 19). In total, 36 students from three classes participated.[9] The students discussed for 35 to 60 minutes in isolation about the extent to which (if any) human gene therapy should be allowed as a treatment.

In total, three midlevel biology classes (Biology B) from two Danish upper-secondary schools participated. The three teachers treated the discussion activity as the concluding part of their mandatory course on genetics. The groups were formed on the basis of the students' answers to an online questionnaire regarding general bioethical issues so as to increase the possibility of heterogeneous standpoints within each group (Clark, D'angelo, & Menekse, 2009).

In each class, the activity began with a short introduction given by me (approx. 15 minutes). Then each student group was directed to its room. Once there, the students received a short written material that introduced the issue (Sadler & Zeidler, 2004), provided a basic description of gene therapy, and projected four positions to the issue on the basis of authentic statements cited from the public debate on the issue in the US. When the students had read the material and felt ready, they began to discuss (the students read, typically in silence, for approx. 20 minutes). Near the end of the activity, the respective teacher and I would visit the groups in order to get a sense of the progress, and, if necessary, remind them of their tasks. When the last group in the class had finished their discussion, the activity was (after a short break) summarized and concluded in a whole-class session. The discussions were audio and video recorded. These recordings were

[9] The project initially aimed at comparing the argumentative use of science content between face-to-face contexts and computer-mediated contexts. The actual design of the study thus includes two parallel datasets. Each of the three classes was divided in two halves – one half discussed the issue face-to-face, the other half discussed the issue in the Google Wave™ environment. Due to substantial technical challenges the computer mediated discussions lacked content and did not function well in any sense of that term. Further, Google™, soon after the data collection, discontinued the Google Wave™ environment. For these reasons it was decided that the project should focus purely on the face-to-face discussions.

subsequently transcribed and prepared for analysis (the transcription process is presented and discussed in section 6.3.2.

1.5.2 Core Commitments in the Design

Four core commitments were made at the outset of the project: (i) That the research context was upper secondary school science teaching; (ii) that the project would be agnostic about the participants' disciplinary abilities, (iii) that the data would consist of transcriptions of student discussions; and (iv) that the discussions should be 'authentic' in the sense that the participants would be arguing on the basis of their own positions and that they would be arguing largely without interruption. In the following, these commitments are substantiated and addressed.

1.5.2.1 *Upper secondary school as the research context.*

It was a natural decision to focus on upper secondary level science. While recent research implies that it is worthwhile to let primary school students discuss socio-scientific issues (even without teacher intervention) (Naylor, et al., 2007), it was important that the students in this study could reasonably be said to have constructed a certain level of disciplinary knowledge. Indeed, the project focused on how students articulate such knowledge in discussions about issues outside the disciplines. A similar argument could be made against the idea of studying a cross-section of the general public.

The best viable research contexts appeared to be either the tertiary or upper secondary school system. While science programmes in tertiary education have an explicit focus on disciplinary content, the Danish upper secondary school system, in general, aims at enabling students to apply disciplinary knowledge on societal issues. During the first two years of upper secondary school (STX), students continuously conduct project work in which they thematise a given issue from the unique perspectives of two or more disciplines – in the course 'general study preparation' (Almen studieforberedelse). Beyond this meta-disciplinary work, the aim of rendering disciplinary knowledge applicable is outspoken *within* the disciplines. For example, chemistry (all levels) aims at giving

> the students the understanding that chemical knowledge and creativity finds applications that are useful for humans and nature, but that inappropriate application can affect health and environment […] The individual is […] put in a position to approach current issues, that have a scientific content, in a reflective and responsible manner (Danish Ministry of Education, 2010, Appendix 30-2).

Physics (all levels) aims at providing a "background for understanding and discussing scientifically and technologically based arguments concerning issues of general human or societal interest" (Danish Ministry of Education, 2010, Appendix 23-5). Finally, biology (all levels)

> contributes to the human's understanding of it self as biological organism and as societal citizen – and which provides the disciplinary background for the development of responsibility, decision-making, and action with respect to present societal conditions with a biological content (Danish Ministry of Education, 2010, Appendix 12-4).

These disciplinary and interdisciplinary aims of STX coincide with the overall focus of this project. Thus STX was a natural choice for the research context.

1.5.2.2 *Being agnostic about the participants' disciplinary knowledge*

A considerable amount of research has been concerned with how students' argumentation relate to the construction of disciplinary knowledge (for an overview see Erduran & Jiménez-Aleixandre, 2007). This project was from the very beginning explicitly *not* aimed at thematising growth of knowledge or learning potentials. Rather, the aim was to observe how students articulate disciplinary content knowledge in a particular type of situation (socio-scientific discussion contexts), and to interpret the argumentative role of such articulations.

In this respect, the project rests on a well-known distinction in media theory between two distinct processes when two or more individuals communicate. While processes of *conveyance* denote the "the transmission of a diversity of new information [...] to enable the receiver to create and revise a mental model of the situation", processes of *convergence* denote "the discussion of pre-processed information about each individual's interpretation of a situation" where the "objective is to agree on the meaning of the information, which requires individuals to reach a common understanding and to mutually agree that they have this understanding" (Dennis, Fuller, & Valacich, 2008, p. 580; Nielsen, 2009, 2010b).

This distinction allows us to talk fruitfully about the difference between, on the one hand, activities in which groups of students familiarised themselves with a specific body of knowledge and, on the other hand, activities in which a group of students move, in a process of convergence, from individual perspectives on such a body of knowledge to a common understanding so as to make a common decision (Nielsen, 2009, 2010b). In those terms, this project focussed primarily on the processes of convergence that occur when students meet in groups and articulate disciplinary content with the broader aim of deciding upon a socio-scientific issue.

1.5.2.3 *Data consisted solely of transcribed discussions*

Any textbook on small-group discussions will emphasise that overtly spoken language is only one aspect among many in a group's dynamic: Group members can communicate through other means than overt language – for example through body-language; and beneath an overtly spoken interaction there may well be a host of socio- and intra-psychological layers that exert influence on the communication (Davis, Laughlin, & Komorita, 1976; Fisher, 1981; Thibaut & Kelley, 1959).

The decision to abstract from these non-overt aspects was mainly practical. A study that takes into accounts the multifarious relations and tacit forms of communication within groups would be massively complex. Even if it were practically feasible to investigate all these layers it may impede the focus of the study. Breadth certainly comes at the price of depth in such complex research contexts.

In other words, it was a conscious decision to focus on overtly spoken language and to investigate that aspect in depth. This commitment reflects the research question: The aim was to analyse certain argumentative strategies in which science content was invoked, in order to interpret and explain the *argumentative* effect of such strategies. As such, this project follows the tradition of argumentation theory and general philosophy – of studying the records of what has been said. Section 6.3.1 will discuss some limitations of this decision.

1.5.2.4 *Group members should contribute from their own perspective*

The dilemma in this context is whether the participants should conduct a *role-play*, in which their positions were pre-determined, or a regular discussion, in which they were allowed to have their own positions. A substantial amount of research literature has been devoted to discussions among students in *role-playing* situations; and this way of framing the context does seem to involve learning potentials (Albe, 2008b; Aubusson, Fogwill, Barr, & Perkovic, 1997; Duveen & Solomon, 1994; Harwood, 2002; Howes & Cruz, 2009; Marks, Bertram, & Eilks, 2008; Yardley-Matwiejczuk, 1997).

For the purpose of this project, the primary reason for opting to study role-play interaction is that it may invite argumentation from those students who usually do not participate. But role-play activities could also skew the discussions. For example, when Simonneaux (2007; see also Simonneaux, 2001) compared the argumentative discourse recorded in (authentic) “debates” and in “role-plays”, he found that (i) the amount of argumentation was significantly higher in the “debate”, (ii) the arguments in the “debate” were “more developed”, (iii) the "role-play"-students sometimes "interpreted incorrectly the information provided in the description of their role", and (iv) that the arguments of the "role-play"-students tended to be "superficial" (p. 186). It seems then that role-play activities could risk skewing the argumentative landscape. Thus it seemed most prudent to study quasi-authentic discussions in which students were to adopt, defend, and elaborate their own positions to a (fictional scenario of a) real issue.

1.5.3 Evolution of the Design – A Brief Narrative

While the four core commitments addressed in Section 1.6.2 remained static, a number of design-aspects changed during the project. Initially, it was planned that the data material should be comprised of 8-12 small-group discussions, and that these should be embedded in the course 'general study preparation' – a course that addresses

> significant natural and cultural phenomena, general human issues [and other] important issues […] through the application of theories and methods from all fields (Danish Ministry of Education, 2010, Appendix 9).

General study preparation aims

> at challenging the students' creative and innovative abilities and critical skills in the application of disciplinary knowledge […] and […] to approach their surroundings and their own development in a reflective and responsible fashion (Danish Ministry of Education, 2010, Appendix 9).

General study preparation is immensely interesting from a research perspective. Every discipline allocates part of the teaching real estate to this meta-disciplinary course, and students work on interdisciplinary projects – through which they familiarise themselves with the particular strengths and weaknesses of a given discipline's approach to concurrent issues.

The initial research design revolved around a plan of finding schools in which a science teacher, in collaboration with teachers from other disciplines, conducted projects in general study preparation. The idea was to attach a discussion activity to *already planned activities* and thus investigate discussions about *multifarious* socio-scientific issues. Not only would it be interesting to compare the argumentative landscape in discussion about different issues; it also seemed intuitive that more teachers would be susceptible to participate, if they had ownership of the topic of the activity.

In order to establish more focus in the project, Biology was chosen as core discipline. The primary reason for this decision was that biology, at least intuitively, opens up to a wide variety of societal issues and could easily collaborate with a host of other disciplines in interdisciplinary activities.

Near the end of 2009, approximately 30 upper secondary biology teachers from more than 15 schools in the region of Southern Denmark were contacted. They were asked permission to observe group discussions among their students about a societal issue (e.g. gene therapy, global warming, nuclear power, or cloning) in the context of their teaching in general study preparation.[10] But no opportunities to collect data arose from that first wave of enquiry. This called for a change in approach.

Six months prior to that – in the summer of 2009 – a discussion activity about gene therapy was piloted. The aim of that pilot was primarily (i) to test various technical issues, such as how best to record the discussions, and (ii) to build a rudimentary experience about how long such discussion could be expected to last, and about how persons generally react in such situations. For the purpose of this initial pilot, an existing discussion activity – *Gene Therapy: A Review of the Past & A Dilemma for the Future* authored by Sadler and Zeidler (2004) – was

[10] Recall that a part of the design involved computer mediated discussions. So it was announced that half of the students in each class would discuss face-to-face – the other half in the Google Wave environment.

selected and adopted to the Danish context (the material is presented in detail in Section 1.5.4 below; it is reprinted in Appendix I). The initial pilot involved 16 science and/or mathematics teachers from primary school who followed a master degree program for in-service teachers at the University of Southern Denmark (for more on this program see Michelsen, Nielsen, & Petersen, 2008; Michelsen & Nielsen, 2008).

Since no research opportunities materialised in the first wave of enquiry, it was speculated that some teachers would possibly be susceptible to participate if the activity involved a fully developed material, and if contact was established through more official channels. Thus in the second wave of enquiry (mid-January 2010), the focus was directed to *gene therapy* and it was advertised that there was a finished material that could be implemented in a two-hour activity with a minimum of practical preparation. In this wave of enquiry, the approach was more formal: Select principals of upper secondary schools on the island of Funen were approached officially through the head of the Department of Mathematics and Computer Science. The principals were told that the University searched for biology B classes in which the two-hour activity could be implemented.[11] Shortly afterwards, four teachers announced that they and their students would participate.

The first class was scheduled to implement the activity in mid-February. A few days before the implementation, some practical matters were discussed with the teacher (in particular about the part of the project on chat-discussion that ran in parallel). The teacher constructed the groups, attempting to match high performing students with less high performing students. In the first class, three face-to-face groups were to discuss, but on the day of the activity a lot of students were missing. In the end, only two groups discussed face-to-face.

[11] See previous footnote.

Eventually, the first implementation of the activity would become part of the pilot study. It was manifest that the students took the activity very lightly – there were no real disagreements in the face-to-face groups and the students were conspicuously uncertain about what their tasks were. Though there is no of knowing why this was so, it seemed that a few changes to the design and implementation could change this. First, the teacher was given the responsibility to introduce the activity. This meant that the teacher presented the aim of the activity from his perspective. For example, he used the phrase that "you just have to talk [rather than discuss] about these things". Though such phrases are useful to deflect potential conflicts, it may, in this case, have had a de-motivational effect. Second, within each of the two groups, the students largely agreed, and the respective discussions soon petered out. But the agreements in one group were radically different from the agreements in the other. By chance, it seems, the groups were very homogeneous.

These observations led to three key changes to the design and implementation of the activity in the three remaining classes. First, I decided to manage the introductory classroom session. This could enable me to steer the activity to a greater extend than before. Second, the students would have to fill out an electronic questionnaire with general bio-ethical questions (see Appendix II). This could enable me to form groups with more heterogeneous views. Such groups would possibly be more prone to discuss (Clark, et al., 2009). Third, the task description in the written material was changed to also ask of the students that they were mindful that their arguments should be strong enough to convince potential opponents. The result of this process was the final design presented in section 1.5.1 above.

Actually nine groups participated (three groups in each class). But in one group (in class B), the videotape was defect and the audio-recorder did not function. So after the discussion it turned out that no discourse had been recorded.

1.5.4 The Written Material

As mentioned above, the final design of the discussion activities was structured around a written material, which initially was intended as a pilot activity. This written material was an adopted version of a material that had already been applied in science education research: *Gene Therapy: A Review of the Past & A Dilemma for the Future* authored by Sadler and Zeidler (2004). The material presents a controversial issue: How should The National Institutes of Health (NIH) review and regulate future research and medical trials concerning gene therapy? The students are asked to

> […] gather information about different perspectives on the issue, share this information with one another, and finally come to consensus on a recommendation for how your group thinks the NIH should proceed (Sadler & Zeidler, 2004, p. 429).

This material has a short systematic and historical description of gene therapy research, which makes it highly flexible in the sense that it can be applied in many contexts across groups with varying prior knowledge. Further, the material projects four archetypical positions towards gene therapy on the basis of authentic statements from participants in the public debate in the US. This could potentially stabilize students' negotiation process by acting as points of reference (Nielsen, 2009, 2010b).

In May 2009, Sadler and Zeidler's (2004) material was translated to Danish and adapted to the European context (with permission from the authors). The adopted material was entitled *Genterapi – Et dilemma for fremtiden?* (En.: Gene Therapy – A Dilemma for the Future?); it is reprinted in Appendix I. The task description in the adopted version was as follows:

> Your task is to discuss the four positions in the column to the right. On the back [of this paper], the four positions

> are backed up by authentic statements from the real debate in the US. Address these statements in your discussion. You must collaboratively try to reach an agreement about what you would advice the section [for bio-medicine and human rights in EU] to do. This means that you must try to reach a decision that all of you can vouch for. (Your decision does not need to reflect one of the four positions). Remember to make it clear how your decision can be supported [or justified, or grounded in reasons (Da.: begrundes)] and be sufficiently detailed in your decision (e.g. if you think that gene therapy should be allowed as a treatment on some diseases, you have to discuss which diseases it should be applied to).

As mentioned above, the implemented activity did not aim at *teaching* genetics. Rather, the aim was to allow students to *apply* already constructed knowledge on a controversial issue. Thus the written material was purely a scaffolding device for the discussion process.

1.6 Analysis – Normative Pragmatics

How does one interpret the workings of students' argumentative strategies (in which they invoke science content)? Indeed, what does it mean to analyse stretches of argumentation from a normative pragmatic perspective? Surprisingly there is no uniform and clear answer to that question. As mentioned above, normative pragmatics is a programmatic sketch of how argumentation should be approached. Until now there has been *no* detailed operationalization of the basic tenets of normative pragmatics for the purpose of studying large amounts of dialogic argumentation in small-group discussions. In fact, while there have been a few explicit applications of normative pragmatics, there is no detailed description of a regimented normative pragmatics analysis procedure.

This dissertation makes an attempt to devise such a regimented procedure. This was decided for two reasons. First, it appeared that a regimented procedure would provide a minimal level of consistency when analysing large amounts of argumentative discourse. Second, it appeared to be a necessary part of achieving the research aim of rendering normative pragmatics viable as a new analytical framework in science education.

The regimented procedure that was constructed during this project is first and foremost a *pragmatic solution* to the question that opened this section. It does not rest, that is, on a predefined analytical approach. It rests on the basic commitments of normative pragmatics and it is inspired by a number of previous empirical normative pragmatic studies.

The regimented procedure is described in relative detail in Papers II through IV. But it is outlined in more detail in this section. It involves four steps: (i) The identification of talk turns in a discussion that feature science content; (ii) the identification of the thematic issues that the participants argued about in the discussion; (iii) a normative pragmatic analysis of the conspicuously used strategies in which science content is invoked; and (iv) an interpretation of the role(s) of such strategies within the overall dialectic of the discussion. This *four-step analysis procedure* is presented in more detail in Subsection 1.6.2. Before that, however, Subsection 1.6.1 presents the contours of the normative pragmatic analysis that was used in this dissertation. Subsections 1.6.3 though 1.6.5 exemplify the procedure in more detail.

1.6.1 Constructing a Normative Pragmatics Analysis Procedure

The purpose of this subsection is to present the outlines of the normative pragmatic analysis that was conducted in this dissertation. This outline is established through general observations about how normative pragmatic analysis was conducted in two illustrative studies. Thus the section begins by illustrating two exemplary normative pragmatic studies; afterwards, the analytical apparatus of this dissertation is presented. This is important: The analytical apparatus of this dissertation was *not* deduced from these previous examples of normative pragmatic analysis. The apparatus that was applied in this dissertation was a *pragmatic solution* to a concrete problem: How do we analyse argumentative strategies of students' in order to explain how these strategies work? In other words, the apparatus used in this dissertation was inspired by a number of different, yet slightly similar previous approaches to studying strategies *as* strategies.

Elements of normative pragmatics have been applied on cases of scientific experts' interactions with laypersons (Goodwin & Honeycutt, 2009), seminal historical speeches (Innocenti, 2006), the argumentative effects of advertisements (Jacobs, 2000), and public participations at school board meetings (Craig & Tracy, 2005).

Goodwin & Honeycutt (2009) sought to "examine what happens when scientists leave what Goodnight (1982) has called the 'technical sphere' and enter the 'public sphere'" (Goodwin & Honeycutt, 2009,

p. 21). To this end, Goodwin & Honeycutt (2009), investigated the discourse that occurred at a public debate between scientists on the issue of "ethanol's 'net energy balance' […] [– i.e.] whether the energy we can obtain from the biofuel is greater (all factors considered) than the energy we put in to produce it" (p. 21). The authors found that during the debate the

> discourse moved from a focus on the analysis of evidence to a focus on the trustworthiness (or not) of scientists: that is, from a technical argument to an appeal to expert authority (Goodwin & Honeycutt, 2009, p. 22).

In line with traditional rhetorical analysis, Goodwin & Honeycutt (2009) presented a number of excerpts from the debate that was each followed by an analysis. By contrasting excerpts from the argumentation of different speakers, Goodwin & Honeycutt (2009) were able to identify two different ways in which the expert speakers used *pronouns* in their argumentation (cf. p. 23ff.). For instance, one of the "pro-ethanol" speakers used the pronoun 'you':

> To the right [of the projected slide], you see a very optimistic estimate of biomass energy across the U.S. (Patzek in Goodwin & Honeycutt, 2009, p. 22)

In contrast, an "anti-ethanol speaker" used the pronouns 'I' and 'we':

> Well, I did want to mention that I was born and brought up on a farm and have dedicated my research and teaching to agriculture and the farmers for the last 40 years. And so I do understand some of the problems we're facing (Pimentel in Goodwin & Honeycutt, 2009, p. 24).

These two different usages of pronouns not just signal two different ways in which the speakers positioned themselves vis-á-vis the audience, they signal two different argumentative "strategies or addressing lay audiences on scientific issues":

> Whereas the first strategy, that of technical argument, involves the scientist *showing* the lay audience evidence, this alternative strategy involves the scientist *telling* the lay audience the conclusion (Goodwin & Honeycutt, 2009, p. 24).

Based on these initial interpretations, Goodwin and Honeycutt (2009) were able to investigate the remainder of the debate through the perspective of these general strategies. Through analysing a number of excerpts they concluded that

> From the speech of the scientists themselves, from the audience construal of the event, and from the scientists' own construal, it appears that the strategy of authority dominated in this debate [...] [T]echnical arguments did *not* readily travel. But scientists personally, and their conclusions, did travel, and their technical arguments were transformed into appeals to authority (p. 28).

This is important: By exemplifying and presenting how they analysed a number of excerpts, Goodwin and Honeycutt (2009) *invite the reader to join the analysis*. In other words, the reader can witness Goodwin and Honeycutt's (2009) analysis as it unfolds. As Papers II through IV testament, this was the aim for this dissertation as well.

Innocenti (2006) made a normative pragmatics analysis of appeals to emotions in a historical speech – ' What to the Slave is the Fourth of July' – from 1852 by Frederick Douglass (1999). Innocenti (2006) proceeded by outlining the theoretical background of normative pragmatics with a focus on the potential of appeals to *create pragmatic reasons* (pp. 327-337). She then moves to present a number of excerpts from the historical speech – followed by an analysis in which she applies the fundamental tenets of normative pragmatics. In the following a selected passage from Douglass' speech is cited along with parts of Innocenti's (2006) analysis.

> [What to the American slave is your Fourth of July?] I answer, a day that reveals to him, more than all other days in the year, the gross injustice and cruelty to which he is the constant victim. To him, your celebration is a sham; your boasted liberty, an unholy license; your national greatness, swelling vanity; your sounds of rejoicing are empty and heartless; your denunciations of tyrants, brass-fronted impudence; your shouts of liberty and equality, hollow mockery, your prayers and hymns, your sermons and thanksgivings, with all your religious parade and solemnity, are to him mere bombast, fraud, deception, impiety, and hypocrisy – a thin veil to cover up crimes which would disgrace a nation of savages. There is not a nation on the earth guilty of practices more shocking and bloody, than are the people of these United States, at this very hour [Douglass, 1999, p. 12]

A normative pragmatist would explain appealing to emotion as a strategy that, under the circumstances, is compelling. […] First, the strategy of using a series of contrasts makes public an apparent surplus of evidence that these celebratory activities are shameful or cause for indignation and a suggestion that more exists. To deny that there are numerous celebratory activities that are shameful when viewed from the slave's perspective would mean that addressees are lying or not paying attention to Douglass's words (Goodwin, 2003, p. 6) […] Second, the strategy of appealing to emotions such as shame and indignation compels recognition of premise adequacy. The appeal "fits" expectations generated by the occasion and the address itself – engages situational norms – and thus creates a pragmatic reason for believing that "scorching irony" is preferable to traditional logical argumentation. […] If indictments of American hypocrisy had become commonplace among abolitionist Fourth of July orations (Branham, 1999), then addressees would expect these kinds of emotional appeals. In addition, the level or intensity of emotion generated "fits" with Douglass's

> statements that he "will use the severest language [he] can command" [Douglass, 1999, p. 5] and that he will answer those who say abolitionists would "make a favorable impression on the public mind [...] [w]ould you argue more, and denounce less, would you persuade more and rebuke less" [Douglass, 1999, p. 6]; as well as with the level of emotional intensity in appeals that preceded it. […] The emotional appeal is a fallible sign that another "mode" – such as traditional logic – would lack propriety, so here appealing to emotion creates a pragmatic reason for believing that traditional argumentation would make Douglass look ridiculous and insult addressees' understanding. It is a compelling reason because not acknowledging propriety would subject addressees to criticism for not understanding the nature of the occasion or for not following the contours of Douglass's argumentation, both of which would render them unfit to pass judgment upon the argumentation (Innocenti, 2006, p. 339-40).

In this analysis, the reader is invited to *see in action* exactly how the strategy of appealing to shame and indignation could work so as to influence the decision of others. But the issue for this dissertation is not the content of Innocenti's (2006) analysis – it is the form. Three aspects deserve attention. First, Innocenti (2006) launched her analysis by identifying the strategy in question in close connection to the excerpt. In other words, the normative pragmatic analysis was solidly embedded in the presented excerpt, allowing the reader to follow the analysis on first-hand. Second, Innocenti (2006) made frequent reference to *other parts* of the corpus. This stabilises her argumentation in her analysis, because it points to thematic themes in the corpus. It also allows the reader to see the excerpt in perspective.

Third, Innocenti (2006) intermittently makes reference to a *body of established knowledge* – both in terms of previous findings about argumentative strategies and in terms of contextual knowledge about thematic issues in abolitionists' oratories. This emphasises that empirical normative pragmatic analysis is *empirically driven* and *theoretically informed* – a conscious decision among defenders of normative pragmatics (e.g. van Eemeren, 1990; van Eemeren & Grootendorst, 2004; van Eemeren & Houtlosser, 2007). Indeed, if a normative pragmatic theory of argumentation intends to "collect […] strategies, dissect them, and explain how they work" (Goodwin, 2001, p. 10) it is implied that previous findings can and should be used to inform the discussion and explanation of novel strategies.

The normative pragmatics analysis in this dissertation was modelled on the following general observations about the illustrated cases:

(1) In both of these illustrated cases, (a) the analysis proceeded from the vantage point that arguers use strategies in order to influence the decisions of others; and (b) the aim was to reach a detailed interpretation of *why* the respective strategies could be compelling.

(2) Both cases, but in particular Innocenti's (2006) analysis, emphasise the importance of conducting *informed analysis* – i.e. analysis, which is guided by theory, or by previous empirical findings within pragmatics, in particular, and argumentation theory, in general.

(3) The normative pragmatic analyses was *strongly embedded in exemplary excerpts*, but it was also *informed by other passages in the corpus*.

(4) In particular, one reason for 'going beyond' the excerpt was that it affords an interpretation of what a speaker said in a given excerpt against the background other *commitments*, which that speaker makes in other parts of the corpus. This resembles the concept of "scorekeeping" in Brandom's (1994) philosophical normative pragmatics: For Brandom (1994), communicative practices involve (deontic) scorekeeping of what a speaker (semantically) "commits" herself to, as well as what she is (semantically) "entitled" to, by uttering some message (pp. 168ff.); in this way the *pragmatic significance* of a given message

is determined by how that message changes the *score* of a dialogue (pp. 180ff).

(5) The two analyses focused on *both content and design* of the messages elicited by the respective speakers. In the case of Goodwin and Honeycutt (2009), the design feature was the use of pronouns; in the case of Innocenti (2006) the design features were the general use of emotive language.

(6) From (5) follows that *design features, in general, can be as vital cues in the normative pragmatics analysis*. The use of pronouns and emotive language are only two out of a host of different design choices that a speaker can make. Some examples are *adjectives* (Gilbert, 1997), *stance adverbs* (Tseronis, 2009), and *interjections* (Blakemore, 1987; Bruce Fraser, 1990; Jaszczolt, 2002).

While the first three observations are concerned with the general aim and nature of normative pragmatic analysis, the latter three are concerned with detailing some *salient aspects* that the analyst must be sensitive to. These salient aspects are in focus in the following.

There are, of course, countless design features in ordinary language use. But for the purpose of this dissertation, some stand out. Some design features have been intensively studied within argumentation theory under the label *argumentative indicators* (cf. Katriel & Dascal, 1984; Snoeck Henkemans, 1996; van Eemeren & Grootendorst, 1982; van Eemeren, et al., 2007; Walton & Krabbe, 1995) – for example, 'yes, but…' and 'I don't think so' could indicate doubt or disagreement of different strength: For example,

(i) 'Yes, but did you consider that gene therapy on germ line cells is hereditary?'

or

(ii) 'I don't think that people in general would agree to be able to design their own baby'

Similarly locutions such as 'what do you mean?' and 'why is that so?' could indicate requests for clarification or justification. For example,

> (iii) 'What do you mean by 'gene therapy on germ line cells is hereditary'?'

or

> (iv) 'Why should anyone mind being able to design their own baby?

In particular, the focus on argumentative indicators appears to be a forceful tool for understanding the *structure* of a stretch of complex dialogic argumentation (Hitchcock, 2003; Snoeck Henkemans, 2003; van Eemeren, Houtlosser, & Henkemans, 2008). Thus, a speaker's use of particular argumentative indicators can be used to acquire an initial overview of the *dialectic* in a given stretch of argumentation.

All the above considerations provide the core of the normative pragmatic analysis conducted in this dissertation. They were operationalized in the following heuristic (compare Papers II through IV):

> For a given stretch of argumentation, consider, beyond the content of the message(s), the following salient aspects:
>
> (A) *The type of speech acts used* (e.g. directives, assertives, and declaratives).
> (B) *The argumentative indicators used* (e.g. 'but', 'I don't think so', 'because', and 'when') – *so as to understand the structural properties of the stretch of argumentation*
> (C) *Other design features used* (e.g. pronouns, emotive adjectives, stance adverbs, and interjections).

(D) *The continuous change in score in terms of commitments and entitlements* (e.g. 'can the speaker, from a semantic perspective, say X after having said Y earlier?').

Identify and elaborate the place and role of some or all of these aspects in the given stretch of argumentation by making reference to theory and contextual knowledge. On the basis of this identification and elaboration, larger interpretations can be made about how the strategy in question works locally as well as in the context of the overall discussion

Similar to the two illustrated cases above, this dissertation also aimed at *presenting* interpretative findings by way of *making explicit* the interpretative process. In other words, just like the illustrated cases, this dissertation intended to *invite the reader to follow the analysis first-hand.*

1.6.2 The Four-step Analysis Procedure

1.6.2.1 *Overview*

In order to scaffold and regiment the normative pragmatics analysis of the transcribed discussions the analysis of the transcribed discussions was implemented in four steps (see Figure 2).

(1) *Indexing science talk turns:* Talk turns in which the speaker expressed, alluded to, or in other ways represented science content were indexed as science talk turns.
(2) *Thematic analysis*: Multiple iterations of open (inductive) coding (Denzin & Lincoln, 1994; Thomas, 2003) led to the identification of thematic issues for each discussion. In this step sequences of talk turns were identified and demarcated in terms of what the issue or object of contention was. Issues that emerged recurrently and were discussed at length were interpreted as thematic issues.

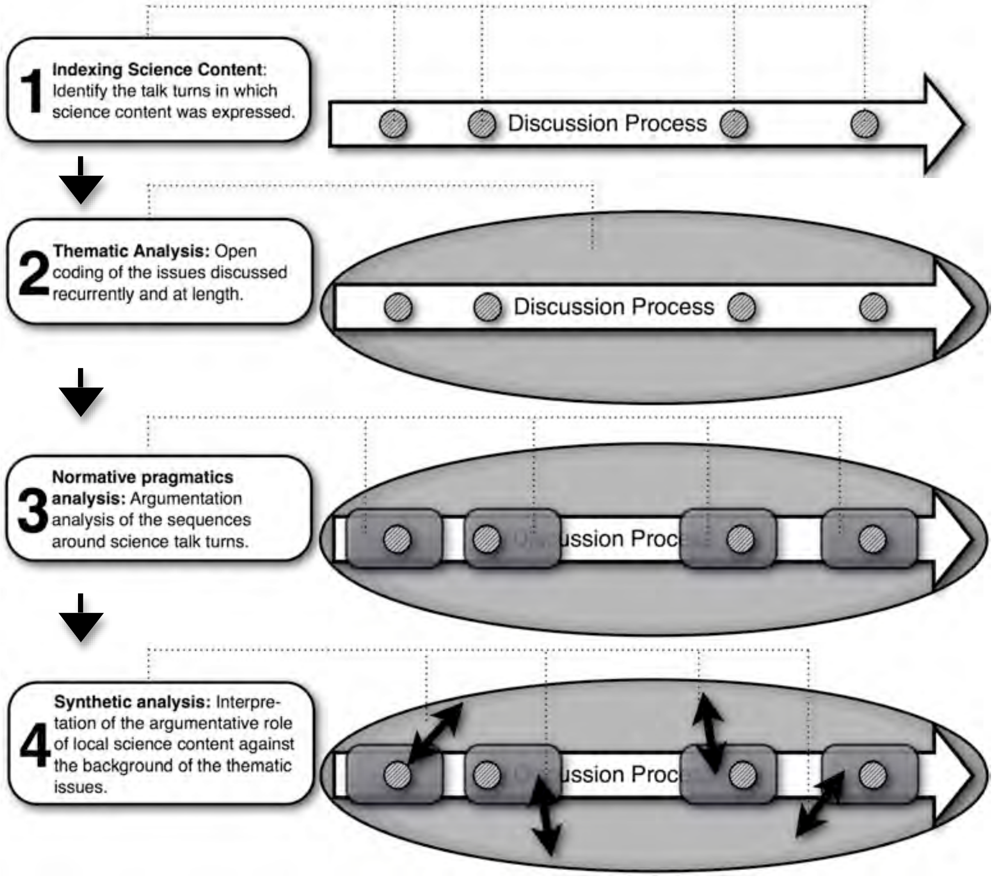

Figure 2: A graphical overview of the four-step analytical procedure

These first two analytical steps were not envisaged to elaborate on the research question *per se*. They, rather, served as scaffolds for the ensuing normative pragmatics analysis.

(3) *Normative pragmatic analysis:* Selected sequences that contained science talk turns were subjected to normative pragmatics analysis in order to establish an interpretation of what local argumentative role a given science talk turn had in the dialectics of the sequence. This step took into account the salient aspects

delineated in the heuristic for normative pragmatics analysis presented in the preceding subsection.

(4) *Synthetic analysis:* The normative pragmatics interpretation of the local role of a given science talk turn was understood and interpreted against the background of the overall thematic dialectic of the discussion. Often the fourth and third analytical steps were made in parallel.

The normative pragmatics analysis (step three) was conducted in a *hermeneutical* manner. Initial local sequences were selected on the basis of information from the first two analytical steps. The initial sequences were subjected to normative pragmatics analysis and then attempts were made to identify similar sequences across other discussions. The analysis of these sequences, in turn, could reveal different dialectical roles of science, which resulted in a new search for sequences across all discussions with similar features and so on. In the preliminary stages of the analysis, parts of the normative pragmatics analysis were shared with and critiqued by an argumentation scholar who had experience with normative pragmatics analysis (see Papers II through IV).

The strength of the four-step procedure is that it allows the analyst to *approach multiple levels of discourse*. While procedure thematises *communicated messages* or even entire talk-turns, it also thematises to identifiable *sequences* of talk turns marked by the content of the participants' talk, as well as the overall *dialectics* of a given discussion as marked by the thematic and recurrent issues that the participants argued about. Thus any interpretation of a given talk turn is made *in light of* its contextualisation in a longer sequence of interaction, and such sequences, in turn, are read and understood *in terms of* the overall themes of the discussion. In other words, the interpretation that occurs in the four-step model moves in a dialectical fashion back and forth between the particular (an individual message or talk turn) and the general (the overall progression of the discussion).

Since the four-step analytical procedure was a *pragmatic solution*, it was not grounded in, or derived from, any archetypical analytical approach.

But there are many features of the four-step procedure that resemble, or at least resonate with, ideas about and approaches to texts in discourse analysis. For example, the four-step procedure divides the discussions into *sequences* that are marked by an (often continuous) exchange about a specific issue. This resonates with approaches in discourse analysis in which recorded discourse is divided into cohesive *segments*, *paragraphs*, or *episodes* in which the speakers engage in coordinated discourse and *consistently* address a theme (Chafe, 1980; Green & Wallat, 1981; Gumperz, 1992; Hinds, 1979; Longacre, 1979). According to van Dijk (1981), such segments exist

> at a 'meso-level' in between the unit of a clause or sentence on the one hand, and the unit of a text, discourse, or conversation as a whole […] [And they] are characterized as coherent sequences of sentences of a discourse, linguistically marked for beginning and/or end , and further defined in terms of some kind of 'thematic unity' (p. 177).

Further, the strong focus on multiple levels of discourse resonates with some more general approaches in research on discourse. For instance, Fairclough (1992) argued for the need to combine "linguistically oriented" analysis on the level of talk units with "social theoretical" analysis on the level of discourse that permeates and possibly constitute social organisations (p. 4). "Any discursive 'event'", Fairclough (1992) argued, is "simultaneously a piece of text, an instance of discursive practice, and an instance of social practice" (p. 4). Consequently, such events must be analysed from the perspective of both local "language analysis" at the level of talk units, analysis of the interactive processes in which the event occurred, and the overall social organisation to which the event belongs.

This integrative vision across multiple levels of the text is, of course, the backbone of critical discourse analysis. Indeed, other critical discourse analysts, such as Wodak (2007), have argued that the "contexts and co-text of […] [a given] utterance have to be systematically integrated into the analysis" of that utterance (p. 209). Now, Wodak's (2007) notion of 'context' covers not just the overall stretch of talk in which the utterance was made; it also involves aspects such as the socio-political or socio-cultural situation in which the stretch of talk occurred. So while the four-step procedure thematises three levels of increasing generality (individual communicated messages, sequences of argumentative interaction, and the overall themes in the discussion) these levels do not correspond directly to three levels of critical discourse analysis. But the key issue here is the general idea that it is beneficial to understand a particular linguistic performance on the basis of its embedding within a more general system.

Within science education, Kelly, Chen, and Prothero (2000) conducted an ethnographically inspired discourse analysis of university students' writing about oceanography. They analysed the data (video- and audiotapes as well as observations) on three levels that correspond to the three levels thematised in the four-step procedure. On the smallest level of generality, Kelly et al. (2000) attended to "[*m*]*essage units*" in "transcribed talk" that are "defined by boundaries of utterances"; on the middle level of generality, they attended to "*sequence units*" that are "[c]ohesive, thematically tied interactions"; and on the highest level of generality, they attended to "*phase units*" that are defined as stretches of "concerted and coordinated action among participants" who "structure their conversations and cue each other through their interactions" (p. 697-8). Roughly speaking, the level of communicated messages, sequences of argumentative interaction, and the overall discussion (in the four-step procedure), respectively, corresponds to the level of message units, sequence units, and phase units.

1.6.2.2 *Step One: Identifying Science Content*

In the first step of the procedure the transcribed discussions were read with the aim of indexing which talk turns contained science content. Since this project did not seek to speak of the use of science content in quantitative terms, this first step was primarily a way of focussing the ensuing analysis. In other words, the primary task in the first step was not to *rigorously measure* the amount of science content used; the task was, rather, to single out potential places for a more thorough and deep normative pragmatics analysis. For this reason, *the focus was on singling out representations of science content in any way, shape, or form.*

The approach was simply to look for talk turns that involved terms, expressions, or the use of knowledge that with reasonable charity could be seen as being scientific or belonging to the scientific vocabulary. These talk turns were coded as 'science talk turns'.

The coding was conducted in the qualitative research analysis software HyperRESEARCH™ (www.researchware.com) for Mac OS X. It affords the creation of projects with multiple cases and sources. Each group was represented as a project, and the corresponding transcription of that group's discussion was the source in that individual project. For each group, two cases were created: While the coding of 'science talk turns' occurred in a case labelled 'Science', the coding of issues (see next section) occurred in a case labelled 'Issues'.

Here are a few examples of talk turns that were coded as 'science talk turns' (the terms or phrases that represent science content have been italicised):

81-3 A1	Allan:	It is that about *SCID* […] yes *it simply lacks a gene that should* […]
49 A2	Cadence:	But that it, you see … but one could say that if one has a child that suffers from *SCID* blah, blah, blah … then one could also just assess … is that damned great? *They don't reach adulthood and they have to be isolated.*
101-5 B2	Deepak:	*One affects certain bodily cells that can't pass on* = […] = *well, it will not get passed on to* = […] = *an offspring*
341 C3	Emily:	It is also difficult to make up one's mind about, you see, because, because, I feel a bit…

well, about *gene therapy* … that there *somatic gene therapy*. But then there is that about, you see, that about that *one would need such a treatment, well, often*

Sometimes it appeared that science knowledge was operative in a talk turn *even though* that turn did not feature terms from the general scientific vocabulary. Here are two examples:

17 A2	Donna:	Yes they are afraid that it [i.e. germ-line gene therapy] will be misused… that one will go and fiddle with something that isn't just something health related
57-61 B2	Christian:	Yes, well, they also say … that it will improve our conditions in nature and … but, you see, we don't need better conditions … you see, we can easily manage =[…]= you see, we live, well, fine =[…]= and if we make it so that everyone survives then we also [become] overpopulated
60-2 C2	Charlene:	I also have difficulty seeing [what] the advantage [with germ-line gene therapy is] = […] = beyond it turning into something cosmetic
214 C3	Anita:	But maybe that is also why there are some who end up being against it [i.e. germ-line gene therapy]. Precisely because one goes in and fiddles with some life, where [the beneficiary] cannot herself [choose whether she would like to have the procedure]…

Even though the speaker in such cases did not explicitly use terms that, broadly put, belong to a scientific vocabulary, the speaker would be semantically *committed* to a science factual proposition. Donna (17 A2), for example, would have to be committed to a proposition to the effect of 'germ-line gene therapy affords engineered changes to more than just traits that affect the overall health of the person'. In other words, Donna's message is semantically assertible only if she is prepared to assert the background science proposition also. And however rudimentary this science content may be, it did indirectly play a role in the production of that turn.

Talk turns that were coded as 'implicit science talk turns' were not treated differently than science talk turns. This means that both types of talk turns in the end were regarded as involving science. This decision rests on the fact that implicit science talk turns often had a pronoun – typically, 'it' – that in the context denotes a science term (such as 'germ-line gene therapy'). So they essentially were science talk turns with an indirect representation of the science content. Also, in cases such as Christian's talk turns (57-61 B2) above, the difference between science turns and implicit science turns is even more blurred. In some interpretations, the terms 'condition', 'nature', and 'overpopulation' could be regarded as science terms. But, to reiterate, whether a talk turn was coded as implicitly or explicitly involving science content did, in the end, not affect its classification as a turn in which the speaker invoked science.

In order to keep the project focussed, nature of science aspects were *not* treated as science. Talk turns that featured nature of science content were consequently *not* coded as science talk turns – *unless*, of course, they also featured scientific terms, expressions, or other expressive representations of science content. Consider, for example, this talk turn:

25 A2	Adriane:	Yes but, you see, there is so much competition when it comes to science … and there one would always want to explore and get better to science

Though Adriane did touch upon some aspects that may be salient for a discussion about the nature of science, she did not exactly represent any science factual knowledge in her turn. Though it may be interesting to investigate the argumentative roles of invocations of knowledge about the nature of science, this project opted for simplicity and focussed only on science content.

1.6.2.3 *Step Two: Thematic Analysis*

The thematic analysis aimed at identifying the issues that were thematic – in the sense of being discussed recurrently and at length – for a given discussion. This step involved two key moves. First, the talk turns in each discussion were coded in terms of an interpretation of the *issue* of that talk turn. The process involved open or inductive coding:

> Inductive coding begins with close readings of text and consideration of the multiple meanings that are inherent in the text. The researcher then identifies text segments that contain meaning units, and creates a label for a new category into which the text segment is assigned. Additional text segments are added to the category where they are relevant (Thomas, 2003, p. 4)

This open coding process was iterated so as to rearrange and refine the codes in each discussion. The aim was to arrive at less than eight emergent thematic issues – since more "coding which finishes up with more than about eight major themes can be seen as incomplete" (Thomas, 2003, p. 5). Second, each discussion was divided into *sequences of talk turns* that were cohesive in the sense that they were about an issue (Green & Wallat, 1981; Gumperz, 1992; Chafe 1980, Longacre 1979, Hinds 1979). These sequences were summarised in prose and they were given a title. In the following these two moves are described in more detail.

In open coding, the analyst has not chosen a list of codes *a priori*. Rather, the codes *emerge* out of the text. In other words, the first concern was to give a descriptive label to each talk turn, subsequently, as the coding was iterated, this landscape of codes was pruned. Here is an example:

127 A2	Cadence:	Yes but I don't know … well, I think a disease is a disease, but, well, of course something like a cold, well, that shouldn't … for one can cure that in many other ways […] but a disease is a disease and as long as it doesn't goes in and

becomes something like… that one must …
that it becomes intelligence and appearance
which are not diseases.

Cadence's discourse in that turn was *about* what counts as a disease. As such she gave a part of a definition of what a (legitimate) disease should be, and she gave some examples of diseases that are negligible or could be cured in other ways than gene therapy. So initially this talk turn was given the code 'Definition and Examples of Diseases'. But as the coding of that discussion (A2) progressed, it became obvious that many talk turns involved slightly similar talk about *diseases*, more generally. For example,

132-4 A2 Adriane: But it [self esteem caused by impaired appearance] will still absolutely determine how your life will be … it could be that you never get married, it could be that you never get any form of job =[…] = it could be that you are so unintelligent that you cannot navigate social relations

Adriane's talk was about the causal effects a person's appearance. Initially, Adriane's turn 132-4 could be coded as 'Causal Potency of Appearance'. But in the context she seems to be concerned with responding to a claim to the effect of 'impaired appearance is not a condition that deserved the status of a disease' (cf. Cadence's turn 127). There is then a rough similarity in terms of issue or *aboutness* in Adriane and Cadence's respective turns. In the end both turns were given the code '(Legitimate) Disease – Definition'. Because the fundamental issue in both is the determination of what counts as a legitimate disease that could be a candidate for human gene therapy.

Formally, an 'iteration' denotes one effort to code a text from beginning to end. Now, the 'pruning' of codes was not always made *after* a full iteration. In many instances codes were changed within one iteration. So a designated code was often renamed and adjusted in light of the coding of the passages that followed. In the end it was possible to establish the emergence of a handful of thematic issues in each discussion. The thematic issues that emerged in *all* discussions are presented in detail in Papers III and IV.

The open coding served the same overall purpose as did the indexing of 'science talk turns' – namely, that of stabilising the ensuing normative pragmatics perspective. As such, the emergent thematic issues were not a *result* in their own right.

The thematic analysis was strengthened by an effort to identify, label, and summarise *sequences of talk turns* in which continuous talk turns shared a general issue. Roughly put, such sequences are *sub-discussions* that about an issue. Some of these sub-discussions are thematic for the overall discussion (in the sense that they are the primary sub-discussions and their issues are discussed at length and recurrently). A thematic sub-discussion was referred to as 'the [THEMATIC ISSUENAME] sub-discussion' – e.g. 'the legitimate disease sub-discussion'.

Now, the effort to summarise each identified sequence was at times a tedious affair, but it proved to afford a valuable overview of the dialectics within the overall discussion. The result was a table as exemplified by Table 1.

Turns	**Dominant Issue**	**Summary with (initial) codes**
274-95 C3	*Legitimate Diseases for, and Practices of, Gene Therapy*	On the surface the participants agree to allow **research**. Christina substantiates her standpoint by arguing against a fictive **closed-future** position [277]. She moderates her standpoint by requesting **regulations** that disallow **research** involving "inhumane experiments" [277]. She exemplifies this by a case where a genetically modified child is being born for the researchers to "see how it grows up" [277]. Diana cannot see why anyone would disagree [278]. But Christina seems to think that Diana has not seen the point: It is no piece of cake to **regulate** this; the danger is that someone might go too "far" [279]. It is reasonable to think that Christina's move is motivated by Diana's previous conviction that it would never get out of hand [see e.g. 237]. Emily is then prompted to stress that she is against exploratory studies [280]. Diana now moves to offer a reason for the importance of doing GT **research**:

	SGT can become “a cure for cancer” - a “severe disease that really marks the world a lot” [282]. Emily suggests that that research can be a means to making the **unknown consequences** known [284]. And, Emily says, if the **research** then finds that GT can be “used for anything”, we can “install some completely clear” **regulations** about which diseases we are “allowed to go in an change genetically” [286-8] - i.e. which **diseases** are **legitimate** objects of GT. Anita pick up on this and proposes that the **regulations** should only name outright **diseases** as **legitimate** [289]. Emily proposes that the criteria could be that a disease in question is “life-threatening” [290] - not even “Down’s syndrome and something like that” [291]. Christina and Anita agree to the criteria of life-threatening diseases.

Table 1: An excerpt from the thematic analysis that exemplifies how the discussions were summarised sequentially.

The reader may note that already this step in the analysis involved interpretations of the speakers’ positions towards an issue. In other words, potential oppositions and challenges in the discourse were identified and compared to the previous (and ensuing) commitments of the involved speakers.

The resulting tables were thus helpful guides in the process of establishing a certain level of overview of the overall *dialectics* of the discussion. They document and represent the *thought* and *interpretation process* that occurred during the analysis. *They were my way of taking notes in the analysis process*. In other words, these tables are *strictu sensu* not results or products; and they purely served an in-house purpose of guiding the interpretation of the goings-on and the thematic issues in a discussion.

One of the key outcomes of the thematic analysis is information about the *aetiology of the final decisions* in a group. The thematic analysis provided a *genealogy* of the moral (or value-laden, at least) decisions. The term ‘genealogy’ as it is used here is miniature caricature of the concept applied by Nietzsche (1967) and later by Foucault (1999). The concept ‘genealogy’ is fitting in this context because the thematic analysis worked to *trace the origins* of the final decision – and thus not to see the final decision as a necessary product of the way in which the argues rationalised over the issue, but, rather, *to understand the dynamic* *roots of the decisions in terms of successive sequences in which the arguers thematised different (subordinate) issues*. In other words, the final decisions of the groups were not conceptualized as the end point of a neatly arranged string of arguments, but rather as something that emerged from a multitude of different sub-discussions that were about different issues and that pointed in many different ways.

1.6.2.4 *Step Three and Four: An Example of Normative Pragmatics Analysis*

Papers II through IV are to a large extend concerned with taking the reader by the hand and depict the analysis as it unfolded. This is the strength of normative pragmatics analysis: The analyst's interpretative decisions are (ideally) transparent. The best way to make explicit what such analysis involves is to show it is practice. Consider the following excerpt (terms and phrases that represent science content are italicised):

42 C3	Diana:	no, but it could be the case, you see, that there are some … (who thinks) that one must do everything within one's power=
43 C3	Christina:	yes
44 C3	Diana:	=well, to cure all people
45 C3	Christina:	yes
46 C3	Diana:	see, there is also another side of the coin
47 C3	Emily:	I just think, like … well, when is it a disease?
48 C3	Christina:	yes. Well, you see it's exactly that which I find difficult
49 C3	Diana:	if you just have the *hereditary predisposition* to get it ...
50 C3	Christina:	should they go in and be changed, then? *Yeah because, one could say, there are a whole lot who have the hereditary predisposition to get cancer. That is, it is said, you see, that it skips a link. So it is, you see, every other in one's family will be, what's it called? … it skips a generation. So every other in one's family would be predisposed to get cancer*

The thematic analysis (step two) indicated that this interaction (turns 42-50) is part of an essential sequence (turns 26-56) for the overall discussion: It is the origin of the *legitimate-disease* sub-discussion[12] in group C3, which was thematic for that group. Further, two other main thematic sub-discussion have their origin here: The *closed-future* sub-discussion[13] and the *genetic elite* sub-discussion[14]. The primary aim of the analysis will be to arrive at an interpretation of what argumentative role Diana and Christina's invocations of science content had in this sequence.

The focus in the following will be on the turns 47 to 50. In the passages leading up to turn 47 (turns 37-46) the discussion was about how far people should take the technology of gene therapy. In particular, Diana made a social fact assertion "that there are some … (who thinks) that one must do everything within one's power […] to cure, well, all people" [44, 46].

Emily responded to this in turn 47; and it could be argued that her response was argumentative. In turn 47, Emily performed a *directive.* She asked a *question* with the aim of getting the others and Diana, in particular, to respond to: "well, when is it a disease?". Prima facie this could be interpreted as requesting a *usage declarative* from Diana: Diana is requested to define or elucidate what she means a disease is. On this interpretation it opens what some refer to as a "conventional activity sequence" through which Emily has "opened a conversational

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[12] The '*legitimate disease*'-issue pertained to the perennial issue in bioethics concerning how to negotiate what would constitute a legitimate target of germ-line gene therapy and somatic gene therapy (e.g. Rabino, 2003). While some diseases may in the future be cured, or removed completely, using gene therapy, some conditions, such as minor discomforts, should maybe not be legitimate targets of gene therapy.

[13] The '*closed future*'-issue pertained to whether it would be ethically permissible to decide on behalf of beneficiaries of germ-line gene therapy – that is, a person's right to an "open future" (Feinberg, 1980) may be violated. The concern was that autonomous choices of, for example, parents or societal institutions might severely limit the autonomy of the beneficiary (e.g. D. S. Davies, 2006; Takala, 2005).

[14] The '*genetic elite*'-issue pertained to whether allowing germ-line gene therapy would be a slippery slope towards a scenario in which a powerful elite can reproduce and amplify their status as an elite. As in the scholarly debate in bioethics (Harris, 1993; Reindal, 2000), this issue often involved considerations about eugenics and vicious attempts to create a perfect race.

project" (Jacobs & Jackson, 1981, p. 124; Jacobs, Jackson, Stearns, & Hall, 1991, p. 46). The conversational project could be about settling what the group members should count as a disease. But the way Emily starts her turn 47 indicates an element of disagreement or doubt. Indeed, Emily could be seen as disagreeing to something in Diana's social fact assertion: "I just think, like … ". Her expression of doubt and her following request for clarification is an indicator of a *single non-mixed dispute* (van Eemeren, et al., 2007, p. 46). But it may very well evolve into a *mixed dispute* if Emily explicitly expresses a standpoint opposite to Diana's.

This is the key point: Emily did more than simply ask a question in order to come to an understanding. She did not just ask for an empirical description of what a disease is. She asked for which *criteria* should be placed on a condition for it to be a disease in the sense that they are talking about. She is asking for a normative distinction of what kinds of diseases they should be talking about. This could, at least tentatively, be supported by reading Emily as conforming Grice's (1989) maxim that one ought not to perform *unnecessary* speech acts – the issue here is not so much what a disease is (for the interlocutors would surely have some idea about that), but rather what counts as a disease in the specific context (van Eemeren & Grootendorst, 1989). This interpretation is further supported by the way in which Christina responded to Emily: "yes. Well it is exactly that which I find difficult" (48). Christina was not prompted to give an empirical description of what a disease is. She was prompted to say something about the task that falls upon them in their decision making process. We are therefore allowed to interpret Emily's move in 47 as involving a challenge to Diana's expression of a social fact.

Now, at this point it's unclear whether Diana really held that it is admissible to "do everything within one's power" to "cure all people". She could merely assert it to be a social fact that some people will think this way. Regardless of this, the argumentative purpose of Emily's turn 47 seems to be directed at the possible results it would have to "do everything within one's powers". In that sense, Emily's turn resonates with the “slippery-slope”-argument against gene therapy which is commonly found in bioethical discussion (Holtug, 1993). The core of such arguments are usually that it will not be possible to demarcate between legitimate and illegitimate diseases, and thus that gene therapy will run amok. Thus Emily's (as well as Christina’s move in turn 48) move in turn 47 could be interpreted as communicating the message that (i) there is a need to decide by which criteria some diseases are legitimate and others not, that (ii) Diana has not sufficiently elucidated these criteria, and – possibly – (iii) that it may not even be possible to identify such criteria. Again, the key is that Emily’s message in turn 47 was much more than a simple request for clarification.

In turn 49 Diana offered her response to Emily: “if you just have the hereditary predisposition to possibly get it” [49]. Interestingly, Diana builds her criteria for what counts as a legitimate disease on a science term – ‘hereditary predisposition’. We could, that is, understand Diana as referring to medical science as the ultimate judge about when a person deserves to be cured using every means we (medical science) has. And that the line between what is to be cured and what is not, can be found through some sort of genetic screening. So Diana presented a concrete *proposal*: A person is a legitimate subject for being cured as long as she has the hereditary predisposition. In that sense she clarifies what Emily was concerned with: there is an obvious candidate for distinguishing what a legitimate disease is - namely the genetic material of persons.

This is, thus, a very straightforward invocation of science: By referring to a yardstick that can be scientifically tested for (does person X have hereditary predispositions (for a specific disease), yes or no?), Diana may accomplish to meet and diffuse the challenge posed to her by Emily and Christina. Notice that the weight of Emily and Christina’s respective challenges is that it *will be a problem* to identify practical criteria for legitimate diseases. But by making reference to a scientific technology, Diana could potentially accomplish to show that the question of whether one has a legitimate disease is very determinate.

The ensuing passages, however, testament that she did not accomplish this.

Christina's reaction – in turn 50 – contained two salient points. First, Christina performed a *directive* – by asking Diana "should they go in and be changed, then?". Second, Christina follows up on her own question by performing a series of *assertives* pertaining to the hereditary characteristics of cancer. I will deal with each aspect in that order in the following.

In the way the directive was performed, it is doubtful that Christina merely aimed at getting Diana to clarify or justify herself. It seems clear that Christina withholds endorsement of Diana's assertion in 49. At this point the *design features* of Christina's question are illuminating. In particular, Christina's use of 'then' in her question indicates a rhetorical question which often functions as a way of indirectly attributing a standpoint to the opponent (Eemeren, Houtlosser, Snoeck Henkemans, 2007, p. 94). In this interpretation, Christina's question in 50 was a vehicle for attributing to Diana the proposal:

(I) All hereditary pre-dispositional diseases should be removed by changing the genetic material

Christina treats Diana's assertion in 49 as a *starting point* and (I) as the *conclusion* that Diana would have to hold in light of the starting point. So, Christina ascribed to Diana the following premises for (I):

(I.Ia) Everything within one's power should be done to cure diseases (from 42, 44)
(I.Ib) A hereditary predisposed disease is also a disease that needs to be cured (from 49)

It is this argument – in particular the proposal (I) – which Christina targeted through the invocation of science factual information in turn 50. Clearly she attempted to make the case that there are so many persons with hereditary predisposition to develop cancer that proposal

(I) would loose its force. To this end, Christina elicited a proclaimed science fact – namely, that “a whole lot” of people have a predisposition to get cancer – and this information was substantiated by a series of assertions (“cancer skips a link”, “every other in one’s family would be predisposed”).

The design features of these assertions are telling: Each assertion is formulated in a matter-of-factual fashion. Indeed, the argumentative indicator ‘you see’ (Danish: ‘jo’) is a discourse connective, which indicates that the speaker attempts to bring her interlocutor to make a pragmatic inference – the pragmatic function being that it appears that a claim (or explanandum) has been, or will now become, sufficiently justified (or explained) (Blakemore, 1987; Bruce Fraser, 1990; Jaszczolt, 2002). Further, Christina proclaimed that “it is said […] that it skips a link” (50). Now, a phrase like ‘it is said’ could be a way of establishing a factual quality; it resembles an appeal to expert authority (Goodwin, 2011; Goodwin & Honeycutt, 2009).

The key point is that Christina did more than bring (new) information to the table. Her assertion has more than “information relevance” - it has “pragmatic relevance” because she puts to use that information argumentatively (Jacobs & Jackson, 1992, p. 162). So Christina made reference to a proclaimed science fact (that ‘a whole lot’ of persons have hereditary predisposition for cancer) in order to install doubt in the rationality of Diana’s proposal.

In other words, Christina’s message seems to be roughly as follows: *if* proposal (I) was accepted *then* it would result in nearly everyone being classified as carrying a disease and thus being legitimate subjects for gene therapy. But Christina gave us no real way of knowing why the number of people would have any importance. Is it too unpractical? Is it a too vast intervention on mankind?

To summarise, Christina attempted to create a reason for undermining Diana's proposal (I) on account of some apparently undesirable consequences. And the argumentative strategy that Christina opted for was one that featured science content. So the science content that Christina expresses in turn 50 had a *local* role of lending (pragmatic) credibility to her reservations about accepting Diana's proposal. In other words, the science content – which Christina invoked – is that which allows her interlocutors to *manifestly see* that proposal (I) would lead to undesirable consequences. Further, the initial rhetorical question remains for Diana to react to. It would now be Diana who has the *burden of proof* in terms of arguing either why the scale of intervention is not a problem, or accepting that the scale of intervention is a problem and argue why the scale of intervention is less than perceived by Christina.

In this short interaction we have witnessed two different argumentative strategies that feature science content. In one case, a speaker invoked science in an attempt to meet and diffuse a challenge. More specifically, the speaker referred to a factual state of affair (whether a person has a hereditary precondition for a disease) as the ultimate criteria of whether that person is eligible for human gene therapy. In the context, this could have allowed the speaker not just to make it appear as if some agreeable criteria for legitimate diseases *exist*, but also to indicate that the issue of determining which cases are eligible is a *determinate* issue – so that it can be judged by a scientific standard.

In the other case, the speaker invoked science content in an attempt to challenge an opponent. More specifically, the speaker listed a series of assertions in a matter-of-factual fashion in order to substantiate that a concrete proposal by an opponent is unsound or unpractical. In the context, this could have allowed the speaker to make it appear as if the proposal that she challenged was rendered unsound by the ‘bare facts’ alone.

Against the background of the thematic analysis (step two in the analysis procedure) it is indicated that the turn 49 and 50 only had an indirect role in the discussion as a whole. These particular points were not addressed directly in the ensuing discussion. Nevertheless, aspects of the scale of intervention were involved in a later key issue for the group: the *regulation* sub-discussion about how to regulate the use of gene therapy so that the technology is directed under some measure of control.

1.7 References

Acar, O., Turkmen, L., & Roychoudhury, A. (2010). Student Difficulties in Socio-scientific Argumentation and Decision-making Research Findings: Crossing the borders of two research lines. *International Journal of Science Education, 32*(9), 1191 - 206.

Albe, V. (2007). Students' Argumentation in Group Discussions on a Socio-Scientific Issue. In Roser Pintó & Digna Couso (Eds.), *Contributions from Science Education Research* (pp. 389-401): Springer Netherlands.

Albe, V. (2008a). Students' positions and considerations of scientific evidence about a controversial socioscientific issue. *Science & Education, 17*(8-9), 805-27.

Albe, V. (2008b). When Scientific Knowledge, Daily Life Experience, Epistemological and Social Considerations Intersect: Students' Argumentation in Group Discussions on a Socio-scientific Issue. *Research in Science Education, 38*(1), 67-90.

Aristotle. (1954). *Rhetoric and Poetics* (W.R. Roberts, Trans.). New York: The Modern Library Press.

Aristotle. (1981). *Aristotle in 23 Volumes, Vol. 20* (H. Rackham, Trans.). Cambridge (MA): Harvard University Press.

Aristotle. (1997). *Topics. Books I and VIII, with excerpts from related texts* (Robin Smith, Trans.). Oxford: Clarendon Press.

Aubusson, P., Fogwill, S., Barr, R., & Perkovic, L. (1997). What happens when students do simulation-role-play in science? *Research in Science Education, 27*(4), 565-79.

Aufschnaiter, C.v., Erduran, S., Osborne, J., & Simon, S. (2007). Arguments and the learning of science. In R Pintó & D Couso (Eds.), *Contributions from Science Education* (pp. 377-88). Dordrecht: Springer.

Aufschnaiter, C.v., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching, 45*(1), 101-31.

Beard, D. (2003). Informal Logic. *Review of Communication, 3*(3), 254-9.

Bell, R.L., & Lederman, N.G. (2003). Understandings of the nature of science and decision making on science and technology based issues. *Science Education, 87*(3), 352-77.

Berland, L.K., & Mcneill, K.L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education, 94*(5), 765-93.

Bermejo-Luque, L. (2006). Toulmin's Model of Argument and the Question of Relativism. *Arguing on the Toulmin Model*, 71-85.

Binkley, R.W. (1995). Argumentation, education and reasoning. *Informal Logic, 17*(2), 127-43.
Blair, J.A. (2006). Pragma-Dialectics and pragma-dialectics. In P Houtlosser & A van Rees (Eds.), *Considering Pragma-Dialectics* (pp. 11-21). Mahwah (NJ): Lawrence Erlbaum Associates.
Blair, J.A., & Johnson, R.H. (1987). Argumentation as dialectical. *Argumentation, 1*(1), 41-56.
Blakemore, D. (1987). *Semantic constraints on relevance*. Oxford: Blackwell Publishers Ltd.
Brandom, R.B. (1994). *Making It Explicit: Reasoning, Representing, and Discursive Commitment*: Harvard University Press.
Branham, R. (1999). Abolitionist Reconstructions of July Fourth. In F. H. van Eemeren, R Grootendorst, J.A. Blair & C. Willard (Eds.), *Proceedings of the Fourth International Conference of the International Society for the Study of Argumentation*. Amsterdam: Sic Sat.
Bricker, L.A., & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education, 92*(3), 473-98.
Castaneda, H. (1960). On a proposed revolution in logic. *Philosophy of Science*, 279-92.
Chafe, W.L. (1980). *The pear stories: Cognitive, cultural, and linguistic aspects of narrative production*. Norwood, NJ: Ablex.
Chambliss, M.J. (1995). Text Cues and Strategies Successful Readers Use to Construct the Gist of lengthy Written Arguments. *Reading Research Quarterly, 30*(4), 778-807.
Chin, C., & Osborne, J. (2010). Students' Questions and Discursive Interaction: Their Impact on Argumentation During Collaborative Group Discussions in Science. *Journal of Research in Science Teaching, 47*(7), 883-908.
Chong, D., & Druckman, J.N. (2007). Framing Theory. *Annual Review of Political Science, 10*(1), 103-26.
Clark, D., D'angelo, C.M., & Menekse, M. (2009). Initial Structuring of Online Discussions to Improve Learning and Argumentation: Incorporating Students' Own Explanations as Seed Comments Versus an Augmented-Preset Approach to Seeding Discussions. *J Sci Educ Technol*, 1-13.
Clark, D., & Sampson, V. (2007). Personally-Seeded Discussions to Scaffold Online Argumentation. *International Journal of Science Education, 29*(3), 253-77.
Clark, D., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. *Journal of Research in Science Teaching, 45*(3), 293-321.
Colebatch, H.K. (1998). *Policy*. Buckingham: Open University Press.
Cooley, J. (1959). On Mr. Toulmin's revolution in logic. *The Journal of Philosophy, 56*(7), 297-319.
Cowan, J. (1964). The Uses of Argument – An apology for logic. *Mind: A Quarterly Review of Philosophy, 73*(289), 27-45.

Craig, R., & Tracy, K. (2005). "The issue" in argumentation practice and theory. In F.H. van Eemeren & P. Houtlosser (Eds.), *Argumentation in Practice* (pp. 11-28). Amsterdam: John Benjamins.

Danish Ministry of Education. (2010). *Bekendtgørelse om uddannelsen til studentereksamen. Nr 692 af 23/06/2010 (Executive Order nr. 692 of 23/06/2010).*

Davies, D.S. (2006). Genetic Dilemmas and the Child's Right to an Open Future. In Helga Kuhse & Peter Singer (Eds.), *Bioethics: An Anthology* (pp. 246-56). Oxford: Blackwell Publishing Ltd.

Davies, H.T.O., Nutley, S.M., & Smith, P.C. (1999). Viewpoint: Editorial: What Works? The Role of Evidence in Public Sector Policy and Practice. *Public Money & Management, 19*(1), 3-5.

Davis, J.H., Laughlin, P.R., & Komorita, S.S. (1976). The social psychology of small groups: Cooperative and mixed-motive interaction. *Annual Review of Psychology, 27*, 501-41.

Dawson, C. (2000). Selling snake oil: must science educatorscontinue to promise what they can't deliver. . In RT Cross & P Fensham (Eds.), *In Science andthe citizen for educators and the public*. Melbourne: Arena Publications.

Dawson, V., & Taylor, P. (1999). Teaching bioethics in science: Does it make a difference? *Australian Science Teachers Journa, 45*(59-65).

Dawson, V., & Venville, G. (2009). High-school Students' Informal Reasoning and Argumentation about Biotechnology: An indicator of scientific literacy? *International Journal of Science Education, 31*(11), 1421-45.

Dennis, A.R., Fuller, R.M., & Valacich, J.S. (2008). Media, tasks, and communication processes: a theory of media synchronicity. *MIS Quarterly, 32*(3), 575-600.

Denzin, N.K., & Lincoln, Y. (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.

Douglass, F. (1999). What to the Slave is the Fourth of July? Extract from an Oration,

at Rochester, July 5, 1852. In J. W. Blassingame, J. R. McKivigan & P. P. Hinks (Eds.), *The Frederick Douglass Papers, Series Two: Autobiographical Writings, Vol. 2* (pp. 264-8). New Haven: Yale University Press.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Dryzek, J.S. (1993). Discoursive Democracy: politics, policy, and political science. In F Fischer & J Forester (Eds.), *The Argumentative turn in policy analysis and planning* (pp. 213-). Durham: Duke University Press.

Duschl, R.A. (2007). Quality Argumentation and Epistemic Criteria. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 159-75): Springer Netherlands.

Duschl, R.A., & Osborne, J. (2002). Supporting and Promoting Argumentation Discourse in Science Education. *Studies in Science Education, 38*, 39-72.

Duveen, J., & Solomon, J. (1994). The Great evolution trial: Use of role-play in the classroom. *Journal of Research in Science Teaching, 31*(5), 575-82.

Eastwood, J.L., Schlegel, W.M., & Cook, K.L. (2011). Effects of an Interdisciplinary Program on Students' Reasoning with Socioscientific Issues and Perceptions of Their Learning Experiences. In Troy D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 89-126). Dordrecht: Springer Netherlands.

Eemeren, F.H.v. (1993). *Reconstructing argumentative discourse*. Tuscaloosa: University of Alabama Press.

Eemeren, F.H.v., & Grootendorst, R. (1992). *Argumentation, communication, and fallacies : a pragma-dialectical perspective*. Hillsdale, N.J.: L. Erlbaum.

Eemeren, F.H.v., & Houtlosser, P. (2002). *Dialectic and rhetoric: the warp and woof of argumentation analysis*. Dordrecht Kluwer Academic Publishers.

Ekborg, M., Ideland, M., & Malmberg, C. (2009). Science for life – a conceptual framework for construction and analysis of socio-scientific cases. *NorDiNa, 5*(1), 35-46.

Entman, R.M. (1993). Framing: Toward clarification of a fractured paradigm. *Journal of Communication, 43*(4), 51-8.

Erduran, S. (2007). Methodological Foundations in the Study of Argumentation in Science Classrooms. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 47-69): Springer Netherlands.

Erduran, S., & Jiménez-Aleixandre, M.P. (2007). *Argumentation in Science Education*. Dordrecht: Springer Netherlands.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88*(6), 915-33.

EU-Commision. (2004). Europe needs more scientists. *Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe*, 1-215.

Evagorou, M. (2011). Discussing a Socioscientific Issue in a Primary School Classroom: The Case of Using a Technology-Supported Environment in Formal and Nonformal Settings. In Troy D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 133-59): Springer Netherlands.

Fairclough, N. (1992). *Discourse and social change*. Cambridge: Polity Press.

Feinberg, J. (1980). The Child's Right to an Open Future. In W. Aiken & H. LaFollette (Eds.), *Whose Child? Children's Rights, Parental Authority and State Power* (pp. 124-53). Totowa (NJ): Littlefield, Admas & Co.

Fensham, P.J. (2002). Time to change drivers for scientific literacy. *Canadian Journal of Science, Mathematics and Technology Education, 2*(1), 9-24.

Fischer, F., & Forester, J. (1993). Editors' Introduction. In F Fischer & J Forester (Eds.), *The Argumentative turn in policy analysis and planning* (pp. 1-17). Durham: Duke University Press.

Fisher, B.A. (1981). *Small Group Decision Making*. London: McGraw-Hill.

Fleming, R. (1986). Adolescent reasoning in socio-scientific issues, part I: Social cognition. *Journal of Research in Science Teaching, 23*(8), 677-87.

Foucault, M. (1999). *Essential Works of Foucault, 1954–1984*. New York: The New Press.

Fowler, S.R., Zeidler, D.L., & Sadler, T.D. (2009). Moral sensitivity in the context of socioscientific issues in high school science students. *International Journal of Science Education, 31*(2), 279-96.

Fraser, B. (1990). An approach to discourse markers. *Journal of Pragmatics, 14*(3), 383-98.

Fraser, B. (1996). Pragmatic Markers. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 6*(2), 167-90.

Freeman, J.B. (2005). Systematizing Toulmin's Warrants: An Epistemic Approach. *Argumentation, 19*, 1-46.

Freeman, J.B. (2009). Argument Strength, the Toulmin Model, and Ampliative Probability. In F. H. van Eemeren & B. Garssen (Eds.), *Pondering on Problems of Argumentation* (pp. 191-205). Dordrecht: Springer.

Fulkerson, R. (1996). *Teaching the Argument in Writing*. Urbana, IL: National Council of Teachers of English.

Funtowicz, S.O., & Ravetz, J.R. (1990). *Uncertainty and quality in science for policy*. Dordrecht: Kluwer Academic Publishers.

Funtowicz, S.O., & Ravetz, J.R. (1993). Science for the post-normal age. *Futures, 25*(7), 739-55.

Garcia-Mila, M., & Andersen, C. (2007). Cognitive Foundations of Learning Argumentation. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 29-45). Dordrecht: Springer Netherlands.

Gilbert, M.A. (1997). *Prolegomenon to a Pragmatics of Emotion.* Paper presented at the Ontario Society for the Study of Argumentation, Brock University, St. Catherine's, ON. Retrieved from http://www.yorku.ca/gilbert/argthry/argthry/arg-papers/mag1997-prol-emo.pdf.

Goldman, A.I. (1999). *Knowledge in a social world*. Oxford: Oxford University Press.

Goodnight, T.G. (1982). The Personal, Technical and Public Spheres of Argument: A Speculative Inquiry into the Art of Public Deliberation. *Journal of the American Forensic Association, 18*, 214-27.

Goodwin, J. (1999). Good argumentation without resolution. *Proceedings of the Fourth International Conference of the International Society for the Study of Argumentation*, 255-7.

Goodwin, J. (2000a). Comments on 'Rhetoric and Dialectic from the Standpoint of Normative Pragmatics'. *Argumentation, 14*(3), 287-92.

Goodwin, J. (2000b). Comments on `Rhetoric and Dialectic from the Standpoint of Normative Pragmatics'. *Argumentation, 14*(3), 287-92.

Goodwin, J. (2001). One Question, Two Answers. In H.V. Hansen, C.W. Tindale, J.A. Blair, R.H. Johnson & R.C. Pinto (Eds.), *Argumentation and Its Implications* (pp. 1-17). Windsor, Ontario: Ontario Society for the Study of Argument, CD-ROM, ISBN:0-9683461-2-X, Retrieved from http://www.public.iastate.edu/~goodwin/pubs/goodwinone.pdf.

Goodwin, J. (2002). Designing issues. In F.H. van Eemeren & P. Houtlosser (Eds.), *Dialectic and rhetoric: The warp and woof of argumentation analysis* (pp. 81-96). Amsterdam: Kluwer.

Goodwin, J. (2003). *Manifestly Adequate Premises.* Paper presented at the Informal Logic @ 25 – The Ontario Society for the Study of Argumentation Conference, Windsor.

Goodwin, J. (2005). Designing premises. In F.H. van Eemeren & P. Houtlosser (Eds.), *Argumentation in Practice* (pp. 99-114). Amsterdam: John Benjamins.

Goodwin, J. (2008). Argument has no function. *Informal Logic, 27*(1), 69.

Goodwin, J. (2011). Accounting for the Appeal to the Authority of Experts. *Argumentation, 25*(3), 285-96.

Goodwin, J., & Honeycutt, L. (2009). When Science goes Public: From Technical Arguments to Appeals to Authority. *Studies in Communication Sciences, 9*(2), 19--30.

Gott, R., & Duggan, S. (2007). A framework for practical work in science and scientific literacy through argumentation. *Research in Science 25*(3), 271-91.

Govier, T. (1980). Assesing Arguments: What Range of Standards? *Informal Logic Newsletter, 3*(1), 1-2.

Govier, T. (2010). *A Practical Study of Argument* (7th ed.). Belmont: Wadsworth Cengage Learning.

Grace, M.M., & Ratcliffe, M. (2002). The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24*(11), 1157 - 69.

Green, J.L., & Wallat, C. (1981). *Ethnography and language in educational settings*. Norwood, NJ: Ablex.

Grice, P. (1989). *Studies in the way of words*. Cambridge, MA: Harvard University Press.

Groarke, L. (Ed.) (2011) The Stanford Encyclopedia of Philosophy (Fall 2008 Edition).

Gross, A.G. (1984). A Comment on the Uses of Toulmin. *College English, 46*, 10-4.

Gumperz, J.J. (1992). Contextualization and understanding. In A. Duranti & C. Goodwin (Eds.), *Rethinking context* (pp. 229-52). Cambridge: Cambridge University Press.

Habermas, J. (1984). *The Theory of Communicative Action: Reason and the rationalization of society* (T. McCarthy, Trans.). Boston: Beacon Press.

Halverson, K.L., Siegel, M.A., & Freyermuth, S.K. (2009). Lenses for Framing Decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education, 31*(9), 1249 - 68.

Hample, D. (1992). The Toulmin model and the syllogism. In W.L. Benoit, D Hample & P.J. Benoit (Eds.), *Readings in argumentation* (pp. 225-38). Dordrecht: Foris.

Harris, J. (1993). Is Gene therapy a Form of Eugenics? *Bioethics, 7*(2-3), 178-87.

Harwood, W.S. (2002). Acting Out Science. Using Senate Hearings to Debate Global Climate Change *Journal of College Science Teaching, 31*(7), 442-7.

Hinds, J. (1979). Organizational patterns in discourse. In T Givón (Ed.), *Syntax and semantics* (pp. 135-58). New York: Academic Press.

Hitchcock, D. (2003). Indicators of complex argumentation: commentary. In J.A. Blair, D. Farr, H.V. Hansen, R.H. Johnson & C.W. Tindale (Eds.), *Informal Logic at 25 – Proceedings of the Windsor Conference*. Windsor, Ontario: OSSA. Retrieved May, 2010 from http://www.humanities.mcmaster.ca/~hitchckd/indicators.pdf.

Hofstein, A., Kipnis, M., & Kind, P. (2008). Learning in and from Science Laboratories: Enhancing Students' Meta-Cognition and Argumentation Skills. In C.L. Petroselli (Ed.), *Science Education Issues and Developments ((*pp. 59-94). New York: Nova Science Publishers.

Hogan, K. (2002). Small groups' ecological reasoning while making an environmental management decision. *Journal of Research in Science Teaching, 39*(4), 341-68.

Hohmann, H. (2000). Rhetoric and Dialectic: Some Historical and Legal Perspectives. *Argumentation, 14*, 223-34.

Holtug, N. (1993). Human Gene Therapy: Down the Slippery Slope? *Bioethics, 7*(5), 402-19.

Horn, L.R., & Ward, G.L. (2005). *The Handbook of Pragmatics*. Malden, MA: Wiley-Blackwell.

Howes, E., & Cruz, B. (2009). Role-playing in science education: An effective strategy for developing multiple perspectives. *Journal of Elementary Science Education, 21*(3), 33-46.

Innocenti, B. (2006). A normative pragmatic perspective on appealing to emotions in argumentation. *Argumentation, 20*(3), 327-43.

Irwin, A., & Wynne, G. (1996). *Misunderstanding science.* . Cambridge: Cambridge University Press.

Jackson, S., & Jacobs, S. (1980). Structure of conversational argument: Pragmatic bases for the enthymeme. *Quarterly Journal of Speech, 66*(3), 251-65.

Jacobs, S. (1999). *Argumentation as Normative Pragmatics.* Paper presented at the the Fourth International Conference of the International Society for the Study of Argumentation, Amsterdam.

Jacobs, S. (2000). Rhetoric and dialectic from the standpoint of normative pragmatics. *Argumentation, 14*(3), 261-86.

Jacobs, S., & Jackson, S. (1981). Argument as a natural category: The routine grounds for arguing in conversation. *Western Journal of Communication, 45*(2), 118-32.

Jacobs, S., & Jackson, S. (1992). Relevance and digressions in argumentative discussion: A pragmatic approach. *Argumentation, 6*(2), 161-76.

Jacobs, S., Jackson, S., Stearns, S., & Hall, B. (1991). Digressions in argumentative discourse: Multiple goals, standing concerns, and implicatures. In K Tracy (Ed.), *Understanding face-to-face interaction: Issues linking goals and discourse* (pp. 43-61). Hillsdale, NJ: Erlbaum.

Jaszczolt, K. (2002). *Semantics and pragmatics: meaning in language and discourse*. Harlow: Pearson Education.

Jiménez-Aleixandre, M.P. (2007). Designing Argumentation Learning Environments. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 91-115). Dordrecht: Springer Netherlands.

Jiménez-Aleixandre, M.P., & Erduran, S. (2007). Argumentation in Science Education: An Overview. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 3-27). Dordrecht: Springer Netherlands.

Jiménez-Aleixandre, M.P., & Pereiro-Muñoz, C. (2005). Argument Construction and Change while Working on a Real Environment Problem. In Kerst Boersma, Martin Goedhart, Onno Jong & Harrie Eijkelhof (Eds.), *Research and the Quality of Science Education* (pp. 419-31). Dordrecht: Springer.

Jiménez-Aleixandre, M.P., Rodriguez, A., & Duschl, R.A. (2000). Doing the lesson or doing science: Argument in high school genetics. *Science Education, 84*(6), 757-92.

Johnson, R.H. (1981a). Toulmin's Bold Experiment (i). *Informal Logic Newsletter, 3*(2), 1-12.

Johnson, R.H. (1981b). Toulmin's Bold Experiment (ii). *Informal Logic Newsletter, 3*(3), 1-9.

Johnson, R.H. (2000). *Manifest rationality: a pragmatic theory of argument*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Johnson, R.H. (2002). Manifest rationality reconsidered: Reply to my fellow symposiasts. *Argumentation, 16*(3), 311-31.

Katriel, T., & Dascal, M. (1984). What do indicating devices indicate? *Philosophy and Rhetoric, 17*, 1-15.

Kauffeld, F.J. (1998). Presumptions and the distribution of argumentative burdens in acts of proposing and accusing. *Argumentation, 12*(2), 245-66.

Keith, W., & Beard, D. (2008). Toulmin's Rhetorical Logic: What's the Warrant for Warrants? *Philosophy and Rhetoric, 41*(1), 22-50.

Kelly, G.J., & Chen, C. (1999). The sound of music: Constructing science as sociocultural practices through oral and written discourse. *Journal of Research in Science Teaching, 36*, 883-915.

Kelly, G.J., Chen, C., & Prothero, W. (2000). The epistemological framing of a discipline: Writing science in university oceanography. *Journal of Research in Science Teaching, 37*(7), 691-718.

Kelly, G.J., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education, 20*(7), 849-71.

Kennedy, G.A. (1999). *Classical rhetoric & its Christian & secular tradition from ancient to modern times* (2nd ed.). Chapel Hill: University of North Carolina Press.

Kitcher, P. (2010). The Climate Change Debates. *Science, 328*(5983), 1230-4.

Kock, C. (2003). Multidimensionality and Non-Deductiveness in Deliberative Argumentation. *Anyone who has a view: Theoretical contributions to the study of argumentation*, 157.

Kock, C. (2006). Multiple warrants in practical reasoning. *Arguing on the Toulmin Model*, 247-59.

Kock, C. (2007). Norms of legitimate dissensus. *Informal Logic, 27*(2), 179-96.

Kock, C. (2008). Dialectical Obligations in Political Debate. *Informal Logic, 27*(3), 223.

Kock, C. (2009). Choice is Not True or False: The Domain of Rhetorical Argumentation. *Argumentation, 23*(1), 61-80.

Kogan, M. (1999). The Impact of Research on Policy. In F Coffield (Ed.), *Speaking Truth to Power: Research and Policy on Lifelong Learning* (pp. 11-8). Bristol: Policy Press.

Kolstø, S.D. (2001). 'To trust or not to trust, . . .'- pupils' ways of judging information encountered in a socio-scientific issue. *International Journal of Science Education, 23*(9), 877-901.

Kolstø, S.D. (2006). Patterns in Students' Argumentation Confronted with a Risk‐focused Socio‐scientific Issue. *International Journal of Science Education, 28*(14), 1689-716.

Kolstø, S.D., Bungum, B., Arnesen, E., Isnes, A., Kristensen, T., Mathiassen, K., et al. (2006). Science students' critical examination of scientific information related to socioscientific issues. *Science Education, 90*(4), 632-55.

Kolstø, S.D., & Ratcliffe, M. (2007). Social Aspects of Argumentation. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (Vol. 35, pp. 117-36). Dordrecht: Springer Netherlands.

Kuhn, D. (1991). *The skills of argument*. Cambridge ; New York: Cambridge University Press.

Levinson, R. (2004). Teaching bioethics in science: Crossing a bridge too far? *Canadian Journal of Science, Mathematics and Technology Education, 4*(3), 353 - 69.

Levinson, R. (2006a). Teachers' perceptions of the role of evidence in teaching controversial socio-scientific issues. *Curriculum Journal, 17*(3), 247-62.

Levinson, R. (2006b). Towards a Theoretical Framework for Teaching Controversial Socio‐scientific Issues. *International Journal of Science Education, 28*(10), 1201-24.

Levinson, R. (2007). *Towards a pedagogical framework for the teaching of controversial socio-scientific issues to secondary school students in the age range 14-19.* University of London., London.

Lewis, J., & Leach, J. (2006). Discussion of Socio-scientific Issues: The role of science knowledge. *International Journal of Science Education, 28*(11), 1267 -- 87.

Longacre, R.E. (1979). The paragraph as a grammatical unit. In T Givón (Ed.), *Syntax and semantics* (pp. 115-34). New York: Academic Press.

Lynch, M. (1982). Closure and disclosure in pre-trial argument. *Human studies, 5*(1), 285-318.

Maloney, J., & Simon, S. (2006). Mapping children's discussions of evidence in science to assess collaboration and argumentation. *International Journal of Science Education, 28*(15), 1817-42.

Marks, R., Bertram, S., & Eilks, I. (2008). Learning chemistry and beyond with a lesson plan on potato crisps, which follows a socio-critical and problem-oriented approach to chemistry lessons - a case study. *Chemistry Education Research and Practice, 9*(3), 267-76.

Mercier, H. & Sperber, D. (2011). Why do Humans Reason? Arguments for an Argumentative Theory. *Behavioral and Brain Sciences*, 34, 57-111.

Mey, J. (1993). *Pragmatics*. New York: Blackwell.

Michelsen, C., Nielsen, J., & Petersen, M. (2008). Science and Mathematics Teachers of the Future. *Interacções, 4*(9), 97-112.

Michelsen, C., & Nielsen, J.A. (2008). Between Teaching and Researching: Envisaging Ownership Benefits of Involving Teachers from an In-Service Teacher Training Program in the PARSEL Project. *Science Education International, 19*(3), 313-22.

Millar, R. (1997). Science education for democracy. In R. Levinson & J. Thomas (Eds.), *Science Today: Problem or Crisis?* (pp. 87-101). London: Routledge.

Millar, R., & Osborne, J. (1998). *Beyond 2000: science education for the future.* London: King's College London.

Molinatti, G., Girault, Y., & Hammond, C. (2010). High School Students Debate the Use of Embryonic Stem Cells: The influence of context on decision-making. *International Journal of Science Education, 99999*(1), 1-17.

Morris, C.W. (1938). Foundations of the theory of signs. In O Neurath, R Carnap & Charles W. Morris (Eds.), *International Encyclopedia of Unified Science*. Chicago: University of Chicago Press.

Munneke, L., van Amelsvoort, M., & Andriessen, J. (2003). The role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research, 39*(1-2), 113-31.

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education, 37*(1), 17-39.

Newman, S., & Marshall, C. (1991). Pushing Toulmin too far: Learning from an argument representation scheme. *Xerox PARC, Palo Alto, CA, USA, Technical Report SSL-92-45*.

Nickerson, R.S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, 2(2), 175-220.

Nielsen, J.A. (2009). Structuring Students´ Critical Discussions Through Processes of Decision-Making on Socio-Scientific Controversies. *Revista de Estudos Universitários, 35*(2), 139-65.

Nielsen, J.A. (2010a). Functional roles of science in socio-scientific discussions. In I Eilks & B Ralle (Eds.), *Contemporary Science Education – Implications from Science Education Research about Orientations, Strategies and Assessment* (pp. 83-96). Aachen: Shaker.

Nielsen, J.A. (2010b). Structuring Discursive Trajectories: Provisional Thoughts on Designing for Critical Discussions and Socio-scientific Decision-making. In C Winsløw & B Evans (Eds.), *Didactics as a Design Science - peer reviewed papers from a Ph.d.-course at the University of Copenhagen* (pp. 23-34). Copenhagen: Department of Science Education.

Nietzsche, F. (1967). *On The Genealogy of Morals and Ecce Homo* (W Kaufmann, Trans.). New Yourk: Vintage.

Nowotny, H. (1990). *In Search of Usable Knowledge. Utilization Contexts and the Application of Knowledge*. Frankfurt am Main: Campus Verlag.

O'Keefe, D. (1977). Two concepts of argument. *Journal of the American Forensic Association, 13*(3), 121-8.

OECD. (2006). *Assessing, Scientific, Reading and Mathematical Literacy - A Framework for PISA 2006*. Paris: OECD.

Okada, A., & Shum, S.B. (2008). Evidence-based Dialogue Maps as a research tool to investigate the quality of school pupils' scientific argumentation. *International Journal of Research & Method in Education, 31*(3), 291-315.

Orlander Arvola, A., & Lundegård, I. (2011). 'It's Her Body'. When Students' Argumentation Shows Displacement of Content in a Science Classroom. *Research in Science Education,* (Advance online publication), 1-25. Retrieved from http://dx.doi.org/10.1007/s11165-011-9237-2. doi:10.1007/s11165-011-9237-2

Osborne, J. (2005). The Role of Argument in Science Education. In Kerst Boersma, Martin Goedhart, Onno Jong & Harrie Eijkelhof (Eds.), *Research and the Quality of Science Education* (pp. 367-80). Dordrecht: Springer Netherlands.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: implications for teaching. *International Journal of Science Education*.

Pedretti, E., & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education, 95*(4), 601-26.

Pontecorvo, C., & Girardet, H. (1993). Arguing and Reasoning in Understanding Historical Topics. *Cognition & Instruction, 11*(3/4), 365.

Primatarova-Miltscheva, A. (1987). Sequence with Concessive, Adversative, and Restrictive Sentences and Clauses and The Simulation of Dialogical Argumentation Patterns in Monological Discourse. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C.A. Willard (Eds.), *Argumentation: Perspectives and Approaches* (pp. 41-53). Dordrecht: Foris.

Rabino, I. (2003). Gene Therapy: Ethical Issues. *Theoretical Medicine and Bioethics, 24*(1), 31-58.

Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. *International Journal of Science Education, 19*(2), 167-82.

Ravenscroft, A., & Mcalister, S. (2008). Investigating and promoting educational argumentation: towards new digital practices. *Int. J. of Res. & Method in Educ., 31*(3), 317-35.

Ravetz, J.R. (1987). Uncertainty, ignorance, and policy. In Harvey Brooks & Chester L. Cooper (Eds.), *Science for public policy* (1st ed., pp. 77-94). Oxford: Pergamon Press.

Raz, J. (1999). *Engaging Reason: On the Theory of Value and Action*. Oxford: Oxford University Press.

Reed, C., & Rowe, G. (2005). Translating Toulmin Diagrams: Theory Neutrality in Argument Representation. *Argumentation, 19*(3), 267-86.

Reindal, S.M. (2000). Disability, gene therapy and eugenics - a challenge to John Harris. *Journal of Medical Ethics, 26*(2), 89-94.

Rémondet, M. (2009). Objets-frontière à l'épreuve. *Revue d'anthropologie des connaissances, 3*(1), 103-26.

Ryder, J. (2001). Identifying Science Understanding for Functional Scientific Literacy. *Studies in Science Education, 36*(1), 1-44.

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-36.

Sadler, T.D. (2011). Socio-scientific Issues in the Classroom. In Troy D. Sadler (Eds.)

Sadler, T.D., & Donnelly, L. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463-88.

Sadler, T.D., & Fowler, S.R. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education, 90*(6), 986-1004.

Sadler, T.D., & Zeidler, D.L. (2003). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education, 88*(1), 4-27.

Sadler, T.D., & Zeidler, D.L. (2004). Negotiating Gene Therapy Controversies. *The American Biology Teacher, 66*(6), 428-33.

Sadler, T.D., & Zeidler, D.L. (2005a). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Resarch in Science Teaching, 42*(1), 112-38.

Sadler, T.D., & Zeidler, D.L. (2005b). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education, 89*(1), 71-93.

Sampson, V., & Clark, D. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92*(3), 447-72.

Sanderson, I. (2002). Evaluation, Policy Learning and Evidence-Based Policy Making. *Public Administration, 80*(1), 1-22.

Schlegoff, E. (1988). Presequences and indirection: Applying speech act theory to ordinary conversation. *Journal of Pragmatics, 12*, 55-62.

Searle, J.R. (1969). *Speech Acts: An Essay in the Philosophy of Language*: Cambridge University Press.

Shea, N., Duncan, R.G., & Stephenson, C. (2011). *Exploring Genetic Literacy: How Undergraduate Science Majors Reason About Authentic Genetic Dilemma*. Paper presented at the NARST.

Simon, S. (2008). Using Toulmin's Argument Pattern in the evaluation of argumentation in school science. *Int. J. of Res. & Method in Educ., 31*(3), 277-89.

Simon, S., & Amos, R. (2011). Decision Making and Use of Evidence in a Socio-scientific Problem on Air Quality. In Troy D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 167-92): Springer Netherlands.

Simon, S., & Johnson, S. (2008). Professional Learning Portfolios for Argumentation in School Science. *International Journal of Science Education, 30*(5), 669 - 88.

Simonneaux, L. (2001). Role-play or debate to promote students' argumentation and justification on an issue in animal transgenesis. *International Journal of Science Education, 23*(9), 903-27.

Simonneaux, L. (2007). Argumentation in Science Education: An Overview
. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education: Perspectives from Classroom-Based Research* (Vol. 35, pp. 179-99): Springer Netherlands.

Simons, H.W. (1990). The Rhetoric of Inquiry as an Intellectual Movement. In H.W. Simons (Ed.), *The Rhetorical Turn: Invention and Persuasion in the Conduct of Inquiry*. Chicago, IL: University of Chicago Press.

Skoumios, M. (2008). The Effect of Sociocognitive Conflict on Students' Dialogic Argumentation about Floating and Sinking. *International Journal of Environmental & Science Education, 3*(3).

Smith, P.C. (1995). Towards a Discursive Logic: Gadamer and Toulmin on Inquiry and Argument. In L. K. Schmidt (Ed.), *The Specter of Relativsm* (pp. 159-77). Evanston: Northwestern University Press.

Snoeck Henkemans, A. (1996). Indicators of independent and interdependent arguments: 'anyway' and 'even'. In J. van Benthem, F.H. van Eemeren, R. Grootendorst & F. Veltman (Eds.), *Logic and argumentation* (pp. 77-87). Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen.

Snoeck Henkemans, A. (2003). Indicators of complex argumentation. In F.H van Eemeren, J.A. Blair, C. Willard & AF Snoeck Henkemans (Eds.), *Proceedings of the Fifth Conference of the International Society for the Study of Argumentation* (pp. 969-73). Amsterdam: Sic Sat.

Star, S.L., & Griesemer, J.R. (1989). Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science, 19*(3), 387-420.

Stevenson, A. (2010). *Oxford dictionary of English* (3rd ed.). New York, NY: Oxford University Press.

Takala, T. (2005). The Many Wrongs of human Reproductive Cloning. In M Häyry, T Takala & P Herissone-Kelly (Eds.), *Bioethics and Social Reality* (pp. 53-66). Amsterdam: Rodolpi.

Thibaut, J.W., & Kelley, H.H. (1959). *The social psychology of groups*. Oxford: John Wiley.

Thomas, D.R. (2003). A General Inductive Approach for Qualitative Data Analysis. Retrieved from http://www.health.auckland.ac.nz/hrmas/Inductive2003.pdf

Tindale, C.W. (2004). *Rhetorical Argumentation: Principles of Theory and Practice*. Thousand Oaks, CA: Sage Publications.

Toulmin, S.E. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Trent, J. (1968). Toulmin's model of an argument: An examination and extension. *Quarterly Journal of Speech, 54*(3), 252-9.

Trompette, P., & Vinck, D. (2009). Revisiting the Notion of Boundary Object. *Revue d'anthropologie des connaissances, 3*(1), 3-25.

Tseronis, A. (2009). *Qualifying standpoints. Stance adverbs as a presentational device for managing the burden of proof.* Utrecht: Netherlands Graduate School of Linguistics.

Tytler, R. (2001). Dimensions of evidence, the public understanding of science and science education. *International Journal of Science Education, 23*(8), 815 - 32.

van Dijk, T. (1981). Episodes as Units of Discourse Analysis. In D Tannen (Ed.), *Analyzing Discourse: Text and Talk.* (pp. 177-95). Georgetown: Georgetown University Press,.

van Eemeren, F.H. (1990). The study of argumentation as normative pragmatics. *Text: Transactions of the Society for Textual Scholarship, 10*(1/2), 37-44.

van Eemeren, F.H., & Grootendorst, R. (1982). The speech acts of arguing and convincing in externalized discussions. *Journal of Pragmatics, 6*(1), 1-24.

van Eemeren, F.H., & Grootendorst, R. (1989). Speech act conditions as tools for reconstructing argumentative discourse. *Argumentation, 3*(4), 367-83.

van Eemeren, F.H., & Grootendorst, R. (2003). A Pragma-dialectical Procedure for a Critical Discussion. *Argumentation, 17*.

van Eemeren, F.H., & Grootendorst, R. (2004). *A systematic theory of argumentation: The pragma-dialectical approach*. Cambridge: Cambridge University Press.

van Eemeren, F.H., Grootendorst, R., & Kruiger, T. (1987). *Handbook of Argumentation Theory: a Critical Survey of Classical Backgrounds and Modern Studies*. Dordrecht: Foris.

van Eemeren, F.H., Grootendorst, R., & Snoeck Henkemans, F. (2002). *Argumentation: analysis, evaluation, presentation*. Mahwah, N.J.: L. Erlbaum Associates.

van Eemeren, F.H., & Houtlosser, P. (1999). Strategic manoeuvring in argumentative discourse. *Discourse Studies, 1*(4), 479-97.

van Eemeren, F.H., & Houtlosser, P. (2000). Rhetorical analysis within a pragma-dialectical framework. *Argumentation, 14*(3), 293-305.

van Eemeren, F.H., & Houtlosser, P. (2002). Strategic maneuvering with the burden of proof. . In F.H. van Eemeren (Ed.), *Advances in pragma-dialectics* (pp. 13-28). New Port News, VA: Vale Press.

van Eemeren, F.H., & Houtlosser, P. (2003). The Development of the Pragma-dialectical Approach to Argumentation. *Argumentation, 17*.

van Eemeren, F.H., & Houtlosser, P. (2007). The study of argumentation as normative pragmatics. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 15*(1), 161-77.

van Eemeren, F.H., Houtlosser, P., & Henkemans, A.F.S. (2008). Dialectical profiles and indicators of argumentative moves. *Journal of Pragmatics, 40*(3), 475-93.

van Eemeren, F.H., Houtlosser, P., & Snoeck Henkemans, A. (2007). *Argumentative indicators in discourse: a pragma-dialectical study*. Dordrecht: Springer.

Verheij, B. (2005). Evaluating Arguments Based on Toulmin's Scheme. *Argumentation, 19*, 47-71.

Walker, K., & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-410.

Walton, D.N. (1998). *The new dialectic: Conversational contexts of argument*. Toronto: University of Toronto Press.

Walton, D.N. (2000). The place of dialogue theory in logic, computer science and communication studies. *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science, 123*(3), 327-46.

Walton, D.N. (2002). *Legal argumentation and evidence*. University Park, Pa.: Pennsylvania State University Press.

Walton, D.N., & Godden, D.M. (2007). Informal Logic and the Dialectical Approach to Argument. In H.V. Hansen & R.C. Pinto (Eds.), *Reason Reclaimed* (pp. 3-17). Newport News, VA: Vale Press.

Walton, D.N., & Krabbe, E. (1995). *Commitment in dialogue. Basic concepts of interpersonal reasoning*. Albany (NY): State University of New York Press.

Wenzel, J. (1993). Rhetoric and Argumentation: An Introduction. *Informal Logic, 15*(1), 1-3.

Wertsch, J.V. (1996). The role of abstract rationality in Vygotsky's image of mind. *Piaget–Vygotsky The social genesis of thought*, 25-42.

Willard, C. (1976). On the utility of descriptive diagrams for the analysis and criticism of arguments. *Communication Monographs, 43*(4), 308-19.

Williams, C., Wainwright, S., Ehrich, K., & Michael, M. (2008). Human embryos as boundary objects? Some reflections on the biomedical worlds of embryonic stem cells and pre-implantation genetic diagnosis. *New Genetics & Society, 27*(1), 7-18.

Wishart, J., Green, D., Joubert, M., & Triggs, P. (2011). Discussing Ethical Issues in School Science: An investigation into the opportunities to practise and develop arguments offered by online and face-to-face discussions. *International Journal of Science Education, Part B, 1*(1), 47-69.

Wodak, R. (2007). Pragmatics and Critical Discourse Analysis: A cross-disciplinary inquiry. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 15*(1), 203-25.

Wohlrapp, H. (1987). Toulmin's Theory and the Dynamics of Argumentation. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C. Willard (Eds.), *Argumentation: Perspectives and Approaches* (pp. 327-35). Dordrecht: Foris.

Wu, Y., & Tsai, C. (2007). High School Students' Informal Reasoning on a Socio-scientific Issue: Qualitative and quantitative analyses. *International Journal of Science Education, 29*(9), 1163-87.

Yardley-Matwiejczuk, K.E. (1997). *Role Play. Theory & Practice*. London: SAGE Publications.

Zeidler, D.L., Osborne, J., Erduran, S., Simon, S., & Monk, M. (2006). The Role of Argument During Discourse About Socioscientific Issues. In Dana L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 97-116). Dordrecht: Springer.

Zeidler, D.L., & Schafer, L.E. (1984). Identifying mediating factors of moral reasoning in science education. *Journal of Research in Science Teaching, 21*(1), 1-15.

Zohar, A. (2007). Science Teacher Education and Professional Development in Argumentation. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 245-68). Dordrecht: Springer Netherlands.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.

2

Paper I

Nielsen, J.A. (To appear). Dialectical Features of Students' Argumentation: A critical review of argumentation studies in science education. *Research in Science Education.*

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Dialectical Features of Students' Argumentation: A critical review of argumentation studies in science education

This paper explores the challenges of using the Toulmin model to analyze students' dialogical argumentation. The paper presents a theoretical exposition of what is involved in an empirical study of real dialogic argumentation. Dialogic argumentation embodies dialectical features – i.e. the features that are operative when students collaboratively manage disagreement by providing arguments and engaging critically with the arguments provided by others. The paper argues that while dialectical features cannot readily be understood from a Toulminian perspective, it appears that an investigation of them is prerequisite for conducting Toulminian analysis. This claim is substantiated by a detailed review of five of the ten most significant papers on students' argumentation in science education. This leads to the surprising notion that empirical studies in the argumentation strand – even those studies that have employed non-dialectical frameworks such as the Toulmin model – have *implicitly* struggled to come to terms with the dialectical features of students' discourse. The paper finally explores how some scholars have worked to attend directly to these dialectical features; and it presents five key issues that need to be addressed in a continued scholarly discussion.
Keywords: science education, argumentation, dialogue, dialectics, Toulmin

2.1 Introduction

Most scholars of the argumentation strand in science education agree that the strand's dominant analytical framework – the Toulmin model – does not properly guide analysts on how to distinguish between the elements – claim, data, warrant and so on – that Toulmin (1958) thought constituted an argument (e.g. Duschl, 2007; Erduran, 2007; Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000). Some scholars have even hinted that interesting discursive aspects may become lost in translation when the Toulmin model is used to reduce the dialogic nature of students' argumentation into passive patterns of arguments (e.g. Hofstein, Kipnis, & Kind, 2008; Naylor, Keogh, & Downing, 2007; Walker & Zeidler, 2007). Though some review articles have mentioned these problems (e.g. Bricker & Bell, 2008; Sampson & Clark, 2008), there is to date no science education paper that has resourced to craft a detailed review of the analytical problems that arise from using the Toulmin model on recorded argumentation. This is unfortunate because such an effort could shed light on some fundamental issues of concern within the argumentation strand. For there is a general tendency in how scholars have reacted to the problems of the Toulmin model by adjusting the model and adjusting the manner in which they have analyzed argumentation. By reviewing in detail five of the ten most significant papers of the argumentation strand, this paper argues that the argumentation strand consistently has struggled to come to terms with the *dialectical features* of students' dialogic argumentation. The paper argues, further, that it is warranted to have a thorough scholarly discussion about how to study and analyze dialogical argumentation.

The dialectical features of students' dialogic argumentation refer in this context to the features that are operative when students collaboratively manage (potential) disagreement by providing arguments and engaging critically with the arguments provided by others. There are a number of reasons for why the argumentation strand in science education should focus on these dialectical features. It has been argued that if the aim of education is to foster the development of rational agents, it involves enabling students to be attentive to their dialectical obligations of providing adequate argumentation and engaging with the argumentation of others (Siegel, 1995). It has been argued that dialectical argumentation is part and parcel of scientific debate (Pera, 1994) – indicating that the approbation of the skills for such argumentative discourse should be a prime aim of science education. Within social psychology, it has been demonstrated that the dialectical processes that students go through upon having their standpoints challenged by peers can aid the construction of more detailed disciplinary knowledge, changing or revisiting world views, and the development more appropriate ways of reasoning (Orsolini & Pontecorvo, 1992; Pontecorvo & Girardet, 1993; Pontecorvo & Pirchio, 2000). This seems to be the case especially if such processes involve negotiation and conciliation attempts (Leitão, 2000, 2001). Finally, within science education it has been argued that the promotion of scientific reasoning would benefit from an "emphasis on the […] dialogue logic found in dialectical contexts" (Duschl, 2007, p. 172).

On the face of it, only few studies in the argumentation strand have investigated the dialectical features of students' dialogic argumentation. But this is not completely correct. This paper argues that scholars of the argumentation strand have more or less been forced to attend to dialectical features of students' argumentative discourse – and that this is true even for the studies that have applied the Toulmin model. Further, the paper argues that – until recently – it has typically been the problems of the Toulmin model that have forced analysts to conduct dialectical interpretation in the first place. Finally, the paper argues that the interpretive efforts and decisions of the analysts who have attended to the dialectical features of dialogic argumentation have – with a few exceptions – remained largely implicit. The paper begins with a theoretical exposition of dialogical argumentation and the Toulmin model. The paper then reviews in detail some of the most significant contributions to the argumentation strand. Lastly, the paper reviews some of the few studies that have explicitly had dialectical features of students' dialogic argumentation as their object of study. On the basis of the review of theory and of empirical studies the paper proposes five key issues that the continued scholarly debate in the argumentation strand needs to address.

2.2 Dialogic Argumentation as an Object for Empirical Studies

In the first instance, argumentation is an activity – something persons do – while an argument is the product that can be distilled from that activity (e.g. O'Keefe, 1977; van Eemeren & Grootendorst, 2004). In most definitions, argumentation is treated as a social activity, which is rationally guided, and primarily comprised of utterances (or speech acts) (e.g. R. H. Johnson, 2002; van Eemeren, Grootendorst, & Kruiger, 1987). When one studies actual argumentative discourse it is important to distinguish between monologic and dialogic argumentation. Following Goldman (1999), this paper draws this distinction at the minimal level of the context of the argumentation: while "monological argumentation [is] a stretch of argumentation with a single speaker [...] dialogical argumentation [is a stretch of argumentation] in which two or more speakers discourse with one another" (p. 131).

Most scholars in the argumentation strand – including those who have applied the Toulmin model – have explicitly embraced students' dialogic argumentation as their primary object of study. But by 'dialogic argumentation' scholars in the argumentation strand have typically meant more than just the context of argumentation. For example, Duschl and Osborne (2002) defined dialogic argumentation as a "social and collaborative process necessary to solve problems and advance knowledge" (p. 41). Similarly, Clark and Sampson (2008) have held that "dialogic argumentation stresses collaboration over competition" (p. 296); and Erduran, Simon, and Osborne (2004) emphasized that "the goals in promoting argumentation in science lessons is to engage learners in dialogical conversation where they can not only substantiate their claims but also refute others' with evidence" (p. 927). So, beyond occurring in a dialogic context, dialogic argumentation has been treated as a collaborative problem-solving affair that can have epistemic outputs for students. Numerous scholars in the argumentation strand have offered equivalent definitions of dialogical argumentation (e.g. Driver, Newton, & Osborne, 2000, p. 291; Erduran, 2007, p. 65; Garcia-Mila & Andersen, 2007, p. 32; Hofstein, et al., 2008, p. 73; Jiménez-Aleixandre, 2007, p. 103; Jiménez-Aleixandre & Pereiro-Munñoz, 2005, p. 420; Kelly & Chen, 1999, p. 885; Kolstø & Ratcliffe, 2007, p. 120; Munneke, van Amelsvoort, & Andriessen, 2003, p. 116; Naylor, et al., 2007, p. 17; Skoumios, 2008, p. 382; Zeidler, Osborne, Erduran, Simon, & Monk, 2006, pp. 99-101; Zohar, 2007, p. 261). Thus it has been standard in the argumentation strand to parse dialogic argumentation as a *specialized way* of arguing in which the participants not just defend own claims, but also engage constructively with the argumentation of their peers. From the perspective of argumentation theory that specialized way of arguing is typically referred to as *dialectical argumentation*.

2.2.1 Dialectical Features of Dialogic Argumentation

The term 'dialectical argument' is typically traced back to Aristotle's *Topics* (1997). He posited dialectical argumentation as a special form of public arguing in which two (or more) arguers elicit arguments *for and against a point of view* (cf. van Eemeren, et al., 1987). This special form of arguing is necessary, Aristotle argued, if the premises that are used are not known to be true (cf. R. Smith, 1993). So in cases where the conclusion cannot be *inferred* from the premises, dialectical argumentation is necessary to establish a rational agreement. Still today, informal logicians distinguish dialectical arguments from inferences. While the latter are certain and valid arguments with conclusions that "can be reached without accounting for others' arguments", the former are a type of dialogic arguments "that arise out of the heterogeneity of other arguments" (Beard, 2003, p. 255; see also R. H. Johnson, 2002; van Eemeren & Grootendorst, 2004; Walton, 2000). Most notably, arguers who engage in dialectical argumentation interact through a register of dialectical *moves* such as questioning, elaborating, requesting justification, anticipating future reactions etc. (e.g. R. H. Johnson, 2002; van Eemeren, et al., 1987).

In recent years, informal logicians have widely agreed that everyday (informal) dialogic argumentation embodies dialectical features (e.g. Blair & Johnson, 1987; van Eemeren & Grootendorst, 1982). Thus the primary issue within informal logic has not been whether, but, rather, *to which extent* the notions of argumentation and argument appraisal should revolve around the notion of dialectics (Finocchiaro, 2006; R. H. Johnson, 2002). While some have stipulated that *all* argumentation should be understood as if it were part of an attempt to dialectically reach an agreement (van Eemeren & Grootendorst, 2004), others have merely stipulated that the arguer has "dialectical obligations" – of anticipating and reacting to others' argumentation – that she needs to "discharge" (R. H. Johnson, 2002, p. 168; see also

Kock, 2007b). The crux of the matter is that in cases where a given dialogic argumentative exchange involves argumentation from premises that are not evidently true, that exchange ideally embodies *dialectical features* – in the sense that arguers *collaboratively* "manage [their potential or perceived] disagreement" (Wenzel, 1993, p. 1) by providing arguments for their claims and constructively engaging with the argumentation of the others (cf. G. Clark, 1990).

2.2.2 Dialogic Argumentation as an Object of Study: Two Kinds of Products

Scholars of the argumentation strand have typically worked on the basis of a conceptual distinction between argumentation as a *process* and arguments as the *products* – i.e. premise-conclusion constellations – that can be distilled from the process (e.g. Berland & Mcneill, 2010; Bricker & Bell, 2008; Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007; Osborne, Erduran, & Simon, 2004; Sampson & Clark, 2008; Zohar & Nemet, 2002). While this distinction is both necessary and in line with a distinction drawn in argumentation theory (O'Keefe, 1977; van Eemeren & Grootendorst, 2004; Walton & Godden, 2007), it may also confuse or conflate two very different kinds of objects of study.

For empirical investigations of dialogic argumentation it is necessary to distinguish between two kinds of products: The argument sequences that consist of the arguers' talk turns, and the argument cores – in the form of e.g. premise-conclusion patterns – that can be extrapolated from the argument sequences (see table 1). *Argument sequences* – that are represented in transcriptions of the occurred dialogic argumentation – consist of an ordered series of speech acts that were exchanged among arguers in the original argumentation process. The key quality of argument sequences is their *sequential* nature: they consist of talk turns that represent a temporally ordered discursive process by registering who said what, at what point. From the perspective of argumentation theory, argument sequences are on par with what Walton (2000) has called "dialogue sequence[s]" (p. 340) or "sequences of rational argumentation" (p. 329) in which "reasoning [is] moving forwards" (Walton & Godden, 2007, p. 8).

<table>
<tr><th></th><th colspan="3">Argumentation</th></tr>
<tr><th></th><th colspan="2">Product</th><th>Process</th></tr>
<tr><th></th><th>Argument core</th><th>Argument sequence</th><th>Dialogic argumentation</th></tr>
<tr><td>Description</td><td>The sentences that are extrapolated as those who play a role in the justification procedure. Typically involving at least a conclusion and one or more premises.</td><td>The product(s) of the arguing in terms of the series of speech acts that were exchanged among the discussants.</td><td>The process in which persons elicit argumentative discourse about some issue.</td></tr>
<tr><td>Status</td><td colspan="2">Passive things</td><td>Activity</td></tr>
<tr><td rowspan="2">Temporality</td><td rowspan="2">Atemporal</td><td colspan="2">Temporal</td></tr>
<tr><td>Sequential</td><td>Ongoing</td></tr>
<tr><td>Persons</td><td>Absent</td><td>Authors of talk turns</td><td>Actors</td></tr>
<tr><td>Representation</td><td>Abstractions</td><td>Transcriptions</td><td>N/A</td></tr>
</table>

Table 2.1: The objects of study for empirical studies on dialogic argumentation.

Argument cores are more abstract than argument sequences. Argument cores typically involve at least a conclusion or claim and one or more premises and these core elements are distilled or extrapolated by the analyst from the argumentation sequence in which they occurred. The key point is that such cores do not exist as concrete entities – they are abstractions from the recorded discourse that the analyst make on the basis of an analytical framework. From the perspective of argumentation theory, argument cores are on par with what Ralph Johnson (2002) called the "illiative core" of an argument which is a descriptor of the level of "structure of argument" (p. 312); they denote what Willard (1989) called a "claims-reason-complex" (p. 77); and they are what Toulmin (1958) called an argument's "pattern [or] shape […] that has been presented in a series of steps conforming to certain basic rules of procedure" (p. 40). In fact, the Toulmin model is one analytical framework that describes *which* kinds of elements an argument core could or should consist of. Thus, analytical frameworks, such as the Toulmin model, mention generic *core elements*, such as claims, data, warrants, backings, qualifiers and rebuttals, and this directs the attention of the analyst to extrapolate talk units from her transcripts as talk units that may fit either of these generic core elements.

Both argument cores and argument sequences are ontologically distinct from the actually occurred dialogical argumentation process: While cores and sequences are "passive" objects, argumentation processes are "activities" (Willard, 1989, p. 27). But argument sequences and argument cores are ontologically distinct from one another: While argument cores are atemporal abstractions that the analyst has extrapolated and rearranged according to an analytical framework, argument sequences are temporal in the sense that they sequentially represent the occurred argumentative exchange; and while argument sequences record who said what in which order, the speakers are "typically absent" in argument cores (R. H. Johnson, 1995, p. 239). In argument cores, that is, the analyst has reduced the dialogic discourse to monological constellations of core elements.

If one is interested in the dialectical features of dialogic argumentation one has to attend to argument sequences for there is no (or at least not sufficient) information about these features stored in extrapolated core elements. The force of extrapolating cores is that it allows the analyst to abstract noise, reconstruct sentences, and freely re-arrange talk units as standing in (informal) logical relations wit each other – such as the relation between claim, data, warrants etc. (Andrews, 2005). But there is a trade off between (informal) logical relations and sequential situation. The extrapolation of core elements carves each reconstructed talk unit out if its sequential context. In the Toulmin model, for example, the (informal) logical relation between the core elements in an argument is intact regardless of the order in which they were uttered in the original argumentative exchange (cf. Toulmin, 1958, pp. 16-7). But in order to attend to the dialectical features, the sequential context is crucial. It makes no sense to speak of the dialectics of an argumentation process without taking into account of who said what, in which order. For example, to thematise the dialectical move of questioning, the analyst must attend to the issues of who questioned whom about what and at what stage in the argumentative exchange. But such a thematization "cannot be accommodated, at least straightforwardly" in approaches that focus on core elements (Walton & Godden, 2007, p. 10). The extrapolation of core elements is fundamentally the creation of a *static* layout of the argumentation; and while this has many benefits it precludes the analyst from studying her object of study as a *dynamic* dialectical exchange that moves forwards (e.g. Fulkerson, 1996; Willard, 1976; Wohlrapp, 1987).

2.2.3 The Toulmin Model

Toulmin's (1958) model of informal argument patterns is by far the best-known framework that proposes which core elements could or should be extrapolated in the analysis of an argument. In an attempt to contest the dominance of formal logic, Toulmin (1958) aimed at expanding the "traditional" notion of logic to denote a science that can also have non-analytical (what he calls "substantive") arguments as its object (see e.g. pp. 114ff). For Toulmin, argumentation, both analytical and non-analytical, is about the construction of "justificatory arguments" (p. 12). He was, that is, not concerned with the practical process through which persons reach conclusions, make decisions, or resolve disagreements; he was, rather, concerned with how "arguments sentence by sentence" *justify* such conclusions, decisions, or resolutions (p. 88). Consequently, the chief concern of the expanded science of logic that he proposed would be to scrutinize the "manner" with which arguers are "laying [their arguments] out" in order to justify claims (p. 88). The key to laying out everyday (substantive) arguments, Toulmin proposed, is to follow an ordered "procedure" (p. 21) of eliciting a number of different "elements" (the above mentioned core elements) – namely "claim", "data", "warrant", "backing", "rebuttal", and "qualifier" (p. 89-95).

Toulmin's most significant break with formal logic was to define the core elements in *functional* terms (cf. p. 87). Data, warrants, backings and so on have "different logical functions" because they perform different roles in the argument (p. 92). They are answers to different questions. While data-elements answer to "What have you got to go on?", warrant-elements answer to "How do you get [from data to claim]?" (p. 90), backing-elements answer to "but why do you think that [the warrant is justified]?" (p. 95), and rebuttal-elements answer to "[what are the] circumstances in which the general authority of the warrant would have to be set aside[?]" (p. 94).

Though *The Uses of Argument* (Toulmin, 1958) was explicitly tentative (cf. p. 1), a vast number of scholars outside the field of argumentation theory have adopted Toulmin's model in studies of actually occurred argumentation. These different empirical studies share a roughly similar *modus operandi*: The Toulmin model provides a list and a description of core elements that the analyst looks for in the recorded argumentation, fitting talk units or sentences are extrapolated and rearranged to reconstruct the layout of the argument, and this resulting layout is either itself discussed and criticized or it is a part of a larger corpus of extrapolated argument cores about which something general is said.

According to Toulmin (1958), the core elements could not be extrapolated on the basis of what he called a "grammatical" interpretation (1958, p. 91). Indeed, from Toulmin's perspective, the insecurity of interpreting messy everyday argument sequences is the *sine qua non* for introducing the distinction between elements such as datum and warrants in terms of their *logical function* rather than in terms of their expressive function in spoken language (see e.g. his famous 'physiology metaphor', 1958, p. 87). As Klumpp (2006) has summarized on behalf of Toulmin: "the form of [a] sentence does not permit the separation [of core elements;] [y]ou cannot simply look at a sentence and tell the function it is serving" (p. 107).

Numerous scholars in argumentation theory have argued that the Toulmin model – as an analytical framework – cannot sufficiently guide an analyst to determine which of the functional question a given talk unit answers to (e.g Bermejo-Luque, 2006; Chambliss, 1995; Cooley, 1959; Freeman, 2005, 2009; R. H. Johnson, 1981a, 1981b; Keith & Beard, 2008; Newman & Marshall, 1991; Reed & Rowe, 2005; Trent, 1968; Verheij, 2005; Willard, 1976). For example, Cowan (1964) and van Eemeren, Grootendorst, and Kruiger (1987) have pointed out that talk units that may be extrapolated as data in one case can be extrapolated as a warrant in others and vice versa; similarly Castaneda (1960), Gross (1984), and Hample (1992) have argued that that there is no meaningful functional distinction between warrants and backings. Hample (1992) summarized the contention among these critics by stating that it is "hopeless" to distinguish between the different core elements "except for the case of someone who actually says 'I have found that ' and 'We may take it that,' " and so on (p. 229). It seems to be a fundamental problem with the Toulmin model that it forces the Toulminian analyst to "engage in considerable translation to see how the argument fits" (Fulkerson, 1996, p. 24); but if this translation, or interpretation, involves the manner in which arguers expressed themselves it would seem to violate Toulmin's (1958) rejection of grammatical interpretation.

Also within the argumentation strand in science education it has been acknowledged that the Toulmin model presents the analyst with interpretative difficulties of determining which core element a given talk unit should be extrapolated as (claim, data, warrant, etc.) a given talk unit should be extrapolated as (e.g. Duschl, 2007; Erduran, et al., 2004; Jiménez-Aleixandre, et al., 2000; Kelly, Druker, & Chen, 1998; Walker & Zeidler, 2007). For example, Erduran (2007) saw this difficulty as the primary issue to be handled in the argumentation strand: If you were to ask scholars of the strand about their greatest concern they would "begin to ask you if you have figured out how to distinguish *data* from *warrants*" (p. 47).

2.3 Toulminian Analysis of Argument Cores in Science Education

This section reviews some of the key contributions to the argumentation strand with the aim of shedding light on how the scholars of the strand have addressed the interpretative difficulties that the Toulmin model creates. Particular attention will be given to five of the ten most significant[1] contributions to the strand: Kelly et al. (1998), Jiménez-Aleixandre et al. (2000), Driver et al. (2000), Erduran et al. (2004), and Osborne et al. (2004). The minute critical points that will be made in the following are not meant to cast doubt on the reliability of these papers. To be sure, there are very good reasons for why these papers are part of the canonical works on argumentation in science education. The points, which this paper aims to illuminate, are general points about some of the issues that the argumentation strand has struggled with since its beginning.

2.3.1 The use of Toulmin in the Early Works of the Argumentation Strand

Kelly, Druker, and Chen (1998) conducted a study of students' dyadic spoken discourse while working on a hands-on performance assessment task relating to electricity problems. Their aim was to investigate how students articulated *evidence* for their claims through scrutinizing the *layout* of the participating students' discourse. In particular, their aim was to device a framework that would enable future investigations of students' discourse from the angle of argumentation. Kelly et al. (1998) revised the Toulmin model: While they did not take account of rebuttals, they added a core element called "challenge", and, finally, they divided the data-element into three different elements according to the type of information relayed in the data – "facts", "empirical data", and "hypothetical data" (p. 856).

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[1] In terms of citations according to a March 2011 search on the terms 'science education' and 'argumentation' on The Social Sciences Citation Index, ISI Web of Knowledge, www.isiknowledge.com

During Kelly et al.'s (1998) analysis, it became apparent that "the identification of 'data', 'claim' and 'warrant' was a subtle affair" (p. 856). Thus they had to find a way to circumvent the problem of determining which generic core element a given talk unit should be extrapolated as. To this end, Kelly et al. (1998) "needed to consider" (i) "the *place of a particular argument made by a student in the context of the conversation*", (ii) "*the relationship of a particular utterance to the others in the argument*", and (iii) "paralinguistic cues" (p. 856; emphasis added). Now, there are unmistakable dialectical connotations in the first two considerations that Kelly et al. (1998) needed to make. Indeed, attending to the dialectical features embodied in an argument sequence is the only way to ascertain "the place" of a set of talk units, or "the relationship" between multiple talk units, in a conversational context. So the picture that emerges from Kelly et al.'s (1998) analysis is that they saw the analysis of dialectical features as a necessary *foundation* for a Toulminian extrapolation of core elements. Further, it were the difficulties of using the Toulmin model as an analytical framework that motivated Kelly et al.'s attention to the dialectical features of argument sequences in the first place. Indeed, as Kelly et al. (1998) stated, it were these difficulties that led the authors to consult the overall "*segment* of the conversation" in their efforts to layout the structure of a given argument (p. 857; emphasis added). But though it is evident that Kelly et al. (1998) "had to look backward, and often forward in the conversation" (p. 857) in order to establish how to extrapolate a given talk unit, they did not explicate what they looked for in the argument sequences and how they interpreted the sequences.

Kelly et al. (1998) to some extend also directly attended to the dialectical features of argument sequences. They wanted to derive a sort of matrix consisting of different "warranting strategies, referents and types" and different "antecedent conditions that led to warranted arguments" – i.e. different argumentative *prompts* (such as a question being posed, a new claim being made, the invocation of empirical data) for the invocation of evidence (p. 867). They found that students were mainly prompted to invoke evidence in support of their antecedent claim when the opponent posed a question, forwarded propositions that somehow conflicted with the antecedent claim, or provided empirical data. This is not too surprising since such moves all belong to the dialectic register of challenges that an opponent may use (van Eemeren, Houtlosser, & Snoeck Henkemans, 2007). Unfortunately it is difficult to get a good sense of how Kelly et al. (1998) understood the different forms of argumentative prompts. For example, they distinguished between "statements" and "challenges", but went on to state that "[i]n either case the speaker may be affirming the previous claim […] [or] offering an alternative interpretation" (p. 866). A challenge that affirms the claim it challenges is not straightforwardly a challenge; and in what sense are statements that offer alternative interpretation different from challenges? Maybe the authors had in mind a distinction between full negations of a claim and merely partial doubts in a claim – such as it is found in e.g. the pragma-dialectical school (van Eemeren & Grootendorst, 2004) – but the text of Kelly et al. (1998) provides no further clues. Even though a part of their study involved attending directly to argument sequences it is difficult to get a firm sense of how they conceptualized such sequences and the dialectical features they embody, and, more importantly, how these features were interpreted.

Jiménez-Aleixandre, Rodriguez, and Duschl (2000) ventured to investigate "argument patterns from high school students [who were] solving genetics problems" (p. 762) in situation where the students were "doing" or "talking science" (e.g. p. 759). In order to layout students' argument patterns, Jiménez-Aleixandre et al. (2000) used a (revised) Toulmin model as a guide for extrapolating core elements from the recorded argumentation. In parallel to argument patterns, Jiménez-Aleixandre et al. also investigated students' "epistemic operations" such as "explanation procedures, causal relations, and analogies" – which the authors argued "are related to knowledge construction, specific from the science domain" (p. 763).

The first thing to note is that Jiménez-Aleixandre et al. (2000) were less explicit than Kelly et al (1998) about the difficulties they faced when using the Toulmin model as a guide to extrapolate core elements. In fact, the authors did not mention any *concrete* difficulties concerning their analysis. Only in the very last sentence of the paper, Jiménez-Aleixandre et al. (2000) raise this as an issue for future research: "A question that deserves more detailed studies is […] "what counts" as explanation, warrant, or even data, and we are currently exploring these issues." (p. 783). So the authors did at some point come to the conclusion that it is not straightforward how different core elements in the Toulmin model should be parsed, but there is no mention of how this affected their analysis. At this point it is revealing to have closer look on why the Jiménez-Aleixandre et al. (2000) also attended to students' epistemic operations.

While Jiménez-Aleixandre et al. (2000) initially stated that their attention to epistemic operations was motivated by their focus on developing scientific knowledge, it appears in later stages of their argument that this addendum to the Toulmin approach is motivated by some difficulties with analyzing argumentation – much akin to the difficulties that Kelly et al. (1998) faced: "The argument pattern from Toulmin was *not enough to interpret some exchanges*, and that is why we developed a frame for epistemic operations" (p. 783; emphasis added). Further, from the coded transcripts that Jiménez-Aleixandre et al. (2000) present in their paper, it is evident that they extended the Toulmin model to include additional types of core elements (cf. in particular pp. 785-792): "Request" (apparently covering requests for justification as well as requests for clarification), "Oppositions" (apparently challenges to antecedent statements), "Counter-oppositions" (apparently re-assertions of an original claim that was being challenged), and "Concessions" (apparently a move that a speaker signals being convinced of the opposition to her original claim). Not only does this indicate that Jiménez-Aleixandre et al. (2000) saw the need for adjusting the Toulmin model so as to more precisely extrapolate core elements from dialogic argumentation, it also indicates that Jiménez-Aleixandre et al. (2000) attended the dialectical features of the students' dialogic argumentation. For notice how the added core elements all denote operations or moves that can only be interpreted from a dialectical perspective and by attending to the argument sequences. Unfortunately Jiménez-Aleixandre et al. (2000) did not describe or discuss these additional core elements in detail. The added elements appear however to be adopted from the "argumentative operations" that Pontecorvo and Girardet added to the Toulmin model (see e.g. Pontecorvo & Girardet, 1993, p. 373); but from Jiménez-Aleixandre et al.'s (2000) text it is difficult to ascertain why and how they were used.

In another paper, Duschl (Duschl, Ellenbogen, & Erduran, 1999) – the third author of Jiménez-Aleixandre et al. (2000) – explicitly denounced the adjusted Toulmin model that was used by Jiménez-Aleixandre et al. (2000). Duschl et al. (1999) reported that when they applied "Toulmin's argument pattern to analyze group reasoning" they

> found that the analysis of discourse employing argumentative and epistemic operations did not adequately distinguish signal from noise. Consequently, distinguishing the structure and patterns of argument was difficult. […] The dialectical nature of the group interview made the assignment of analytic epistemic operations like definition, categorization, predication, evaluation, warrants and backings awkward. At times it felt as if square pegs were being forced into round holes (Duschl, et al., 1999, p. 421; also in Duschl, 2007, p. 168-9)

The metaphor of forcing square pegs into round holes epitomizes the image that emerges from the early works of the argumentation strand – namely that scholars recognized the difficulty of taming dialogic argumentation by extrapolating talk units as one of the core elements in the Toulmin model. Further, in the passage above, Duschl et al. (1999) explicated the relation between this difficulty and the dialectical features of dialogic argumentation: Toulmin's description of the core elements in terms of their *logical function* is potentially out of sync with the *dialectical nature* of the recorded dialogic argumentation. Thus empirical studies that seek to resolve the difficulties that the Toulmin model causes must in the first place involve an interpretation of the dialectics of the dialogic argumentation.

This issue was also made explicit in what is undoubtedly the most significant contribution to the argumentation strand (in terms of citations at least) – namely *Establishing the norms of scientific argumentation in classrooms* by Driver, Newton, and Osborne (2000). Driver et al. (2000) were concerned that the Toulmin model was insufficient when analyzing real dialogic argumentation for "[n]o recognition is given to the interactional aspects of argument" or to the fact that arguments generally are "influenced by [their] linguistic and situational contexts" (p. 294). According to Driver et al. (2000) what is needed for the Toulmin model to be a sufficient guide in the extrapolation of core elements is that the wider *sequential* context is taken into account: "the natural flow of conversation points are not necessarily developed sequentially and reference has to be made across extensive sections of the text to identify features of the argument" (p. 294). So Driver et al. (2000) also argued that empirical studies of students' dialogic argumentation, in which the analyst seeks to extrapolate Toulminian core elements, are parasitic to an interpretation of the individual talk units against the background of its place and role in the dialectical context. But beyond this recognition, Driver et al. (2000) provided no description – even in embryotic form – of a regimented procedure for how analysts consult the dialectical features of dialogic argumentation

A trend emerges from these primary contributions to the early argumentation strand. First, the analysts who used the Toulmin model faced difficulties pertaining to which generic core element a given talk unit should be extrapolated as. Second, because of these difficulties the analyst needed to consider the dialectical features of the occurred dialogic argumentation. The analyst, that is, needed to consider the dialectics of the dialogue – either by attending to the wider sequential context as Driver et al. (2000) proposed, by looking "forward" and "backward" in the argument sequences as Kelly et al. (1998) did, or by attending to "epistemic operations" and marking dialectical moves such as "requests", "oppositions" and "concessions" as Jiménez-Aleixandre et al. (2000) did. Third, the analyst's interpretation of the dialectical features of the dialogic argumentation was only referred to rather than explicitly explained and discussed. So while it is evident that some dialectical interpretations were made, it is unclear what that interpretational work consisted of and how topical interpretative decisions were made.

2.3.2 A New Operationalization of the Toulmin Model

The two papers *Enhancing the quality of argumentation in school science* (Osborne, et al., 2004) and *TAPping into argumentation* (Erduran, et al., 2004) defined the gold standard for how scholars in the argumentation strand operationalized the Toulmin model in subsequent years. The primary outcome of the two papers, in particular of Erduran et al. (2004), was the authors' proposal for a *regimented procedure* for the use of the Toulmin model that could possibly be used to elucidate a variety of research questions within (science) education. As such, their aim was to "improve the use of TAP [Toulmin's Argumentation Patterns]" (Erduran et al., 2004, p. 931) in a way that circumvents the analytical difficulties and in a way that would make the Toulmin model attractive for investigations of the "the quantity and quality of argumentation" in science classrooms on a larger scale (Erduran, et al., 2004, p. 916).

The fulcrum of the regimented procedure proposed in Erduran et al. (2004) and Osborne et al. (2004) is a coding scheme that can be used to classify individual arguments in one of five levels of *sophistication* or complexity (cf. Erduran et al., 2004, pp. 926-7; Osborne et al., 2004, p. 1008). In this coding scheme "better quality arguments" are classified on a higher level in the scheme (Erduran et al., 2004, p. 927). The qualitative measure that Erduran at al. (2004) used concerned the type, number, and quality of Toulmin's core elements in a given argument (cf. p. 928). Arguments that consist only of claims (in particular oppositional claims – claims, that is, against other claims or against counter-claims) are situated on the *first level*. Arguments that also involve some sort of justification belong on the *second level*. Arguments that – beside claim and justification – also involve "the occasional weak rebuttal" (p. 928) belong on the *third level*, while arguments that involve one or more rebuttals – that are strong in the sense that they "make a clear, self-evident connection to the data supporting the original claim" (p. 929) – belong to *levels four* and *five*, respectively.

Against the background of this coding scheme, it is possible to spell out – in skeletal form –Erduran et al. (2004) and Osborne et al.'s. (2004) regimented procedure for using the Toulmin model: The analyst must (i) identify argumentative sequences in the data – Erduran et al. (2004) "focused on those instances where there was a clear opposition between" the participants (p. 920-1) – (ii) identify argument cores by extrapolating core elements from the identified argument sequences under the guide of a revised Toulmin model, (iii) classify each of the extrapolated argument cores under one of the five levels of sophistication, and (iv) collect and compare the development of frequencies of arguments of different levels of sophistication over time or across contexts.

Needless to say, this quantification of the quality of arguments speaks to those scholars who are interested in large-scale studies of the quality of argumentation in science education. Indeed, Erduran et al.'s operationalization of the Toulmin model, in general, and the five-level coding scheme, in particular, has been adopted in many contexts: The coding scheme has been applied in an unaltered fashion in other studies (Aufschnaiter, Erduran, Osborne, & Simon, 2008; Osborne, 2005; Simon, 2008; Zeidler, et al., 2006); it has been extended and elaborated by others in the strand (Chin & Osborne, 2010; D. Clark & Sampson, 2007; Skoumios, 2008); it has been used in parallel with other analytical approaches (D. Clark & Sampson, 2008; Shea, Duncan, & Stephenson, 2011; Simon & Johnson, 2008; Wishart, Green, Joubert, & Triggs, 2011); it has inspired scholars to devise similar coding schemes (Dawson & Venville, 2009; Sadler & Donnelly, 2006; Sadler & Fowler, 2006); and it has been discussed by and inspired many other studies (e.g. Aufschnaiter, Erduran, Osborne, & Simon, 2007; Gott & Duggan, 2007; Maloney & Simon, 2006; Molinatti, Girault, & Hammond, 2010; Okada & Shum, 2008; Ravenscroft & Mcalister, 2008; Wu & Tsai, 2007).

The first two steps in the regimented analysis procedure proposed by Erduran et al. (2004) are of primary interest for this paper. The issue is how the authors proposed to regiment the procedure of identifying points of opposition among students and of extrapolating argument cores at those points according to the Toulmin model. The regimented procedure, which Erduran et al. (2004) proposed, hinges on (a) *argumentative indicators* – i.e. specified words or phrases that indicate to the analyst the presence of an opposition or of one of the Toulminian core elements – and (b) that inter-rater reliability can be established on the basis of using such indicators as cues for coding (cf. Erduran et al., 2004, pp. 920-3; Osborne et al., 2004, p. 1008).

In the first step, Erduran et al. (2004) sought to "identify episodes of opposition and dialogical argument" (p. 927). Their focus was on "explicit" (p. 927) or "genuine" (Osborne et al., 2004, p. 1007) episodes in which students had opposing standpoints. Such episodes, the authors stated, were indicated by words or phrasings such as "but," "I disagree with you," "I don't think so," (Erduran et al., 2004, p. 927). In essence, this first analytical step is very similar to how Kelly et al. (1998) coded their data for "challenges" and to how Jiménez-Aleixandre et al. (2000) apparently coded their data for "oppositions". But the new idea of Erduran et al. (2004) and Osborne et al. (2004) was the use of argumentative indicators so as to regiment the analysis procedure.

Erduran et al. (2004) also suggested the use of argumentative indicators for identifying core elements in the second step of the procedure: "[T]he data for the argument […] is often preceded by words such as "because," "since," or "as" " (Osborne et al., 2004, p. 1006); and words such as "so" typically mark that the speaker is "reaching conclusions from data" (Erduran et al., 2004, p. 919). It has to be noted that the approach of looking for argumentative indicators in order to extrapolate core elements had been used before by Jiménez-Aleixandre and Pereiro-Muñoz (2002) but they only mentioned indicators "such as 'because' or 'since'" (p. 1177).

In order to further stabilize the extrapolation of core elements, Erduran et al. (2004) divided the analytical work into two phases. First, the analyst should identify claims and possible grounds (a concatenation of data, warrants and backings) for the claim and the possible rebuttals of the argument for the claim (cf. Erduran et al., 2004, p. 920). According to the authors, these core elements are "*first-order* elements" (Osborne et al., 2004, 1006). Second, the analyst may venture into identifying "*second-order* elements which are the components of the grounds for the claim – that is, the data, warrants, and backings" (Osborne et al., 2004, 1006). Though the authors indicated "that there is inevitably a process of interpretation to be made" (Osborne et al., 2004, p. 1006) in the process of extrapolating core elements, "there was little problem in distinguishing claims or rebuttals" (p. 926).

The way that Erduran et al. (2004) and Osborne et al. (2004) proposed this regimented analysis procedure raises some issues. It is difficult to get a sense of the conceptual foundation of Erduran et al.'s (2004) identification of oppositional episodes (cf. p. 927; Osborne et al., 2004, p. 1007). As argued above, oppositions or challenges can take different forces and degrees; indicators such as "I disagree with you", and "I don't think so" may represent different *forces* of a "mixed" *form* of disagreement, whereas an indicator such as "but" may represents a "nonmixed" form of disagreement (such as casting doubt, or merely refraining from endorsement) (Eemeren & Grootendorst, 1992, p. 21ff.). While it in principle could be possible to concatenate these different forces and forms of disagreement into a generic concept of opposition, the fact that the authors did not discuss what they took an oppositional episode to be obscures the readers understanding of what analytical yardstick was used to identify oppositional episodes.

Further, the few remarks that Erduran et al. (2004) gave on how they classified rebuttals according to their strength suggest that the classification happened on the basis of a dialectical interpretation. Erduran et al. (2004) defined a strong rebuttal as making "direct reference to a piece of evidence (data, warrants, or backings) offered, thereby engaging with a presented argument" (p. 921); so a rebuttal that "does not make a clear, self-evident connection to the data supporting the original claim" is a "weak rebuttal" (p. 929). This would mean that in order to judge whether a given a talk turn can be extrapolated as a strong rebuttal, the analyst must *ipso facto* look at its *coherence* with other talk turns in its context. The analyst must, that is, essentially attend to the rebuttal in its dialectical context and evaluate it from that perspective. However, Erduran et al. (2004) and Osborne et al. (2004) did not describe the yardstick used to assess the *degree* to which a particular rebuttal makes reference to pieces of evidence given at another place in the dialogue.

This leads to a more general issue: Beyond providing three typical argumentative indicators for speakers eliciting a premise, Erduran et al. (2004) did not discuss which argumentative indicators were used to identify and extrapolate core elements in general, and why *these* indicators were used. Other disciplines have spawned numerous works on the many different types of argumentative indicators in discourse (Fraser, 1975; Pomerantz, 1984a, 1984b; Snoeck Henkemans, 1992; van Eemeren, et al., 2007). Indeed, it has been a longstanding discussion in argumentation theory whether and how specific argumentative indicators can be used as analytical guides in the analysis of argumentative discourse (Katriel & Dascal, 1984; Snoeck Henkemans, 1996; van Eemeren & Grootendorst, 1982; van Eemeren, et al., 2007; Walton & Krabbe, 1995). But such a discussion is not reflected in Erduran et al. (2004) and this again shrouds their analytical yardstick.

It is important to note that the rationale behind using argumentative indicators is that the analyst conceptualizes the recorded argumentative discourse as sequential in the sense that she is analyzing a conversational exchange that consist of moves and countermoves that relate to one another (van Eemeren, et al., 2007; see also Krabbe, 1999; Walton, 1999). In other words, to believe in the utility of argumentative indicators is to believe that speakers in specific situations express themselves in specific fashions, and that this fashion is a function of what happened before and of what the speaker anticipates will happen next. Thus, in the terminology of this paper, the use of argumentative indicators as guides when extrapolating argument cores from argument sequences, may be parasitic on, or even a part of, an interpretation of the *dialectical features* of argumentation. For example it may depend on the dialectical context whether the use of 'therefore' marks that a speaker will now elicit data or whether the speaker provides an explanation (van Eemeren, et al., 2007). Likewise 'but' only in some cases mark an explicit challenge to a standpoint, in some cases it merely indicates doubt on the content of another talk turn, and in other cases it may even indicate other dialectical moves such as dissociating various aspects of an issue (as in "I was not talking about football *but* handball") that also play a role in the dialectics of argumentation (cf. e.g. Rees, 2009). Further, a number of standard indicator words such as 'because', 'therefore', 'so' and, 'since' do not necessarily indicate that an argument is being made; they may just as reliably indicate an explanation – a discursive act which is fundamentally different from an argument (Govier, 2010). Sorting this out is an affair of interpreting on the dialectics of the exchange at hand. Thus the intense interpretation that Erduran et al. (2004) went through – in order to decide whether a given talk unit was to be coded as this or that core element – must have been a *dialectical analysis* – even though it was not identified as such.

Erduran et al. (2004) were able to reach a satisfactory inter-rater reliability (p. 922; Osborne et al., 2004, p. 1008). Thus the reliability is not in doubt. In fact, reliability may not even be the interesting feature to look for. The point to note is that the reliability was a "product of the significant time devoted to resolving disagreements" among the coders (p. 920). Indeed, as Erduran et al. (2004) emphasized, the extrapolation of argument cores requires intense "interpretation" (p. 922), for in ordinary argumentative talk there are not always conspicuous indicators that uniformly mark that a particular talk unit is to be coded as a token of a generic core element. The intense interpretations that go into extrapolating talk units as core elements, the discussion among coders, and the final analytical decisions are in themselves highly interesting and deserve to be illuminated. Lunsford (2002), for example, has argued that – in educational research in general – these is a lack of transparency of these interpretations, discussions, and decisions in Toulminian studies of students' argumentative discourse: "What tend to remain invisible are the numerous decisions the analysts must make to match specific pieces of data to the Toulminian codes, as well as the negotiations among coders over different possible applications of the model" (Lunsford, 2002, p. 115).

2.3.3 Summary and Discussion of the uses of the Toulmin model

The purpose of the reviews above has been to highlight (i) that concrete operationalizations of the Toulmin model require that an interpretation of the dialectical features of the dialogical argumentation *precedes* the actual use of the Toulmin model; further, (ii) that in science education this type of interpretation that precedes the use of the Toulmin model has rarely been recognized as what it actually is – namely, an interpretation of the *dialectical features* of dialogical argumentation; and finally (iii) that even though this immense amount of interpretation has been recognized as a required part of the analysis procedure, the decisions that analysts made in that interpretation remain *implicit*.

Within the argumentation strand in science education, the necessity to investigate and interpret the dialectical features of dialogic argumentation has largely arisen in a roundabout way. The investigation of the dialectical features has primarily served an instrumental purpose of preparing the analyst for extrapolating Toulminian core elements from dialogic argumentation. In short, the interest in dialectical features has mainly arisen from the difficulties that permeate Toulminian analysis. This is unfortunate because the interpretation of dialectical features is a complex affair that merits substantial documentation and discussion. It should not be stowed away as a preparatory interpretation. Also it puts to the question the rationality of reducing argumentative discourse to core elements as a way of conducting large-scale studies.

So far this paper has concentrated largely on the use of the Toulmin model in empirical studies in science education. But the trend that analysts have seen themselves forced to prepare the use of the Toulmin model by making dialectical interpretations is a manifestation of a deeper-rooted problem. Within argumentation theory and philosophy, it has been argued that the monological view afforded by the Toulmin model cannot meaningfully be applied the complex dialogic dynamics of everyday argumentation (e.g. Fulkerson, 1996; Habermas, 1984; R. H. Johnson, 1981a, 2002; Lynch, 1982; Primatarova-Miltscheva, 1987; van Eemeren, et al., 1987; Willard, 1976; Wohlrapp, 1987). So though the Toulminian analyst may intend to investigate dialogic argumentation, her direct object of study is *monologic* – it is dialogic only in terms of the distant dialogic context in which the object of study was recorded. This puts to the question the *a priori* consistency of the Toulmin model. Indeed, the key tenet of the discursive paradigm that emerged within the social sciences and philosophy in the 20th century is that no talk unit or part of a dialogue can be categorized or extrapolated *as anything at all* without attending to its relation parts of the dialogue (e.g. Habermas, 1984; Schlegoff, 1988). So the fundamental problem is that the Toulmin model simply does not include the conceptual tools that are needed in order to understand and thematise the dialogic context it presupposes for everyday non-analytical argumentation (P. C. Smith, 1995).

From an *a priori* perspective, then, empirical studies that apply the Toulmin model are forced to supplement it with another framework that affords the dialectical interpretation that the Toulmin model manifestly requires before it can be applied. But such supplements cannot be chosen haphazardly. Any supplementing framework must be in *a priori* agreement with the foundational ontological tenets of the Toulmin model. It seems at this point that the argumentation strand is required to discuss in more detail, which frameworks might fit if the strand wishes to continue some form of use of the Toulmin model. Some scholars have taken the ultimate consequence of this disconcerting predicament and have approached students' dialogic argumentation explicitly from a dialectical perspective. The following section outlines some of these contributions.

2.4 Dialectical Studies in Science Education

One of the strongest advocates for attending explicitly to the dialectical features of students' argumentation has been Duschl (2007) who has proposed that science education researchers use Walton's framework for presumptive reasoning. According to Walton (1996), presumptive reasoning is a special type of argumentation that permeates everyday dialogic argumentation: For example "John's hat is not on the peg. Therefore John has left the house" (p. 17). In such argumentation the speaker *draws* a conclusion partly based on the tacit premise (the presumption) "If John's hat is not on the peg, then (we can normally expect), he has left the house" (p. 17). Walton's (1996) notion of presumptive reasoning is a way to spell out the dialogue logic of dialectical argumentation: Presumptive reasoning involves conclusion that are "defeasibly drawn from the premises rather than strictly implied by the premises" (p. 17); and if the antagonist present a *sound* argument for her standpoint, the opponent has to either accept the conclusion or rebut the argument. In other words, "[w]ith presumption then, the burden of (dis)proof lies on the respondent, not on the proponent" (Walton 1996, xii; see also p. 10). For Walton (1996), a sound argument is one in which the speaker follows one of 25 recognized argumentation schemes that fits the dialogic context of the discussion; and each scheme is followed by a list of "critical questions" that mark criteria for the cogency of the delivered argument (Walton, 1996, pp. 46-110). If an opponent attempts to rebut a delivered presumptive argument she would ideally begin to scrutinize the critical questions.

Duschl et al. (1999; see also Duschl, 2007) applied Walton's framework in an investigation of students' argumentative discourse in small group interviews. The procedure that can be distilled from Duschl (2007) is that the analyst interpreted argument sequences in order to identify one of nine different argumentation schemes, and thereby establishes a quantitative measure of the relative number of occurrences of a given scheme under changing circumstances or over time (cf. p. 169-170). In order to guide the identification most schemes were followed by a number of argumentative indicators or conversational markers. For this approach, just like for the Toulmin model, there is a substantial obstacle of how to determine which type of scheme a given argument follows. In order to circumvent this obstacle, Duschl et al. (1999; see alsoDuschl, 2007) collapsed the schemes into four categories. It is possible that for an explicitly dialectical framework such as Walton's, this difficulty is less problematic than it is for the Toulmin model. To recall, the main problem that arose from the difficulty of extrapolating individual core elements was that the analyst had to do interpretative work on the dialectical features that could not be conceptualized from within the Toulmin model. But, in order to assess whether this interpretative problem is also an issue for Walton's framework, more theoretical discussions and empirical studies are needed. And there are indeed indications that more such work will appear in the near future. For example, Castells, Erduran, and Konstantinidou (2009) conducted a similar type of study of the frequency of selected argumentation schemes in students' discourse – although they interwove Walton's notion of argumentation schemes with that of Perelman and Olbrechts-tyteca (1969).

It seems straightforward, however, that Walton's framework could also be used on small-scale studies that go deeper into selected cases of interesting argument sequences rather than comparing frequencies of schemes under different circumstances or over time. In any case, Duschl (2007) appears to be correct in asserting that Walton's framework, in comparison to the Toulmin model, more adequately fit the discourse structures (e.g., dialectical and rhetorical) and reasoning sequences" that are typical for group discourse such as the object of study of the argumentation strand" (p. 169) and that "[p]resumptive reasoning analyses seem to be a natural entry point for the assessment and development of student's argumentation strategies" (p. 173).

However, one rebuttal may be appropriate at this place. There are indications that Walton's notion of presumptive reasoning may be at odds with a very common form of practical argumentation, namely that of *deliberative argumentation* in which two or more speakers deliberate about what to do (not what is true). As Kock (2007a, 2008) has argued, there are many instances of practical deliberation were it would be wrong to suggest that just because an argument is "not rebutted, such an argument is strong enough to immediately mandate the decision (albeit in a presumptive way); and it is just as wrong to suggest that if a pertinent critical question is raised about the argument, then it is rebutted and as it were dealt with" (p. 93). For example, in most political discussions, an arguer who does not successfully rebut her opponent's argumentation will hardly succumb and agree with the standpoint of her opponent; and, Kock (2007b, 2008) argues, this is tolerable as long as she is observant of her other dialectical obligations. In short, there can be *legitimate* dissensus. From the perspective of Kock (2007a), the notion of presumptive reasoning is more ideally fitted for argumentation about *propositions* – rather than proposal about what to do. For the science education context this is important because if this is so, then Walton's framework seems well fitted for scientific argumentation about propositions, but not for socio-scientific argumentation about, for example, whether gene therapy should be allowed.

In a study of peer argumentation in small student groups during scientific inquiry activities Kim and Song (2005) explicitly attended to the "overall structure of argumentation involving several people" and "the process of argumentation rather than the form and content of the argument" (p. 215). The study by Kim and Song (2005) was explorative: Rather than using a predetermined coding scheme for analyzing their multifarious data types, they inductively constructed a scheme during their analysis. Some of the dimensions of the dialectical features of the discourse that Kim and Song (2005) focused on concerned the types of argumentative "strategies" that students would use in the discussions, and the discussion "stages" in terms of the dialectical "purpose" of a series of "conversational turns" (p. 219). For example they found that while some argumentative strategies pertained to the "cognitive" content of the argumentation (e.g. "questioning", "elaborating" etc.), other strategies pertained to the "social", or overall dialectical, aspects of the discussion ("conflict inducing" or "cooperative inducing" strategies) (pp. 221-223). This is resonant with some of the findings of Leitão (2000) in social psychology. Kim and Song (2005) also found that discussions go through stages of "focussing", "debating", "exchanging", and "closing" (p. 219).

Kim and Song's (2005) study was explicitly interpretative and was markedly grounded on previous expositions of conversational interaction. Such small-scale interpretative studies necessarily serve a different purpose than the studies that quantify larger amounts of data and score according to an *a priori* coding scheme. The force of the study of Kim and Song (2005) is the explicit role that their intense dialectical interpretations play in the report paper on the study.

In another small-scale study, Naylor, Keogh, and Downing (2007) applied a specially designed model (the "Downing model") for analyzing "the nature of the interaction between the individuals" who participated in the study (p. 22; emphasis added). In particular they focused on how the interactional dynamics changed in students' group discussions when the teacher was present (cf. p. 32). Though the "Downing model" includes seven levels, it is not hierarchical; and while some of the levels – such as level 3 "[p]upils begin to offer grounds to support their claims" (p. 23) – seem to resemble levels in the coding scheme of Erduran et al. (2004), other levels indicate the attention to the interactional features of students argumentation. For example, level 5 ("[p]upils respond to ideas from others in the group") and level 6 ("[p]upils are able to sustain an argument in a variety of ways") (Naylor et al., 2007, p. 23). As in the case of the paper by Kim and Song (2005), the paper of Naylor et al. (2007) presents, interprets and discusses multiple and extensive transcripts of the recorded dialogic argumentation. One of the aspects of young science students' discussions that Naylor et al. (2007) were able to document was that "given a suitable stimulus" even young pupils "can and do engage in argumentation" which they sustain over considerable time (p. 36); and further, that the way in which students in their study argued indicated that they co-constructed their arguments dialectically "rather than viewing argumentation as confrontational" (p. 36).

Nielsen (2010; To appear [Paper II]) has proposed another dialectical approach to students' dialogic argumentation in the context of a study on how science facts and human values are interweaved in small group discussions on a socio-scientific dilemma. The recorded dialogic argumentation in that study was approached in different analytical steps (cf. Nielsen, 2010; Nielsen, To appear [Paper II]). First, each talk turn in the argument sequences was inductively coded so as to interpret which issue an individual talk turn was about. This coding led to the identification of a handful of key thematic issues for each discussion. Second, select argument sequences of each discussion were analyzed using a generic approach from argumentation theory – normative pragmatics (Goodwin, 2001; Jacobs, 2000; van Eemeren & Houtlosser, 2007). In this step the objective was to interpret, from an argumentation theory perspective, both the content (what was said?) and the design (how was it said?) of the interactive messages that the students elicited during the discussion. Third, the normative pragmatics analysis culminated in an interpretation of the design and content of sequences of talk turns *against the background* of the thematic issues of the discussion. In that way, the overall objective of this form of analysis was to identify different argumentative strategies in which students blurred the fact-value distinction, to explain how these different strategies work argumentatively, but also, more importantly, how such strategies function within the discussion as a dynamic and organic whole. Nielsen (2010; To appear [Paper II]) found that the argumentative strategies in which students invoke science alongside value claims or judgments can be dialectically complex – in the sense that some of the argumentative strategies that students conspicuously used involved subtle challenges to others and were executed in several talk turns at different places in the overall discussion sequence.

So while there have been a small number of studies in science education that attend directly and explicitly to the dialectical features of students' argumentation, it is still too soon to portray a general tendency among these studies beyond their common dialectical focus on dialogic argumentation.

2.5 Concluding Remarks

This paper has presented an argument for the necessity of a thorough theoretical discussion in the argumentation strand about how to understand and analyze the dialectical features of students' dialogic argumentation. The dialectical features, which are operative when students collaboratively argue for and against a standpoint, are interesting from an educational perspective; but, more importantly, it has been impossible for analysts to avoid interpreting on these features, even if those analysts have set out to investigate non-dialectic aspects of students' argumentation. Thus the argumentation strand has, since its beginning, struggled to come to terms with the dialectical features of its object of study. The paper has further argued that the interpretative decisions and discussions of analysts have mostly not been communicated in a clear way. And it is still to soon to gather a general overview of the studies that explicitly set out to interpret the dialectical features of students' discourse; for these studies are few in numbers and still emerging. From these points emerge five key issues for the continued scholarly debate within the argumentation strand in science education.

The first issue pertains to the object of study of the argumentation strand. As this paper has attempted to show, most scholars in the strand have set out to investigate dialogic argumentation. But while the strand's standard definition of dialogic argumentation implies that such argumentation is dialectical, the dominant approach within in the strand has been attempts to reduce the dialectical nature of discourse to measurable constructs of core elements. This suggests that there has been a mismatch between the intended object of study and the analytical approaches used to investigate that object of study. In order to resolve this the first issue that the argumentation strand must address is *how dialogic argumentation should best be conceptualized from a science education perspective*.

It has been thematic for the argumentation strand that attention to the dialectical features of students' argumentation has been motivated by difficulties of applying the Toulmin model. Analysts have thus largely seen themselves forced to adjust or add supplementary approaches to the Toulmin model. But it is manifest that, *if* future attempts to adjust the Toulmin model or to crossbreed it with other analytical frameworks are to succeed, *then* these adjustments or added analytical frameworks must be explicitly built to guide the analyst in her interpretation of the dialectical features of students' argumentation. But this, in turn, means that the scholars of the strand need to revisit what they see as viable analytical frameworks in general. Thus the second issue, which the argumentation strand needs to address, is this: *Given a firm conceptualization of dialogic argumentation, which available analytical frameworks and approaches allow science education analysts to analyze the dialectical features of dialogical argumentation*?

On the face of it, the Toulmin model has many advantages. The analyst is able to quantify large amounts of qualitative data, and can compare patterns of core elements across subjects, contexts, and time; and as a model, the Toulmin model potentially enables researchers to reconstruct, structure, and organize messy argumentation in order to get an overview of the situation (Andrews, 2005). So while there are some disconcerting theoretical problems with the Toulmin model, it does propose itself for semi large-scale quantitative studies. The third issue for the argumentation strand is, then, *how to salvage the appealing aspects of frameworks such as the Toulmin model that focus on core elements of arguments without having to face the substantial problems of the original Toulmin model.*

Connected with the third issue is a more general and strategic issue. There will always be a certain trade off between having measurable constructs in the form of (informal) logical relations between core elements, on the one hand, and taking account of the dialectical context in which they originated, on the other. But where should the argumentation strand stake its money in the nearest future? Thus the fourth issue that the strand needs to address is *whether the strand can better aid science education by large scale studies that focus on the (informal) logical relations in students' discourse or on smaller studies that are more explorative of students' argumentative discourse*.

In any case it is crucial that the strand finds a viable solution to the practical problem of how to communicate and discuss the dialectical interpretation and interpretative decision that are a natural part of argumentation studies. From the reviews in this paper it is manifest that this is an aspect that deserves much more attention. The scholars of the argumentation strand may need to look in more detail to other fields that study discourse, but this will surely not be enough for the same problems are due to exist there as well. But the issue remains for the argumentation strand to address: *Exactly how and in which forums should scholars communicate to, and discuss with, other scholars how the dialectical features were interpreted in a given study and why*?

It is clear that such issues cannot be addressed in a vacuum. Scholars of the argumentation strand have to look to science education as an overarching endeavor, other scholarly fields, practitioners, and policy makers in order to properly discuss these issues. Nor do such issues have determinate answers. Thus the task of resolving these issues is similar to the activities that we in the argumentation strand love to study: The rewarding part is not the final claim or decision, nor is it the individual premises that substantiate it; the progress lies in the dialectics of the continued discussion.

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2.7 References

Andrews, R. (2005). Models of argumentation in educational discourse. *Text: Transactions of the Society for Textual Scholarship, 25*(1), 107-27.

Aristotle. (1997). *Topics. Books I and VIII, with excerpts from related texts* (Robin Smith, Trans.). Oxford: Clarendon Press.

Aufschnaiter, C.v., Erduran, S., Osborne, J., & Simon, S. (2007). Arguments and the learning of science. In R Pintó & D Couso (Eds.), *Contributions from Science Education* (pp. 377-88). Dordrecht: Springer.

Aufschnaiter, C.v., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching, 45*(1), 101-31.

Beard, D. (2003). Informal Logic. *Review of Communication, 3*(3), 254-9.

Berland, L.K., & Mcneill, K.L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education, 94*(5), 765-93.

Bermejo-Luque, L. (2006). Toulmin's model of argument and the question of relativism. In D. Hitchcock & B. Verheij (Eds.), *Arguing on the Toulmin Model* (pp. 71–85). Dordrecht: Springer.

Blair, J.A., & Johnson, R.H. (1987). Argumentation as dialectical. *Argumentation, 1*(1), 41-56.

Bricker, L.A., & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education, 92*(3), 473-98.

Castaneda, H. (1960). On a proposed revolution in logic. *Philosophy of Science*, 27, 279-92.

Castells, M., Erduran, S., & Konstantinidou, A. (2009). Argumentation & scientific conceptions in peer discussions: A comparison between Catalan & English students. In G Cakamaki & M.F. Tasar (Eds.), *Contemporary Science Education Reserach: Scientific Literacy and Social Aspects of Science. A Collection of Papers Presented at ESERA 2009 Conference* (pp. 51-60). Ankara: Pegem Akademi.

Chambliss, M.J. (1995). Text Cues and Strategies Successful Readers Use to Construct the Gist of lengthy Written Arguments. *Reading Research Quarterly, 30*(4), 778-807.

Chin, C., & Osborne, J. (2010). Students' Questions and Discursive Interaction: Their Impact on Argumentation During Collaborative Group Discussions in Science. *Journal of Research in Science Teaching, 47*(7), 883-908.

Clark, D., & Sampson, V. (2007). Personally-Seeded Discussions to Scaffold Online Argumentation. *International Journal of Science Education, 29*(3), 253-77.

Clark, D., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. *Journal of Research in Science Teaching, 45*(3), 293-321.

Clark, G. (1990). *Dialogue, dialectic, and conversation : a social perspective on the function of writing*. Carbondale: Southern Illinois University Press.

Cooley, J. (1959). On Mr. Toulmin's revolution in logic. *The Journal of Philosophy, 56*(7), 297-319.

Cowan, J. (1964). The Uses of Argument – An apology for logic. *Mind: A Quarterly Review of Philosophy, 73*(289), 27-45.

Dawson, V., & Venville, G. (2009). High-school Students' Informal Reasoning and Argumentation about Biotechnology: An indicator of scientific literacy? *International Journal of Science Education, 31*(11), 1421-45.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Duschl, R.A. (2007). Quality Argumentation and Epistemic Criteria. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 159-75): Springer Netherlands.

Duschl, R.A., Ellenbogen, K., & Erduran, S. (1999). Middle school students' dialogic argumentation. In M. Komorek, H. Behrendt, H. Dahncke, R. Duit, W. Gräber & A. Kross (Eds.), *Research in science education: Past, present and future; Proceedings of the Second International Conference of the European Science Education Research Association* (pp. 420-2). Kiel: IPN.

Duschl, R.A., & Osborne, J. (2002). Supporting and Promoting Argumentation Discourse in Science Education. *Studies in Science Education, 38*, 39-72.

Eemeren, F.H.v., & Grootendorst, R. (1992). *Argumentation, communication, and fallacies : a pragma-dialectical perspective*. Hillsdale, N.J.: L. Erlbaum.

Erduran, S. (2007). Methodological Foundations in the Study of Argumentation in Science Classrooms. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 47-69): Springer Netherlands.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88*(6), 915-33.

Finocchiaro, M.A. (2006). Reflections on the Hyper Dialectical Definition of Argument. In P Houtlosser & A van Rees (Eds.), *Considering Pragma-Dialectics* (pp. 51-62). Mahwah (NJ): Lawrence Erlbaum Associates.

Fraser, B. (1975). Hedged performatives. In P. Cole & J.L. Morgan (Eds.), *Syntax and semantics 3: Speech acts* (pp. 187-210). New York: Academic Press.

Freeman, J.B. (2005). Systematizing Toulmin's Warrants: An Epistemic Approach. *Argumentation, 19*, 1-46.

Freeman, J.B. (2009). Argument Strength, the Toulmin Model, and Ampliative Probability. In F. H. van Eemeren & B. Garssen (Eds.), *Pondering on Problems of Argumentation* (pp. 191-205). Dordrecht: Springer

Fulkerson, R. (1996). *Teaching the Argument in Writing*. Urbana, IL: National Council of Teachers of English.

Garcia-Mila, M., & Andersen, C. (2007). Cognitive Foundations of Learning Argumentation. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 29-45). Dordrecht: Springer Netherlands.

Goldman, A.I. (1999). *Knowledge in a social world*. Oxford: Oxford University Press.

Goodwin, J. (2001). One Question, Two Answers. In H.V. Hansen, C.W. Tindale, J.A. Blair, R.H. Johnson & R.C. Pinto (Eds.), *Argumentation and Its Implications*. Windsor, Ontario: Ontario Society for the Study of Argument, CD-ROM, ISBN:0-9683461-2-X, Retrieved from http://www.public.iastate.edu/~goodwin/pubs/goodwinone.pdf

Gott, R., & Duggan, S. (2007). A framework for practical work in science and scientific literacy through argumentation. *Research in Science 25*(3), 271-91.

Govier, T. (2010). *A Practical Study of Argument* (7th ed.). Belmont: Wadsworth Cengage Learning.

Gross, A.G. (1984). A Comment on the Uses of Toulmin. *College English, 46*, 10-4.

Habermas, J. (1984). *The Theory of Communicative Action: Reason and the rationalization of society* (T. McCarthy, Trans.). Boston: Beacon Press.

Hample, D. (1992). The Toulmin model and the syllogism. In W.L. Benoit, D Hample & P.J. Benoit (Eds.), *Readings in argumentation* (pp. 225-38). Dordrecht: Foris.

Hofstein, A., Kipnis, M., & Kind, P. (2008). Learning in and from Science Laboratories: Enhancing Students' Meta-Cognition and Argumentation Skills. In C.L. Petroselli (Ed.), *Science Education Issues and Developments ((*pp. 59-94). New York: Nova Science Publishers.

Jacobs, S. (2000). Rhetoric and dialectic from the standpoint of normative pragmatics. *Argumentation, 14*(3), 261-86.

Jiménez-Aleixandre, M.P. (2007). Designing Argumentation Learning Environments. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 91-115). Dordrecht: Springer Netherlands.

Jiménez-Aleixandre, M.P., & Erduran, S. (2007). Argumentation in Science Education: An Overview. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 3-27). Dordrecht: Springer Netherlands.

Jiménez-Aleixandre, M.P., & Pereiro-Muñoz, C. (2005). Argument Construction and Change while Working on a Real Environment Problem. In Kerst Boersma, Martin Goedhart, Onno Jong & Harrie Eijkelhof (Eds.), *Research and the Quality of Science Education* (pp. 419-31). Dordrecht: Springer.

Jiménez-Aleixandre, M.P., & Pereiro-Muñoz, C. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education, 24*(11), 1171-90.

Jiménez-Aleixandre, M.P., Rodriguez, A., & Duschl, R.A. (2000). Doing the lesson or doing science: Argument in high school genetics. *Science Education, 84*(6), 757-92.

Johnson, R.H. (1981a). Toulmin's Bold Experiment (i). *Informal Logic Newsletter, 3*(2), 1-12.

Johnson, R.H. (1981b). Toulmin's Bold Experiment (ii). *Informal Logic Newsletter, 3*(3), 1-9.

Johnson, R.H. (1995). Informal logic and pragma-dialectics: Some differences. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C. Willard (Eds.), *Proceedings of the Thirs ISSA Conference on Argumentation, Volume I: Perspectives and Approaches* (pp. 237- 45). Amsterdam: SicSat.

Johnson, R.H. (2002). Manifest rationality reconsidered: Reply to my fellow symposiasts. *Argumentation, 16*(3), 311-31.

Katriel, T., & Dascal, M. (1984). What do indicating devices indicate? *Philosophy and Rhetoric, 17*, 1-15.

Keith, W., & Beard, D. (2008). Toulmin's Rhetorical Logic: What's the Warrant for Warrants? *Philosophy and Rhetoric, 41*(1), 22-50.

Kelly, G.J., & Chen, C. (1999). The sound of music: Constructing science as sociocultural practices through oral and written discourse. *Journal of Research in Science Teaching, 36*, 883-915.

Kelly, G.J., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education, 20*(7), 849-71.

Kim, H., & Song, J. (2005). The Features of Peer Argumentation in Middle School Students' Scientific Inquiry. *Research in Science Education, 36*(3), 211-33.

Klumpp, J. (2006). Warranting Arguments, the Virtue of Verb. In D Hitchcock & B Verheij (Eds.), *Arguing on the Toulmin Model* (pp. 103-13). Amsterdam: Springer Netherlands.

Kock, C. (2007a). Is Practical Reasoning Presumptive? *Informal Logic, 27*(1), 91-108.

Kock, C. (2007b). Norms of legitimate dissensus. *Informal Logic, 27*(2), 179-96.

Kock, C. (2008). Dialectical Obligations in Political Debate. *Informal Logic, 27*(3), 223.

Kolstø, S.D., & Ratcliffe, M. (2007). Social Aspects of Argumentation. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (Vol. 35, pp. 117-36). Dordrecht: Springer Netherlands.

Krabbe, E. (1999). Profiles of dialogue. In J. Gerbrandy, M Marx, M de Rijke & Y. Venema (Eds.), *JFAK. Essays dedicated to Johan van Benthem on the occasion of his 50th birthday, III* (pp. 25-36). Amsterdam: Amsterdam University Press.

Leitão, S. (2000). The potential of argument in knowledge building. *Human Development, 43*(6), 332-60.

Leitão, S. (2001). Analyzing Changes in View During Argumentation: A Quest for Method. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 2*(3). Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/907/1983

Lunsford, K. (2002). Contextualizing Toulmin's model in the writing classroom. *Written Communication, 19*(1), 109-74.

Lynch, M. (1982). Closure and disclosure in pre-trial argument. *Human studies, 5*(1), 285-318.

Maloney, J., & Simon, S. (2006). Mapping children's discussions of evidence in science to assess collaboration and argumentation. *International Journal of Science Education, 28*(15), 1817-42.

Molinatti, G., Girault, Y., & Hammond, C. (2010). High School Students Debate the Use of Embryonic Stem Cells: The influence of context on decision-making. *International Journal of Science Education, 32*(16), 2235-2251.

Munneke, L., van Amelsvoort, M., & Andriessen, J. (2003). The role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research, 39*(1-2), 113-31.

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education, 37*(1), 17-39.

Newman, S., & Marshall, C. (1991). Pushing Toulmin too far: Learning from an argument representation scheme. *Xerox PARC, Palo Alto, CA, USA, Technical Report SSL-92-45*.

Nielsen, J.A. (2010), Functional roles of science in socio-scientific discussions. In Ingo Eilks & Bernd Ralle (Eds.) *Contemporary Science Education – Implications from Science Education Research about Orientations, Strategies and Assessment* (pp. 83-96). Aachen: Shaker.

Nielsen, J.A., (To appear), Co-opting Science: A preliminary study of how students invoke science in value-laden discussions. *International Journal of Science Education.*

O'Keefe, D. (1977). Two concepts of argument. *Journal of the American Forensic Association, 13*(3), 121-8.

Okada, A., & Shum, S.B. (2008). Evidence-based Dialogue Maps as a research tool to investigate the quality of school pupils' scientific argumentation. *International Journal of Research & Method in Education, 31*(3), 291-315.

Orsolini, M., & Pontecorvo, C. (1992). Children's Talk in Classroom Discussions. *Cognition and Instruction, 9*(2), 113-36.

Osborne, J. (2005). The Role of Argument in Science Education. In Kerst Boersma, Martin Goedhart, Onno Jong & Harrie Eijkelhof (Eds.), *Research and the Quality of Science Education* (pp. 367-80). Dordrecht: Springer Netherlands.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020.

Pera, M. (1994). *The discourses of science*. Chicago: University of Chicago Press.

Perelman, C., & Olbrechts-Tyteca, L. (1969). *The new rhetoric: a treatise on argumentation*. Notre Dame, Ind.: University of Notre Dame Press.

Pomerantz, A.M. (1984a). Agreeing and disagreeing with assessments: Some features of preferred/dispreferred turn shapes. In J.M. Atkinson & J. Heritage (Eds.), *Structures of social action. Studies in conversation analysis* (pp. 57-101). Cambridge: Cambridge University Press.

Pomerantz, A.M. (1984b). Giving a source or basis: The practice in conversation of telling 'how I know'. *Journal of Pragmatics, 8*, 607-25.

Pontecorvo, C., & Girardet, H. (1993). Arguing and Reasoning in Understanding Historical Topics. *Cognition & Instruction, 11*(3/4), 365.

Pontecorvo, C., & Pirchio, S. (2000). A Developmental View on Children's Arguing: The Need of the Other. *Human Development, 43*(6), 361-3.

Primatarova-Miltscheva, A. (1987). Sequence with Concessive, Adversative, and Restrictive Sentences and Clauses and The Simulation of Dialogical Argumentation Patterns in Monological Discourse. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C.A. Willard (Eds.), *Argumentation: Perspectives and Approaches* (pp. 41-53). Dordrecht: Foris.

Ravenscroft, A., & Mcalister, S. (2008). Investigating and promoting educational argumentation: towards new digital practices. *Int. J. of Res. & Method in Educ., 31*(3), 317-35.

Reed, C., & Rowe, G. (2005). Translating Toulmin Diagrams: Theory Neutrality in Argument Representation. *Argumentation, 19*(3), 267-86.

Rees, M. V. (2009). *Dissociation in argumentative discussions: a pragma-dialectical perspective*. Dordrecht: Springer.

Sadler, T.D., & Donnelly, L. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463-88.

Sadler, T.D., & Fowler, S.R. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education, 90*(6), 986-1004.

Sampson, V., & Clark, D. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92*(3), 447-72.

Schlegoff, E. (1988). Presequences and indirection: Applying speech act theory to ordinary conversation. *Journal of Pragmatics, 12*, 55-62.

Shea, N., Duncan, R.G., & Stephenson, C. (2011). *Exploring Genetic Literacy: How Undergraduate Science Majors Reason About Authentic Genetic Dilemma*. Paper presented at the NARST.

Siegel, H. (1995). Why Should Educators Care about Argumentation? *Informal Logic, 17*(2), 159-76.

Simon, S. (2008). Using Toulmin's Argument Pattern in the evaluation of argumentation in school science. *Int. J. of Res. & Method in Educ., 31*(3), 277-89.

Simon, S., & Johnson, S. (2008). Professional Learning Portfolios for Argumentation in School Science. *International Journal of Science Education, 30*(5), 669 - 88.

Skoumios, M. (2008). The Effect of Sociocognitive Conflict on Students' Dialogic Argumentation about Floating and Sinking. *International Journal of Environmental & Science Education, 3*(3).

Smith, P.C. (1995). Towards a Discursive Logic: Gadamer and Toulmin on Inquiry and Argument. In L. K. Schmidt (Ed.), *The Specter of Relativsm* (pp. 159-77). Evanston: Northwestern University Press.

Smith, R. (1993). Aristotle on the uses of dialectic. *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science, 96*(3), 335-58.

Snoeck Henkemans, A. (1992). *Analysing complex argumentation. The reconstruction of multiple and coordinatively compound argumentation in a critical discussion.* Amsterdam: Sic Sat.

Snoeck Henkemans, A. (1996). Indicators of independent and interdependent arguments: 'anyway' and 'even'. In J. van Benthem, F.H. van Eemeren, R. Grootendorst & F. Veltman (Eds.), *Logic and argumentation* (pp. 77-87). Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen.

Toulmin, S.E. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Trent, J. (1968). Toulmin's model of an argument: An examination and extension. *Quarterly Journal of Speech, 54*(3), 252-9.

van Eemeren, F.H., & Grootendorst, R. (1982). The speech acts of arguing and convincing in externalized discussions. *Journal of Pragmatics, 6*(1), 1-24.

van Eemeren, F.H., & Grootendorst, R. (2004). *A systematic theory of argumentation: The pragma-dialectical approach*. Cambridge: Cambridge University Press.

van Eemeren, F.H., Grootendorst, R., & Kruiger, T. (1987). *Handbook of Argumentation Theory: a Critical Survey of Classical Backgrounds and Modern Studies*. Dordrecht: Foris.

van Eemeren, F.H., & Houtlosser, P. (2007). The study of argumentation as normative pragmatics. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 15*(1), 161-77.

van Eemeren, F.H., Houtlosser, P., & Snoeck Henkemans, A. (2007). *Argumentative indicators in discourse: a pragma-dialectical study*. Dordrecht: Springer.

Verheij, B. (2005). Evaluating Arguments Based on Toulmin's Scheme. *Argumentation, 19*, 47-71.

Walker, K., & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-410.

Walton, D.N. (1996). *Argumentation schemes for presumptive reasoning*. Mahwah, N.J.: L. Erlbaum Associates.

Walton, D.N. (1999). Profiles of dialogue for evaluating arguments from ignorance. *Argumentation, 13*, 53-71.

Walton, D.N. (2000). The place of dialogue theory in logic, computer science and communication studies. *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science, 123*(3), 327-46.

Walton, D.N., & Godden, D.M. (2007). Informal Logic and the Dialectical Approach to Argument. In H.V. Hansen & R.C. Pinto (Eds.), *Reason Reclaimed* (pp. 3-17). Newport News, VA: Vale Press.

Walton, D.N., & Krabbe, E. (1995). *Commitment in dialogue. Basic concepts of interpersonal reasoning*. Albany (NY): State University of New York Press.

Wenzel, J. (1993). Rhetoric and Argumentation: An Introduction. *Informal Logic, 15*(1), 1-3.

Willard, C. (1976). On the utility of descriptive diagrams for the analysis and criticism of arguments. *Communication Monographs, 43*(4), 308-19.

Willard, C. (1989). *A theory of argumentation*. Tuscaloosa: University of Alabama Press.

Wishart, J., Green, D., Joubert, M., & Triggs, P. (2011). Discussing Ethical Issues in School Science: An investigation into the opportunities to practise and develop arguments offered by online and face-to-face discussions. *International Journal of Science Education, Part B, 1*(1), 47-69.

Wohlrapp, H. (1987). Toulmin's Theory and the Dynamics of Argumentation. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C. Willard (Eds.), *Argumentation: Perspectives and Approaches* (pp. 327-35). Dordrecht: Foris.

Wu, Y., & Tsai, C. (2007). High School Students' Informal Reasoning on a Socio-scientific Issue: Qualitative and quantitative analyses. *International Journal of Science Education, 29*(9), 1163-87.

Zeidler, D.L., Osborne, J., Erduran, S., Simon, S., & Monk, M. (2006). The Role of Argument During Discourse About Socioscientific Issues. In Dana L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 97-116). Dordrecht: Springer.

Zohar, A. (2007). Science Teacher Education and Professional Development in Argumentation. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 245-68). Dordrecht: Springer Netherlands.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.

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Paper II

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Co-opting Science:
A preliminary study of how students invoke science in value-laden discussions.

Letting students deliberate on socio-scientific issues is a tricky affair. It is yet unclear how to assess whether, or even support that, students weave science facts into value-laden socio-scientific deliberations without committing the naturalistic fallacy of deducing 'ought' from 'is'. As a preliminary step, this study investigated how Danish upper secondary biology students actually interwove science facts and values in socio-scientific discussions. In particular, the focus was the argumentative effects of different ways of blurring the fact-value distinction. The data consisted of the transcriptions of three 45-60-minute discussions among 4-5 students about whether human gene therapy should be allowed. The data was analysed from a normative pragmatics perspective – with a focus on how the students designed and elicited messages to influence the decisions of others. It was found that the students regularly co-opted science to make it appear that their evaluative claims were more solidly supported than those of their opponents. Further, the students tended to co-opt science content so as to redefine what the issue or object of contention should be. The findings suggest that assessment of whether students *properly* used correct science facts in socio-scientific learning activities is very difficult. From the perspective of teachers this means that much more work needs to be done in order to sort out how the fact-value distinction should be addressed appropriately. From the perspective of researchers it means a continued negotiation of what they mean when they say that students' should become able to use science on issues from outside science.
Keywords: science education, argumentation, socio-scientific issues, fact-value distinction

3.1 Introduction

One of the key rationales of science education is to enable future citizens to 'engage in debate and decision-making in contexts featuring scientific information' (Ryder, 2001, p. 3; see also EU-Commision, 2004; Millar & Osborne, 1998; OECD, 2006). But the idea of weaving scientific information tightly into the fabric of societal decision-making can quickly lead to trouble: Scientific information could never by itself authorize or justify a value-decision; and decisions about societal issues tend to be just that – value-decisions. Indeed, it is a logical fallacy to derive a practical decision (about what to do) from an array of scientific factual statements (about how things are) (Hare, 1952; Nowell-Smith, 1954). Science education researchers and teachers must enable students to be reflective about the correctness of scientific information. But it is equally important that students learn to invoke such factual information correctly and distinguish it from value-claims. It is well established that science educators should pay attention to the fact-value distinction, but it is not clear how they should assess student discourse that interweaves facts and values. This paper explores how groups of students actually interwove science facts and human values in socio-scientific discussions. Based on the findings, it is argued that future attempts to assess socio-scientific discourse in this regard face fundamental challenges.

3.1.1 Socio-scientific Issues and the Fact-value Distinction

Issues that pertain to areas such as stem cell research, climate change, and human gene therapy are often referred to as socio-scientific issues: They have a conceptual basis in science, but they are issues within the ethical, political, and economical realm of society (Sadler & Zeidler, 2003). It has been demonstrated that socio-scientific issues are effective devices for students to access science content (Galvão, Reis, Freire, & Almeida, 2010; Zeidler, Sadler, Simmons, & Howes, 2005), and that students can take many different stances towards such issues, which creates an incentive for students to engage in argumentation (Walker & Zeidler, 2007). In the following, a socio-scientific issue – such as whether to allow human gene therapy (Sadler & Zeidler, 2004) – will be treated as an issue that calls for a discussion about what to *do* – not merely a discussion about what is *true*. A socio-scientific discussion is, thus, a discussion about a proposal – not a proposition (Kock, 2009).

Socio-scientific issues present some practical challenges in the traditional science classroom. Even though science is ever more important for resolving socio-scientific issues, the scientific information that many of these issues relate to is tentative at best. The sheer complexity (Ryder, 2001) and tentative nature (Millar, 1997) of the science relevant to many socio-scientific issues renders such science content difficult to transpose to the classroom. Consequently, much science education research has been devoted to how students argumentatively manage scientific knowledge claims in a sea of tentative and conflicting evidence (Kolstø, 2001, 2006; Patronis, Potari, & Spiliotopoulou, 1999; Sadler, 2004; Zeidler, Osborne, Erduran, Simon, & Monk, 2006). These investigations share the outlook that the messiness of bringing societal issues into science classrooms can be harnessed through a focus on informal reasoning patterns, allowing students to 'formulate positions, and provide supporting evidence' (Sadler, 2004, p. 515). To be sure, argumentation is a key aspect of harnessing the messiness of socio-scientific issues, but a focus on how, and how well, students provide evidence for positions might be too narrow. Recall, that a position on a socio-scientific issue could never be fully justified by scientific evidence. There will always be a value-laden reason that supports the position, and such reasons are not evidence in the strictest sense. They are principles, rather, that arguers point to in their arguing. So, the traditional predominant focus on evidence-giving provides little understanding of how students interweave science facts (as evidence) and values in socio-scientific discussions.

In this light, the tentative nature of science is not the only reason that socio-scientific issues are challenging. Socio-scientific issues accentuate the perils of the naturalistic fallacy (i.e. the logical error of deducing normative statements from purely descriptive statements), which is borne out of the distinction between facts and values. Scientific facts are the states of affairs that science has disclosed, and they can be expressed in factual statements such as '(It is a fact that) motor neurons are longer than any other human cells' (Armstrong, 1997). Values, in contrast, are principles that guide action; persons value some objects, or circumstances, more than others and they choose their action accordingly. Consequently a value-statement differs categorically from factual statements because the former has no truth-value – it is neither definitely true nor definitely false. The terms 'value-judgement' and 'evaluation' will, following Dewey (1981), refer to discursive acts in which the speaker states what she thinks ought to be valued.

The fact-value distinction has not gone unnoticed in science education. Some have argued that an emphasis on the fact-value distinction is important for the development of students' ability to critically assess scientific knowledge claims, and that such an emphasis is needed for students to be less prone to commit the naturalistic fallacy themselves (Kolstø, 2001; Zeidler, et al., 2006). Even more important, an emphasis on the fact value distinction is central for making students aware of the balance of roles played by science facts and human values, respectively. To be sure, a decision on a socio-scientific issue is *informed* only if it is made against the background of scientific knowledge (e.g. Kitcher, 2010). But it is, logically speaking, possible to make such a decision without invoking science (Dawson, 2000; Irwin & Wynne, 1996) and students tend to do just that (Kolstø, 2000; Lewis & Leach, 2006; Ratcliffe, 1997; Ryder, 2001; Sadler & Donnelly, 2006). The dilemma is this: Though science is needed, it could never be the final arbiter in a socio-scientific context. Socio-scientific teaching activities should therefore involve a negotiation of what role science should play so that it informs students' decisions without being blindly followed (Sadler & Zeidler, 2006). The conclusion from previous research is this: *If* students must learn to invoke science when they deal with socio-scientific issues, *then* the fact-value distinction must be made explicit in the learning process (Levinson, 2007). But little has been written on how best to address the distinction.

Two notable studies have pointed to a common way that facts and values are interwoven in students' discourse. From a study on students' self-reports concerning their standpoints on a socio-scientific issue, Albe (2008) was able to conclude that when students were asked how to make a socio-scientific decision, they reduced the issue to an underlying scientific controversy and relied on science to resolve the issue. Failure to observe the fact-value distinction in this respect leads, potentially, to fallacious reasoning. Science could never be the ultimate arbiter on how people should resolve a socio-scientific issue. Lindahl (2009) similarly documented that students, when interviewed about their thoughts on genetic testing for hereditary diseases would often rely on science as a referee for deciding when and who was subject to moral considerations. He found, for example, that '[b]iological knowledge …was often used to objectify a fetus or person, thus excluding him/her from the moral party' (Lindahl, 2009, pp. 1308-9).

These studies indicate that students do interweave science factual and evaluative statements in their arguments on socio-scientific issues, and that students do so in a manner that blurs the fact-value distinction. For in both studies it was found that students relied on science to determine which evaluative stance would be preferable. But the studies did not directly address how students interwove facts and values in their argumentation. It is still an open question whether there are different argumentative outcomes when students interweave science factual information and human values; and whether the interweaving can occur in different shapes and forms. Such questions must be central for future attempts to assess students' socio-scientific discourse. Also, the studies of Albe (2008) and Lindahl (2009) did not explore discussions among groups of students. This leaves open the question of how students interweave factual information and values in an attempt to autonomously manage their disagreement on socio-scientific issues. The research question of this study is therefore the following: *how and for what purpose do students interweave factual and evaluative statements in group discussions about a controversial socio-scientific issue?* In particular, the study aimed at exploring the argumentative effects of a number of different ways of invoking science in a value-laden discussion about human gene therapy.

3.1.2 Argumentation

In discussions, people manage disagreement by putting forward and responding to arguments. Therefore the concept of argumentation is central for any study that explores how students navigate facts and values in discussions. This study was different in two respects from traditional investigations of student argumentation in science education. First, many science educators have investigated student argumentation because of the idea that science can and should be taught through argumentation-activities (Driver, Newton, & Osborne, 2000). The topical focus has so far been on how students handle the epistemological game of providing and asking for evidence for science knowledge claims (Aufschnaiter, Erduran, Osborne, & Simon, 2008; Clark & Sampson, 2007; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Kelly, Druker, & Chen, 1998; Patronis, et al., 1999; Simon, 2008; Zohar & Nemet, 2002). In contrast, this study focussed on how students use science claims in the process of negotiating non-scientific standpoints about what society should do about human gene therapy.

Second, previous investigations have largely focused on the structure of student arguments and relied heavily on Toulmin's (1958) model of argumentation patterns in their analyses. The same is true for many previous investigations into students' socio-scientific argumentation (e.g. Kolstø, 2006; Sadler, 2004; Sadler & Donnelly, 2006; Sadler & Zeidler, 2005a). The general approach has been to record student discourse and then break individual utterances into units that could be reconstructed to match the different structural elements (viz. data, claim, warrant, etc.) that Toulmin thought constituted an argument (for a critical review of the use of Toulmin's model in science education see Sampson & Clark, 2008). This approach has practical advantages: The analyst is able to quantify large amounts of qualitative data, and can compare argumentation patterns across subjects and contexts (Andrews, 2005). But Toulmin's functional descriptions of how, for example, a warrant is different from a datum are difficult to apply on real dialogic discourse. This difficulty has been demonstrated at length in argumentation theory (Castaneda, 1960; Cooley, 1959; Cowan, 1964; Hample, 1977; Keith & Beard, 2008; Trent, 1968; van Eemeren, Grootendorst, & Kruiger, 1987) and in science education (Duschl, 2007; Erduran, Simon, & Osborne, 2004; Jimenez-Aleixandre, et al., 2000; Kelly, et al., 1998).

Further, structural analyses of socio-scientific discussions (such as Toulminian analyses) necessarily reduce the dialectical interactive discussion process to monological chains of reasoning (Habermas, 1984; Johnson, 2002; Lynch, 1982; Smith, 1995; van Eemeren, et al., 1987). The aim of this study was to investigate the argumentative role factual scientific statements have in socio-scientific discussions. For this purpose it was important not to dismiss the dialectical dimension (i.e. how arguers use language to manage disagreement). This requirement is resonant with a recent recognition among some science educators that the dialectical features of students' argumentation deserve a closer look (Duschl, 2007; Hofstein, Kipnis, & Kind, 2008; Kerlin, McDonald, & Kelly, 2010; Walker & Zeidler, 2007)

3.1.3 Normative Pragmatics

The concept of argumentation that formed the background of this study has been proposed by a group of scholars in argumentation theory under the name of 'normative pragmatics' (sometimes called 'design theory') (Goodwin, 2000; Jacobs, 2000; van Eemeren & Houtlosser, 2007). From the perspective of normative pragmatics, argumentation is about managing disagreement: Argumentation is a reciprocal affair in which two or more people use language to carry out their individual project of 'influencing the decisions' of the other(s) (Goodwin, 2001, p. 14). In other words, arguers attempt to make others *do* something (e.g. acknowledge their standpoint, provide more reasons, clarify what they said before etc.) by designing messages that have specific effects on the recipients.

Linguistic messages have two notable aspects or dimensions: Messages have specific *contents* (i.e. that which is being said) but they also have specific *designs* (i.e. how that which is being said is said) (Jacobs, 2000).[1] Taking both aspects into account is important for a full

[1] This distinction roughly corresponds to Searle's (1969) distinction between the propositional content of an utterance and the act in which that content is elicited (Jackson & Jacobs, 1980). Argumentation from this perspective is a speech act complex. The argumentation of a speaker must have the illocutionary effect of bringing about that the interlocutor realizes that the speaker is presenting argumentation, and argumentation always involves the speaker's attempt to bring about the perlocutionary effect of convincing her interlocutor (van Eemeren & Grootendorst, 1982).

understanding of argumentative messages. For example, note that the following two utterances have a roughly similar content:

> (1) Well you wouldn't say that merely being predisposed to be, like, really, really fat should simply be dealt with using gene therapy do you?
>
> (2) Being predisposed to be overweight is not a condition that should fall under the purview of gene therapy treatments

The design aspects of these two utterances, however, are very different. In utterance (1), the speaker used strong evaluative adjectives and the pronoun 'you', and she elicited the content in a directive speech act (it is a question). All these aspects indicate that it would play a different argumentative role than utterance (2). In particular, utterance (1) seems to displace the balance of the burden of proof. The speech act analytical approach of normative pragmatics takes into account such design features of argumentative talk-in-interaction.

What is involved in uttering words so as to influence the decisions of others? For one, an arguer must deal with many 'practical difficulties' (such as '[securing] the adequacy of her premises') by designing her statements so as to create 'expeditiously the unchallengeable adequate premises she needs' (Goodwin, 2005, p. 100). In other words, an arguer must design and present reasons in a way that shows her interlocutor that she has adequately justified her standpoint (see also Brandom, 1994; van Eemeren & Houtlosser, 2002). Further, in order to achieve her goal of influencing the decisions of her interlocutors, the speaker must use argumentative *strategies* (Goodwin, 2001). Some argumentative strategies are very simple. For example, the strategy of providing justification for a standpoint that one proposed earlier can be used to influence the recipients to hold a similar standpoint (Innocenti, 2006). Some strategies are more complex. For example, a strategy of accusing someone not only requests that the accused explain her position, but it also implies that her position is wrong (Kauffeld, 1998). Other strategies work by the very act of uttering something rather than on the propositional content of the act. Just as making a promise is an act that can be a reason for the recipient to act in a specific way, some argumentative strategies create 'pragmatic reasons' for the recipients to do something (e.g. acknowledge the adequacy of a premise) (Innocenti, 2006). Pragmatic reasons are created by the act of saying/doing something, while (regular, non-pragmatic) reasons are brought about by the content of a message.

Another way that a speaker can influence the decisions of others is to actively design what the disagreement is about, and thereby steer the discussion in a direction that is beneficial for her. She can, that is, design the issue that is up for discussion – for an issue does not merely happen to become an object of contention, it 'arises when we *make an issue of it*' (Goodwin, 2002, p. 86). For example, the abortion debate can be designed as a pro-life or pro-choice issue (Craig & Tracy, 2005).

The goal of normative pragmatics analysis is to identify 'strategies as strategies [and] explain how an arguer's utterance of some words can be expected to accomplish things like the imposition of probative burdens' (Goodwin, 2001, p. 9). Against this background, the research question behind this study (how and for what purpose do students interweave factual and evaluative statements in group discussions about a controversial socio-scientific issue?) will be approached through three analytical questions: (1) Are there different argumentative strategies that involve the weaving together of science factual and evaluative statements? (2) How do such strategies work? (3) How does the interweaving of science factual and evaluative statements contribute to the speaker's attempt to design issues?

3.2 Methods

3.2.1 Research Design

To elucidate the research question (through the analytical questions) three socio-scientific group discussions were subjected to a normative pragmatics analysis. The study was designed as a multiple case study (Yin, 2009). Each case consisted of the transcriptions of a 45-60 minute discussion among 4-5 students about whether human gene therapy should be allowed. Three teachers in three different classes from two Danish upper secondary schools implemented the discussion activities in January and February 2010. All three teachers were experienced biology teachers and used the activity as a conclusion to their standard unit on genetics. The students in all three classes were introduced to the activity in a uniform manner, they were given the same written material, which they read in the groups immediately before the discussion, and they sat undisturbed for the majority of the activity. The similarities across the three cases afforded that findings in one case could be compared and related to findings from the other cases (Yin, 2009).

The written material – 'Gene Therapy – A Dilemma for the Future?' – was inspired by the activity 'Negotiating Gene Therapy Controversies' developed by Zeidler and Sadler (2004). It described the difference between somatic and germ-line genetic therapy, and how these technologies work. It will be helpful to recall that *gene therapy on germ cells involves engineered changes that are heritable and persist throughout the lifespan of the beneficiary, whereas gene therapy on somatic (bodily) cells involves engineered changes that are not heritable and disappear with the affected cells.*

The written material also presented four real life positions on whether to allow gene therapy – each supported by statements from a public debate in America. The explicit task of the students was to decide on how the European Council should be advised on future legislation regarding human gene therapy.

3.2.2 Sample Data

This study was the first part of a longer study of the role of science in students' socio-scientific discussions. Because of the significant amounts of data accumulated in each group discussion, this preliminary study was limited to three groups – one from each class. At the point of writing, these three groups are the only groups that have been analysed in full. The first group (group A) was chosen because it was the first group from the first class whose discussion was transcribed. The two other groups (B and C) were chosen at random from their respective classes.

3.2.3 Analysis

The key aim of the normative pragmatics analysis was to elucidate the analytical questions listed above. There is, however, no regimented procedure for conducting normative pragmatics analysis. Therefore a number of scaffolds were implemented so as to structure the analysis. First, the talk turns in which science was invoked were indexed. Second, the thematic issues (i.e. the issues that were discussed recurrently and at length) of the discussions were identified. This was done through two iterations of open (inductive) coding (Denzin & Lincoln, 1994; Thomas, 2003) in which the discussions were split into sequences according to the issue that the participants discussed in that sequence. This created two basic analytical tiers that acted as guidelines for the ensuing normative pragmatics analysis.

The normative pragmatics analysis of sequences in which science factual and evaluative statements were interwoven was guided by four questions:

1) What kind of *speech acts* were being used (van Eemeren & Grootendorst, 1989)? For example, questions (directives) usually have a different argumentative function than do assertions (van Eemeren & Grootendorst, 2004).
2) What kind of *argumentative indicators* were explicit in the talk turn? For example, locutions such as ‘yes, but…’ and ‘I don’t think so’ are indicators of doubt or disagreement of different strength, while locutions such as ‘how do you mean?’ and ‘why is that so?’ are indicators of requests for clarification or justification (van Eemeren, Houtlosser, & Henkemans, 2007). This provided a basis for interpreting what the talk turn was a response to and what kind of

response it was (i.e. a confrontation, justification, standpoint etc.).

3) What other linguistic indicators deserve attention? For example, *pronouns* (Goodwin & Honeycutt, 2009), *adjectives* (Gilbert, 1997), and *stance adverbs (*Tseronis, 2009) can be revealing design features that can have an argumentative function.
4) What is the connection between the talk turn in question and the thematic issues of the discussion?

The normative pragmatics analysis was conducted in a hermeneutic fashion. The first two tiers of the analysis revealed places in the discussions where science and values appeared interwoven. On the basis hereof, a particular sequence of turns in the first discussion was chosen. The normative pragmatics analysis of that first sequence revealed a particular way that science and values were combined. The rest of the data were then explored for indicators of similar combinations. This led to the identification of new sequences, some of which featured a roughly similar combination, while others showed other ways that facts and values were interwoven. The latter sequences, in turn, became stepping-stones for identifications of new combinations and so on. This afforded a focus on describing the different science-value combinations and how they differed. The normative pragmatics analysis was shared with and critiqued by a scholar in argumentation theory who is experienced in conducting normative pragmatics analysis.

3.3 Findings and Discussion

3.3.1 Impressions From the First Two Analytical Tiers

The following number of talk turns was coded as featuring science: 105 for group A (23 percent of all turns in that group); 91 for group B (18 percent); and 79 for group C (15 percent). These figures are not meaningful by themselves, but they do provide some insight into how often science is used in this sort of context. For the purpose of this study, turns which featured science were marked merely to choose where to make a detailed normative pragmatics analysis.

The second tier of the analysis identified the groups' decisions and the issues that were thematic for each group (i.e. the issues that were discussed at length and recurrently). All final decision of the three groups displayed openness to both germ-line and somatic gene therapy, with the reservation that germ-line gene therapy is a last resort only to be used on very few diseases and with utmost caution. For some students, this meant that considerable compromises needed to be made. For example, Allan (group A), Dwight (group B), and Anita (group C) all consistently held that germ-line gene therapy should not be allowed; but their respective peers eventually persuaded them otherwise.

Three thematic issues were occurred in every group. First, every group discussed the concern that misuse of gene therapy could have unfortunate social consequences. For example, using the technology to change 'appearances' (Betsy, B188), decide whether a 'child should be homosexual or not' (Bettina, A306), entirely 'eradicate [a] disease' (Diana, C364), or even to create extreme socio-economic gaps so that 'those who have money that can get the healthy, smartest and most beautiful children' (Dwight, B186). Second, every group discussed which diseases would be legitimate objects for gene therapy treatment. For example, cancer was often brought to the table: 'of course one could not say that cancer, that one should not do that…if it could be changed using germ-line gene therapy' (Allan, A171). But the issue also concerned how to draw the line between legitimate and illegitimate diseases: 'one should have a clear definition of when a disease is a real disease if one could put it that way' (Christina, C52). Third, every group discussed the long-term effects of germ-line gene therapy and in all discussions this was identified and acknowledged as an (at least potential) ethical problem. For example, Allan argued that germ-line gene therapy 'has that lasting effect […] [so] I think also still that it's dangerous to say that this should just be researched' (A142). Allan thus proposed not to allow germ-line gene therapy research based on a concern about the long-term effects of germ-line therapy (coupled with the concern that research in such a field would have an impact). One of the key potential ethical issues concerning the long-term effect that the students identified was the concern that it might violate a persons right to an "open future" (Feinberg, 1980) – the concern, that is, that the autonomous choices of, for example, parents or societal institutions might severely limit the autonomy of the beneficiary (Davis, 2006; Takala, 2005). For example, Christina argued that by using germ-line gene therapy 'we, well, go in and then choose on behalf of another individual in some way' (C52). Thus, in every group, one of the primary arguments raised *against germ-line gene therapy was the concern that persons who are not the result of genetic engineering have an autonomy which is qualitatively more desirable or greater than that of persons who are the result of genetic engineering.* In sum, the bioethical issues that are usually identified as the core potential issues or dilemmas concerning gene therapy – namely, the fear that gene therapy is a slippery slope, the fear that gene therapy leads to eugenics, and the fear that germ-line gene therapy closes the future of its beneficiaries (Holland, 2003; Wilkinson, 2010) – were reproduced and discussed as key issues in every group. This does not mean that every participant shared these core concerns. In fact, all groups eventually decided on taking a rather positive stance towards gene therapy. But it does emphasise that even if one believes that gene therapy is sound – from an ethical perspective – the core issues outlined above still need to be discussed as potential issues of concern (see in particular Harris, 1993).

3.3.2 Normative Pragmatics Analysis

3.3.2.1 Science and value-statements in socio-scientific discussions

Even though a socio-scientific decision necessarily involves at least one value judgement, scientific statements seem particularly apt to be starting points (i.e. the 'bare' facts that a discussion can be had in light of) in such discussions. The clearest structure of a socio-scientific argument could be portrayed as follows: In light of these and these facts about Y, and because Z is valued, X should be done. This structure was regularly found, and it can be illustrated with these examples:

A203	Allan:	Yes yes, but that is what I mean, that one maybe therefore should be more passive regarding that germ-line gene therapy because it has a lasting effect

B97-9	Dwight:	as soon as you make germ-line treatment […] well then the offspring that two persons get is not genetically identical with them. That, I think, is a big crisis […] that I think is ethically completely irresponsible that the offspring one gets is not genetically identical with oneself

In such cases science content is kept separate from evaluative statements. When a speaker presented this structure of argumentation, her peers were invited to engage in a pro- and contra-argumentation about the values (e.g. 'do we value other values higher than Z?'), and to engage in a negotiation of the practical conclusion of the argumentation (e.g. 'should we really do X?').

3.3.2.2 The fusion of value-statements and science content
Emily in group C argued for allowing 'some forms of gene therapy, that is, on these life-threatening diseases' (C26)

C28	Emily:	[…] because I don't feel that you can totally ignore that you can actually cure an enormous number of unbelievably horrible diseases by using this and then just chose to say we don't want that

Here Emily used a scientific fact about gene therapy (that gene therapy can cure diseases) as part of her reason for why gene therapy should be allowed. Three design aspects of her argumentation stand out. First, the stance adverb 'actually' (in Danish: 'faktisk') indicates that Emily insists that gene therapy *indisputably* can cure diseases; and that she anticipates that this indisputable fact is incompatible with the argumentation of her opponents (Tseronis, 2009, pp. 70-1). In fact, although group C later discussed how both kinds of gene therapy function as a cure and what kinds of diseases should legitimately be treated using gene therapy, the group never discusses which diseases gene therapy can cure or treat. So in the context of this group, the statement 'gene therapy can cure diseases' has already evolved into what Latour and Woolgar (1979) called a 'type 5 statement,' a 'taken-for-granted fact' that is made explicit only in rare situations (e.g. involving people how require 'some introduction' to it) (Latour & Woolgar, 1979, p. 76).

Second, Emily used the evaluative adjective 'enormous,' and the emotive adjectives 'unbelievably horrible.' This indicates that Emily was doing more than introducing a 'taken-for-granted fact.' To say that the diseases that gene therapy can cure are both plentiful and 'unbelievably horrible' is to make an evaluation; it is not a scientific fact. (This is so because an assertion to the effect of "disease X is unbelievably horrible" is not an assertion that could be either definitely true or definitely false; science could possible test whether persons in general think that disease X is unbelievably horrible, but whether it is correct to think that a disease is unbelievably horrible is not a determinate question). Emily made an appeal to emotions by installing emotive adjectives (Gilbert, 1997; Innocenti, 2006); but, more importantly, she chose to fuse the emotive adjectives with the science factual statement in one assertion. The science-evaluation package that Emily presented can be seen as an attempt to make the value-laden statement '[gene therapy] can actually cure an enormous number of unbelievably horrible diseases' into an indisputable starting point for the discussion (i.e. something that the arguers mutually agree on). In other words, Emily made it appear that her value-judgement is indisputable by piggybacking it on the indisputability of a scientific factual statement.

Third, Emily designed her turn as a challenge to possible opponents. According to Emily, those who do not think that gene therapy should be allowed would say 'we don't want' to allow gene therapy and they would 'totally ignore' the benefits of gene therapy. Not only is this a possible line of counter-argumentation against the standpoint of those who are opposed to gene therapy, it can be seen as a way of requesting a particular line of argumentation from those who are opposed. Emily's strategy was to 'make an issue of' whether or not to ignore the benefits of gene therapy, and she made it apparent that her potential opponents are 'obligated, or forced by circumstances, to address' why they ignore the benefits, and, if they do, why they are justified in doing so (Goodwin, 2002, p. 88). Emily's opponents would have to have considered themselves challenged to show that they are not 'totally' ignoring what she takes to be ever so obvious benefits of gene therapy. In other words, Emily's potential opponents must not only give positive reasons for being opposed; they must argue why they are opposed even in light of the benefits of gene therapy (viz. that it can 'cure an enormous number of horrible diseases'). It is precisely because the benefits of gene therapy are introduced as indisputable that Emily's potential opponents would be required to present that line of argumentation

In sum, Emily (i) fused evaluative terms like 'unbelievably horrible' to a scientific factual statement and (ii) presented a value-science package as indisputable. Further, (iii) the very act of presenting the value-science package created a pragmatic challenge to Emily's interlocutors – putting them in a position where they would have to undertake an unacceptable burden of proof if they would deny the value-science package claim. In the end, this strategy of fusing-presentation-challenge actually worked to make the value-science package a starting point for the rest of the discussion.

Values and science were interwoven in other ways. Bettina (group A) presented a factual scientific statement alongside a value-laden description of some possible macro-social circumstances as being undesirable. She did so in a way that made it appear that there is an indisputable causal link between allowing germ-line gene therapy and unacceptable macro-social circumstances:

A12	Bettina:	In the book it also says […] that if one found out that there were some gene-errors in a foetus and one went there to change it then the diseases that the foetus might have gotten, then they would become much more tabooed; and then those that were born with the disease they would feel that they shouldn't have been alive

By appealing to the authority of 'the book', Bettina used the science fact that the predisposition to hereditary diseases can be removed by using germ-line gene therapy. Bettina, unlike Emily, did not present an evaluative judgement *per se* together with that science fact. But Bettina did point to some undesirable macro-social outcomes of allowing germ-line gene therapy – namely, that such treatable hereditary diseases 'would become much more tabooed,' and, in particular, that the persons who for some reason were not treated would be burdened with guilt. These assertions are not in themselves value-statements, but the implicit undesirability of the outcome (which would be a value-laden claim) leads to a blurring of the fact-value distinction. The interweaving of facts and values in the case of Bettina, unlike in the case of Emily, accomplished to naturalise a link between using germ-line gene therapy and some macro-social consequences that are unacceptable according to a set of values that remained implicit in the argumentation of Bettina's. As such this is a slippery slope argument, which is fallacious unless one explicitly points to the causal mechanisms that make the slope slippery (Govier, 2010). But rather than saying which causal mechanisms would work this way, Bettina made it appear that the causal link is indisputable; and she used that indisputability to challenge her opponents by making it apparent that if one allowed germ-line gene therapy, one would either be logically inconsistent or have an unacceptable burden of proof as to why such macro-social consequences could be tolerated. It is unclear whether it was Bettina's talk turn that successfully established the indisputability of that causal link in discussion A, but it is a recurrent theme in the discussion of the group, and she did actually consistently use the apparent indisputability of the causal link in the discussion: e.g.

A306	Bettina:	[…] if it is the case that one can go in and change whether one's child should be homosexual or not; then it becomes a giant taboo for the others

In cases such as Emily and Bettina's evaluative judgments are explicitly interwoven with science factual claims. The focus of the next sections will be on more complex instances of how facts and values were combined.

3.3.2.3 The conjunction of scientific statements and confrontation

Talk turns in which the speaker exposes, defines or explains a science concept (e.g. phrases such as 'germ-line gene therapy is about changing the genes of the zygotes') enjoy a special status. Such talk turns are not in themselves arguments (Govier, 2010). They typically consist of speech acts such as declarations (e.g. 'No, I was talking about germ-line cells', 'force is that which causes a body to accelerate') and often only contribute to argumentation by enhancing 'the understanding of other relevant speech acts' (van Eemeren & Grootendorst, 2004, p. 66). But in some cases explanations of science concepts had argumentative purposes in talk sequence in which they were located. The students in this study at times injected evaluative terms into their explanations of science concepts. Gilbert (1997) has argued that expressive message declarations – such as 'it's as if one makes a decision on behalf of one's future children' (Connie, A195) – 'can lead and turn the argumentation in ways that might not have been anticipated' (Gilbert, 1997, p. 5). In other words, such expressive declarations are devices that speakers can use to design issues.

Betsy from group B undertook to explain to Andrea exactly what germ-line gene therapy is:

B149	Betsy:	It is the germ-line cell of a mother and a father. Then you go in and mate them and then you say okay there is a disease here that might kill them when they are 17 so that if there is one can maybe remove that disease and they can live without dying when they are 17

Abstracted from its context, the turn seems to be merely an explanation – not an argument. Also, it is not obvious that Betsy fused the science content with evaluative terms. Betsy, rather, gave a (relatively fitting) factual account of how germ-line gene therapy works and what it can be used for – namely that the technology 'can maybe remove' diseases that otherwise would 'kill' patients 'when they are 17'. But notice how Betsy *chose* to exemplify the workings of germ-line gene therapy. The example that Betsy chose (i.e. removing diseases that kill you when you are 17) was not arbitrary; she used it recurrently: e.g.

B91	Betsy:	it would still be great if one could remove those diseases like for example cystic fibrosis so that there aren't people who go around and die from it when they are 17

Judging from the context of Betsy's turn 149, it becomes clear that Betsy was, in fact, arguing. For in the following turn she pointed to Dwight and said:

B151	Betsy:	And that's what he ((points to Dwight)) thinks that one is not allowed to do

It now becomes clear that when Betsy presented her explanation she laid the groundwork for a challenge to Dwight – who at that time was strictly opposed to allowing germ-line gene therapy. According to

Betsy, then, Dwight would not take the necessary steps to alleviate patients with diseases that 'kill them when they are 17' and thus stop such patients from 'dying when they are 17' (Betsy, B149). The strategy that Betsy used was to turn the issue about whether or not to allow germ-line gene therapy into an issue about whether or not to rescue some patients from a certain and untimely death.

The strategy of presenting a scientific explanation in conjunction with a value-laden confrontation functions in a similar manner to the strategy that Emily used above: It potentially challenges the opponent with an unacceptable burden of proof if she or he denies the standpoint. One of the reasons that the strategy can be successful might be the factual character of the scientific explanation. For whether or not germ-line gene therapy can be used to remove the genes that makes a person disposed to having these diseases is what Goodwin would call a 'highly determinate' issue in the sense that there is no 'middle ground' – either germ-line gene therapy can do this or it can't (Goodwin, 2002, p. 83). This is not so for the 'germ-line gene therapy'-issue that the group was discussing (i.e. whether or not to allow germ-line gene therapy). The latter issue is significantly less determinate than the former. But Betsy used an explanation of how germ-line gene therapy works as a device that turned the less determinate 'germ-line gene therapy'-issue into an issue about whether or not to help patients. And the latter issue can be presented as if it was highly determinate – in the sense that either you are opposed to rescuing these patients or you are not. The upshot, then, is that Betsy's presentation can be interpreted as a strategy that designs the issue so that it becomes considerably more difficult for Dwight (and others who have a similar standpoint) to argue that germ-line gene therapy should not be allowed.

3.3.2.4 Complex confrontation

The strategy of presenting a scientific explanation in conjunction with a value –laden confrontation can also work in cases where the target of the confrontation is disguised or where the confrontation is implicit. In turn C131, Anita disagreed with Diana's claim in turn C130 that no one objects to 'do research in' germ-line gene therapy:

C130	Diana:	I don't think that there are any who say that one shouldn't do research in [germ-line gene therapy]
C131	Anita:	yes, but I believe there are. I believe that
C132	Christina:	There are those…
C133	Anita:	everything with germ-line cells, there you go in and steal lives in some way if there is anything that goes wrong

In turn C133 Anita used the scientific information that germ-line genetic therapy has consequences for every cell in the resulting person seemingly to provide a reason for her disagreement (i.e. that there are people who object to research in germ-line gene therapy). As will be argued, there are indications in other parts of the discussion that Anita in turn C133 is confronting more than just Diana's standpoint in C130.

How does turn C133 work with respect to turn C130? According to Anita's exposition, it is the nature of germ-line gene therapy that if things go wrong at the level of pre-embryonic engineering there is the risk that the potential embryo will not develop properly (hence the medical engineers would 'steal' the life of that beneficiary). The expression 'steal lives' indicates a specific appeal to emotion but, as it stands, it is unclear that Anita fused science and values explicitly (like Emily did). Notice, 'steal lives' is not necessarily a result of an evaluative judgement about whether or not embryos are persons. Anita could just have referred to a fact she made earlier: that 'if one changes the genes' in the pre-embryonic state it could result in a situation where that beneficiary 'gets an entirely different behaviour' (Anita, C30). Regardless of whether or not Anita (in turn C133) fused science and values into one assertion, her act of presenting that particular exposition of what germ-line gene therapy is could create a pragmatic reason for accepting that there are some who would find germ-line gene therapy research morally objectionable.

Anita's main interlocutors were Diana and Emily, who both to some extent endorsed germ-line gene therapy – or at least that it would be 'stupid to close one's eyes to [its benefits]' (Emily, C71). Anita was consistently opposed to germ-line gene therapy (at least until the very end of the discussion), and her way of reacting to the others' talk about germ-line gene therapy throughout the discussion displayed a particular pattern of presenting the type of exposition found in C133: e.g.

C30	Anita:	one knows the consequences of that germ-line cells, one knows what consequences it has if one changes the genes because, as we talked about yesterday, if one then gets an entirely different behaviour and grows up to be someone entirely different than who one maybe should be

or

C179	Anita:	But the thing, like, is, you see, that one can, after all treat now with these somatic cells, but it's just not permanent, see…

In light of this it is not clear that C133 was designed only as a reason for why Anita thinks Diana was wrong in turn C130. It seems more likely that Anita took Diana's standpoint that no one objects to *research* in germ-line gene therapy as a part of Diana's argumentation for allowing germ-line gene therapy *treatments*. The pattern that Anita displayed suggests that her expositions of what germ-line gene therapy is were part of a co-optive strategy: she redesigned the issue about whether or not to allow germ-line gene therapy into an issue about whether or not to permanently alter the potential beneficiary or even expose the embryo to grave dangers in the process. This strategy makes sense as a reaction to, for example, Emily's attempt to frame the issue about gene therapy as whether or not to cure 'unbelievably horrible diseases.' But the issue that Anita introduced is, as in Betsy's use of confrontation above, seemingly more determinate than the issue about whether or not to allow germ-line gene therapy. For example, it could be conjectured that many people would find it more difficult to approve of 'steal[ing] lives' than to approve of research in germ-line gene therapy.

The upshot of the case of Anita versus Diana (and Emily) is that it is not always obvious what the target of a strategically presented explanation of a science concept is; and that analysts in some cases need to take the dialectics of the entire discussion into account in order to interpret what kind of issue the speaker is designing at a particular point.

3.3.2.5 The use of science to push an ethical stance

The focus has so far been on how specific ways of presenting science factual claims can influence the apparent acceptability of evaluative judgements about particular issues (e.g. the potential of germ-line gene therapy) or even causal processes (e.g. the causal effects of allowing gene therapy). But in some situations science is also used as a device that pushes or reinforces a specific conception of the Good. Dwight and Betsy argued about whether or not to allow somatic gene therapy. Dwight was for using that technology; Betsy was against:

B255	Dwight:	Why do you not want somatic?
B256	Betsy:	There I just have something… when they have become people … when they have become … come out and they are as they are supposed to be, that you should damned not fiddle more with them. No, that, I can't… That, I can't have
B279	Betsy:	[…] when they have become humans

		then there is a reason [Danish: 'mening' is equivocal: could also be 'meaning' or 'purpose'] for it, damn it
B309	Betsy:	[…] it [somatic gene therapy] is to go in and change when they have become humans
B312	Dwight:	But Betsy, you forget that our cells are constantly being changed, because we surround us with radioactive sources all the time. I have a cell phone here ((gestures to his pants pocket))
B318	Dwight:	[…] cancer comes from mutations in the cells, that do that there is a change in genes. Why are we then not allowed to do the same? When people actually agree that cancer mutations are not natural, but for example can happen because you smoke then your chance for mutations increase. Why can't we do it the other way around? And try to treat it in the same way as it comes

According to Betsy, somatic gene therapy should not be allowed because that would be to 'fiddle' with 'people' in a way that is not permissible because they are humans that have 'become' who they are for a reason and should not be 'changed'. Dwight's strategy was to challenge Betsy's argumentation by presenting just how normal it is that cells change as a consequence of interaction with the environment.

Dwight elicited science content in the two turns B312 and B318 (viz. 'our cells are constantly being changed', 'cancer comes from mutations in the cells that do that there is a change in genes', 'cancer mutations […] can happen because you smoke'). He used three particular design choices to challenge Betsy. First, Dwight established that human cells change over time as an indisputable fact, not by simply stating it but by saying that Betsy is forgetting that fact. Short of directly accusing one's opponents of being logically inconsistent, to say that they 'forget' something in their reason is a form of face-saving device. Pragmatically it creates a challenge to the Betsy's standpoint by making it appear that it is just a matter of Betsy realizing the forgotten fact for her to come to Dwight's conclusion (that somatic gene therapy should be allowed). Second, Dwight (in turn B318) says that 'people actually agree that cancer mutations [...] can happen because you smoke'. As with the case of Emily, the stance adverb 'actually' indicated that Dwight insists on the indisputability of the ensuing claim (Tseronis, 2009). Third, Dwight's usage of the pronoun 'people' is revealing: The people he referred to are hardly laypersons. In that sense he insisted on experts agreeing 'that cancer mutations [...] can happen because' of human conduct. As such Dwight *appealed to expert authority* (cf. Goodwin & Honeycutt, 2009). In sum, turns B312 and B318 can be recognized as acts that did more than simply convey scientific information about human cells – they also installed doubt in Betsy's argumentation on account of Betsy missing something obvious and indisputable.

Turn B318 is complicated by the fact that Dwight did two things at once. On the one hand, he provided positive reasons for why somatic gene therapy should be allowed. His argument, in a nutshell, was that somatic gene therapy should be allowed (on some diseases) because doing somatic gene therapy is just the opposite of a normal process of nature. On the other hand, Dwight made further attempts to challenge Betsy's argumentation. Note how he repeated a pattern of (i) putting forward a science statement that is insisted to be indisputable and then (ii) posing a question to Betsy (viz. '[w]hy are we then not allowed to do the same?' and '[w]hy can't we do it the other way around?'). By posing such questions Dwight made it appear that Betsy should have the burden of proof (van Eemeren & Houtlosser, 2002). So instead of simply giving positive reasons for his own standpoint by pointing to how somatic gene therapy mirrors nature, Dwight obliged Betsy to argue in a way that accommodates this mirroring. Dwight, then, made an issue out of whether or not somatic gene therapy is a natural thing to do. And, as in the previous cases, this issue was presented as being more determinate than the original issue about somatic gene therapy.

It is not arbitrary that Dwight turned the issue about whether to allow somatic gene therapy into the issue about whether somatic gene therapy is natural. There are indications in other parts of the discussion that there is more at stake for Dwight than just persuading Betsy and the others that somatic gene therapy should be allowed on certain diseases. At multiple times in the discussion he elicits an ethical worldview according to which the Good corresponds to what is natural and the bad corresponds to what is unnatural:

B49-50	Dwight:	[…] we are purely a product of nature so the thoughts we have now, they are a product of nature. That means that we can principally, seen from nature, not be wrong
B55	Dwight:	[…] To my mind it can't be wrong to really wish to come further scientifically and to say that it is against nature when we are just a product of nature
B399	Dwight:	[Somatic gene therapy] is not unnatural to the same degree [than germ-line gene therapy is]

Dwight's challenge to Betsy's argumentation in turns B312 and B318 can be interpreted as a way of reinforcing that ethical worldview. On this interpretation Dwight used the scientific fact of cell mutation being a constant part of life not just as way of supporting his stance that somatic gene therapy should be allowed (on some diseases), but as a vehicle in a continuous attempt to enforce a sort of ethical naturalism.

3.4 Similarities and Differences in the Presented Usages of Science

This study has shown that when students use science to argue for an evaluative claim it is often not just a matter of conveying information. For the speaker, it is often a matter of demonstrating that her evaluative claim is more solidly supported than the one of her addressees or that the evaluative claim of her addressees is insufficiently supported.

There are some differences between the explored cases. But, as will be argued below, all cases are different manifestations of a general strategy in which the speaker blurs the fact-value distinction for argumentative purposes by presenting science content in conjunction with a value-laden challenge to the interlocutor. The differences between the cases – as suggested by the sub-headings of the preceding section – is primarily in terms of the complexity with which the strategy of blurring the fact-value was carried out (ranging from 'simple' cases where values were fused with factual scientific statements in one assertion to dialectically complex cases where the execution of the strategy happened over a considerable number of talk turns). The differences in terms of complexity indicate that it is not enough merely to observe whether a given utterance has factual and evaluative content because science and values can be interwoven in various ways and to various degrees. Even though a given science factual claim bears no evaluative content it could very well be used in a way that supports adjacent (or implicit) evaluative claims. There is, further, a difference between the cases in the sense of the outcomes of the execution of the strategy of blurring the fact-value distinction. In particular, science can be co-opted (a) to make an evaluation of the technology appear indisputable (e.g. gene therapy can cure 'unbelievably horrible diseases'); (b) to introduce a particular causal link between using the technology and some undesirable consequences as if that link was indisputable (e.g. the diseases that are not treated with gene therapy 'would become much more tabooed'); or (c) to reinforce a particular view of what is natural or a particular conception of what is 'good' (e.g. 'we can principally, seen from nature, not be wrong'). Such differences, both in terms of complexity and pursued outcome, must be kept in mind when researchers or teachers assess students' socio-scientific discourse.

For each of the presented cases it has been shown how the notion of designing issues aids the understanding of the strategies in which science and values are interwoven in a way that blurs the fact-value distinction. Science can be co-opted so as to steer the discussion in a specific direction. This finding is an elaboration of, or comment to, the findings of Lewis and Leach (2006) that the conceptual science knowledge of students determines which aspects they find in a socio-scientific issue and that this in turn determines the attitudes they express (for a similar interpretation see Fowler, Zeidler, & Sadler, 2009). Clearly, it must be correct that science knowledge, for example the knowledge that there are two types of gene therapy and that they differ substantially, is required for a person to identify the difference between the two types of gene therapy *as an issue* that is worth arguing. But, as has been argued in this paper, issues do not just happen to become objects of contention; they are made such objects. And the students in this study did not seem to make such issues in lack of other issues to find. Rather, they used science to design issues so as to feather their own argumentative nests.

Each of the explored cases represents a unique way of designing issues. Nevertheless, all cases display a general pattern or strategy: the speaker presented science content in conjunction with creating a value-laden challenge to the interlocutor. Three affordances of the pattern deserve emphasis. First, a speaker can use the strategy to blur the fact-value distinction so as to make it appear that her value-laden challenge (or any evaluative claim) is authorized by science. In other words, something that should be up for discussion is guised as something beyond every doubt.

Second, the strategy can make it appear that a particular issue is – factually speaking – more important than other issues. If the speakers' challenge to her opponent appears to be authorized by science she can use that authority to make it apparent that her take on what the issue 'really' is, is more firmly grounded in 'the facts' than the issue entertained by her opponent.

Third, the strategy can make it appear that there is a clear answer to the issue at hand. Most science issues, at least at the level of secondary school science, are highly determinate (Goodwin, 2002). In contrast to this there is no clear right or wrong answer to the issue about whether or not to allow gene therapy. However, if a speaker can successfully make it appear that science authorizes that the gene therapy issue is actually an issue about making sure that a group of 17 year olds do not face an untimely death, she would have turned an irresolvable issue into an easy choice. So it is not just that science can make it seem that a particular issue is the "real" issue, the scientification of that issue makes it appear that there is a clear answer to how people should deal with it.

3.5 Limitations

The small-scale nature of this investigation afforded an interpretation of the data in great detail – a potential that was also harnessed by Pouliot (2008) in a study of students' conceptions of socio-scientific issues. Both in terms of scale and purpose this study was exploratory and in that sense it followed the lead of a number of recent qualitative explorative studies on discursive aspects of socio-scientific issues by explicitly not attempting to be generalisable or exhaustive (Albe, 2008; Barrett & Nieswandt, 2010; Lindahl, 2009; Marttunen, 1997; Pouliot, 2008; Sadler, 2006; Sadler & Zeidler, 2005a). The aim was not to count or enumerate the instances in which science factual and evaluative statements were interwoven. There are undoubtedly other ways in which the blurring of the fact-value distinction can be used strategically and such strategies also deserve to be analysed and explained. The type and frequency of a particular kind of strategy will probably vary corresponding to physical context, the question that is being discussed, and the people involved. Further, this study cannot address whether student's level of scientific knowledge had an impact on whether they co-opted science. Goodwin and Honeycutt (2009) found that also scientists also perform appellative argumentative moves when discussing socio-scientific issues with laypersons. So the speaker's level of knowledge seems to underdetermine which way she uses science in discussions. To establish such an impact of different degrees of scientific knowledge future investigated are needed. Finally, it is hard to know the extent to which the results can be generalized without a random sample. This study, however, is not meant to comment on the frequency with which these strategies are used in the general population. Rather, the modest aims of this study were to demonstrate that such strategies exist, describe how they work, and show how they can be used.

3.6 Conclusion and Implication

The most important issue raised by this study is the difficulty of addressing the fact-value distinction in science teaching. There are dimensions of students' socio-scientific argumentation that need to be researched in more detail. It is of course important to focus on students' reasoning abilities in terms of evidence-giving procedures (as documented by Sadler & Zeidler, 2005b), but the findings of this study suggest that following evidence-giving procedures is just one aspect of successful socio-scientific arguing. In dialectical socio-scientific discussions, arguers not only use science to justify their standpoints, they also use science to authorize that certain issues are more central for making a decision than others. If such aspects become the topic of future research, researchers need to apply analytical frameworks that take into account the dialectical aspects of students' argumentation.

Research on students' argumentation in science education has primarily been concerned with the content of science factual utterances. The focus has been on what a student said and which kind of argumentative function (claim, warrant, data, etc.) that propositional content can be interpreted as having. This study has shown that a number of aspects (such as strategies in which science is used in a co-optive fashion) in students' argumentative discourse on socio-scientific issues can only be fully understood through a focus on how the scientific content in utterances plays together with the design of such utterances (i.e. how the content is elicited in the utterance). A conspicuous design choice (e.g. asking a question) is neither arbitrary nor impotent. A focus only on the content (or structure) of argumentation neglects that, in practice, arguers perform speech acts that are designed to *show* (rather than tell) that a standpoint has been adequately argued for.

Using science to make it appear that one's value judgements are to be exempt from criticism is at odds with an arguer's dialectical obligations, if not outright fallacious. In practical contexts of deliberation, it must be case that the reasons that an arguer presents are subject to scrutiny (Kock, 2008). Even though the different co-optive usages of science all had something to do with the naturalistic fallacy (of taking a leap from the descriptive to the normative) they work and look differently, and they are not always immediately obvious.

Scholars who are interested in socio-scientific decision-making as learning activities should take the findings of this study as an emphasis on the complexity of such activities. Even if teachers encourage students to use science argumentatively so as to make evaluative decisions, there are multifarious ways in which science can be used. The findings, in particular, suggest that teachers and science education researchers need to be aware of the complexity with which science and values can be interwoven in such activities. From the perspective of teachers this means that much more work needs to be done in order to sort out how the fact-value distinction should be addressed appropriately. From the perspective of researchers it means a continued negotiation of what they mean when they say that students' should become able to use science on issues from outside science.

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3.8 References

Albe, V. (2008). Students' positions and considerations of scientific evidence about a controversial socioscientific issue. *Science & Education, 17*(8-9), 805-27.

Andrews, R. (2005). Models of argumentation in educational discourse. *Text: Transactions of the Society for Textual Scholarship, 25*(1), 107-27.

Armstrong, D.M. (1997). *A World of States of Affairs*: Cambridge University Press.

Aufschnaiter, C.v., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching, 45*(1), 101-31.

Barrett, S.E., & Nieswandt, M. (2010). Teaching about ethics through socioscientific issues in physics and chemistry: Teacher candidates' beliefs. *Journal of Research in Science Teaching, 47*(4), 380-401.

Brandom, R.B. (1994). *Making It Explicit: Reasoning, Representing, and Discursive Commitment*: Harvard University Press.

Castaneda, H. (1960). On a proposed revolution in logic. *Philosophy of Science*, 279-92.

Clark, D.B., & Sampson, V. (2007). Personally-Seeded Discussions to Scaffold Online Argumentation. *International Journal of Science Education, 29*(3), 253-77.

Cooley, J. (1959). On Mr. Toulmin's revolution in logic. *The Journal of Philosophy, 56*(7), 297-319.

Cowan, J. (1964). The Uses of Argument – An apology for logic. *Mind: A Quarterly Review of Philosophy, 73*(289), 27.

Craig, R., & Tracy, K. (2005). "The issue" in argumentation practice and theory. In F.H. van Eemeren & P. Houtlosser (Eds.), *Argumentation in Practice* (pp. 11-28). Amsterdam: John Benjamins.

Davies, D.S. (2006). Genetic Dilemmas and the Child's Right to an Open Future. In Helga Kuhse & Peter Singer (Eds,), *Bioethics: An Anthology* (pp. 246-256). Oxford: Blackwell Publishing Ltd.

Dawson, C. (2000). Selling snake oil: must science educatorscontinue to promise what they can't deliver. . In RT Cross & P Fensham (Eds.), *In Science andthe citizen for educators and the public*. Melbourne: Arena Publications.

Denzin, N.K., & Lincoln, Y. (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.

Dewey, J. (1981). *The Later Works, 1925–1953*. Carbondale: Southern Illinois University Press.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Duschl, R.A. (2007). Quality Argumentation and Epistemic Criteria. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 159-75). Dordrecht: Springer Netherlands.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse. *Science Education, 88*(6), 915-33.

EU-Commision. (2004). Europe needs more scientists. *Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe*, 1-215.

Feinberg, J. (1980). The Child's Right to an Open Future. In William Aiken & Hugh LaFollette (Eds.). *Whose Child? Children's Rights, Parental Authority and State Power* (pp. 124-53). Totowa (NJ): Littlefield, Adams & Co.

Fowler, S.R., Zeidler, D.L., & Sadler, T.D. (2009). Moral sensitivity in the context of socioscientific issues in high school science students. *International Journal of Science Education, 31*(2), 279-96.

Galvão, C., Reis, P., Freire, S., & Almeida, P. (2010). Enhancing the Popularity and the Relevance of Science Teaching in Portuguese Science Classes. *Research in Science Education*, 1-16.

Gilbert, M.A. (1997). *Prolegomenon to a Pragmatics of Emotion.* Paper presented at the Ontario Society for the Study of Argumentation, Brock University, St. Catherine's, ON. Retrieved from http://www.yorku.ca/gilbert/argthry/argthry/arg-papers/mag1997-prol-emo.pdf.

Goodwin, J. (2000). Comments on 'Rhetoric and Dialectic from the Standpoint of Normative Pragmatics'. *Argumentation, 14*(3), 287-92.

Goodwin, J. (2001). One Question, Two Answers. In H.V. Hansen, C.W. Tindale, J.A. Blair, R.H. Johnson & R.C. Pinto (Eds.), *Argumentation and Its Implications* (pp. 1-17). Windsor, Ontario: Ontario Society for the Study of Argument, CD-ROM, ISBN:0-9683461-2-X, Retrieved from http://www.public.iastate.edu/~goodwin/pubs/goodwinone.pdf.

Goodwin, J. (2002). Designing issues. In F.H. van Eemeren & P. Houtlosser (Eds.), *Dialectic and rhetoric: The warp and woof of argumentation analysis* (pp. 81-96). Amsterdam: Kluwer.

Goodwin, J., & Honeycutt, L. (2009). When Science goes Public: From Technical Arguments to Appeals to Authority. *Studies in Communication Sciences, 9*(2), 19-30.

Govier, T. (2010). *A Practical Study of Argument*. Belmont: Wadsworth Cengage Learning.

Habermas, J. (1984). *The Theory of Communicative Action: Reason and the rationalization of society* (T. McCarthy, Trans.). Boston: Beacon Press.

Hample, D. (1977). The Toulmin model and the syllogism. *Journal of the American Forensic Association, 14*, 1-9.

Hare, R.M. (1952). *The Language of Morals*. Oxford: Clarendon Press.

Harris, J. (1993*).* Is Gene Therapy a Form of Eugenics? *Bioethics*, 7(2-3), 178-87.

Hofstein, A., Kipnis, M., & Kind, P. (2008). Learning in and from Science Laboratories: Enhancing Students' Meta-Cognition and Argumentation Skills. In C.L. Petroselli (Ed.), *Science Education Issues and Developments* (pp. 59-94). New York: Nova Science Publishers.

Holland, S. (2003). *Bioethics. A philosophical Introduction*. Cambridge: Polity.

Innocenti, B. (2006). A normative pragmatic perspective on appealing to emotions in argumentation. *Argumentation, 20*(3), 327-43.

Irwin, A., & Wynne, G. (1996). *Misunderstanding science.* Cambridge: Cambridge University Press.
Jackson, S., & Jacobs, S. (1980). Structure of conversational argument: Pragmatic bases for the enthymeme. *Quarterly Journal of Speech, 66*(3), 251-65.
Jacobs, S. (2000). Rhetoric and dialectic from the standpoint of normative pragmatics. *Argumentation, 14*(3), 261-86.
Jimenez-Aleixandre, M., Rodriguez, A., & Duschl, R. (2000). Doing the lesson or doing science: Argument in high school genetics. *Science Education, 84*(6), 757-92.
Johnson, R.H. (2002). Manifest rationality reconsidered: Reply to my fellow symposiasts. *Argumentation, 16*(3), 311-31.
Kauffeld, F.J. (1998). Presumptions and the distribution of argumentative burdens in acts of proposing and accusing. *Argumentation, 12*(2), 245-66.
Keith, W., & Beard, D. (2008). Toulmin's Rhetorical Logic: What's the Warrant for Warrants? *Philosophy and Rhetoric, 41*(1), 22-50.
Kelly, G., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education, 20*(7), 849-71.
Kerlin, S., McDonald, S., & Kelly, G. (2010). Complexity of Secondary Scientific Data Sources and Students. *International Journal of Science Education, 32*, 1207-25.
Kitcher, P. (2010). The Climate Change Debates. *Science, 328*(5983), 1230-4.
Kock, C. (2008). Dialectical Obligations in Political Debate. *Informal Logic, 27*(3), 223.
Kock, C. (2009). Choice is Not True or False: The Domain of Rhetorical Argumentation. *Argumentation, 23*(1), 61-80.
Kolstø, S.D. (2000). Consensus projects: teaching science for citizenship. *International Journal of Science Education*, *22*(6), 645-64
Kolstø, S.D. (2001). 'To trust or not to trust, . . .'- pupils' ways of judging information encountered in a socio-scientific issue. *International Journal of Science Education, 23*(9), 877-901.
Kolstø, S.D. (2006). Patterns in Students' Argumentation Confronted with a Risk-focused Socio-scientific Issue. *International Journal of Science Education, 28*(14), 1689-716.
Latour, B., & Woolgar, S. (1979). *Laboratory life: the social construction of scientific facts*. Beverly Hills: Sage Publications.
Levinson, R. (2007). *Towards a pedagogical framework for the teaching of controversial socio-scientific issues to secondary school students in the age range 14-19.* University of London., London.
Lewis, J., & Leach, J. (2006). Discussion of Socio-scientific Issues: The role of science knowledge. *International Journal of Science Education, 28*(11), 1267-87.
Lindahl, M.G. (2009). Ethics or Morals: Understanding Students' Values Related to Genetic Tests on Humans. *Science & Education, 18*(10), 1285-311.
Lynch, M. (1982). Closure and disclosure in pre-trial argument. *Human studies, 5*(1), 285-318.

Marttunen, M. (1997). Electronic Mail as a Pedagogical Delivery System: An Analysis of the Learning of Argumentation. *Research in Higher Education, 38*(3), 345-63.

Millar, R. (1997). Science education for democracy. In R. Levinson & J. Thomas (Eds.), *Science Today: Problem or Crisis?* (pp. 87-101). London: Routledge.

Millar, R., & Osborne, J. (1998). *Beyond 2000: science education for the future.* London: King's College London.

Nowell-Smith, P.H. (1954). *Ethics*. Balitmore: Penguin Books.

OECD. (2006). *Assessing, Scientific, Reading and Mathematical Literacy - A Framework for PISA 2006*. Paris: OECD.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: implications for teaching. *International Journal of Science Education*, 21, 745-54

Pouliot, C. (2008). Students' inventory of social actors concerned by the controversy surrounding cellular telephones: A case study. *Science Education, 92*(3), 543-59.

Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. *International Journal of Science Education, 19*(2), 167-82.

Ryder, J. (2001). Identifying Science Understanding for Functional Scientific Literacy. *Studies in Science Education, 36*(1), 1-44.

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-36.

Sadler, T.D. (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education, 17*(4), 323-46.

Sadler, T.D., & Donnelly, L. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463-88.

Sadler, T.D., & Zeidler, D.L. (2003). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education, 88*(1), 4-27.

Sadler, T.D., & Zeidler, D.L. (2004). Negotiating Gene Therapy Controversies. *The American Biology Teacher, 66*(6), 428-33.

Sadler, T.D., & Zeidler, D.L. (2005a). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Resarch in Science Teaching, 42*(1), 112-38.

Sadler, T.D., & Zeidler, D.L. (2005b). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education, 89*(1), 71-93.

Sadler, T.D., & Zeidler, D.L. (2006). Scientific Errors, Atrocities and Blunders. In Dana L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 261-85). Dordrecht: Springer.

Sampson, V., & Clark, D. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92*(3), 447-72.

Searle, J.R. (1969). *Speech Acts: An Essay in the Philosophy of Language*: Cambridge University Press.

Simon, S. (2008). Using Toulmin's Argument Pattern in the evaluation of argumentation in school science. *International Journal of Research & Method in Education, 31*(3), 277-89.

Smith, P.C. (1995). Towards a Discursive Logic: Gadamer and Toulmin on Inquiry and Argument. In L. K. Schmidt (Ed.), *The Specter of Relativsm* (pp. 159-77). Evanston: Northwestern University Press.

Takala, T. (2005). The Many Wrongs of human Reproductive Cloning. In M Häyry, T Takala & P Herissone-Kelly (Eds.), *Bioethics and Social Reality* (pp. 53-66). Amsterdam: Rodolpi.

Thomas, D.R. (2003). A General Inductive Approach for Qualitative Data Analysis. Retrieved from http://www.health.auckland.ac.nz/hrmas/Inductive2003.pdf

Toulmin, S.E. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Trent, J. (1968). Toulmin's model of an argument: An examination and extension. *Quarterly Journal of Speech, 54*(3), 252-9.

Tseronis, A. (2009). *Qualifying standpoints. Stance adverbs as a presentational device for managing the burden of proof.* Utrecht: Netherlands Graduate School of Linguistics.

van Eemeren, F.H., & Grootendorst, R. (1982). The speech acts of arguing and convincing in externalized discussions. *Journal of Pragmatics, 6*(1), 1-24.

van Eemeren, F.H., & Grootendorst, R. (1989). Speech act conditions as tools for reconstructing argumentative discourse. *Argumentation, 3*(4), 367-83.

van Eemeren, F.H., & Grootendorst, R. (2004). *A systematic theory of argumentation: The pragma-dialectical approach*. Cambridge: Cambridge University Press.

van Eemeren, F.H., Grootendorst, R., & Kruiger, T. (1987). *Handbook of Argumentation Theory: a Critical Survey of Classical Backgrounds and Modern Studies.* Dordrecht: Foris.

van Eemeren, F.H., & Houtlosser, P. (2002). Strategic maneuvering with the burden of proof. . In F.H. van Eemeren (Ed.), *Advances in pragma-dialectics* (pp. 13-28). New Port News, VA: Vale Press.

van Eemeren, F.H., & Houtlosser, P. (2007). The study of argumentation as normative pragmatics. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 15*(1), 161-77.

van Eemeren, F.H., Houtlosser, P., & Henkemans, A.F.S. (2007). *Argumentative indicators in discourse: a pragma-dialectical study*. Dordrecht: Springer.

Walker, K., & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-410.

Wilkinson, S. (2010). On the distinction between positive and negative eugenics. In M Häyry, T Takala & P Herissone-Kelly (Eds.), *Arguments and Analysis in Bioethics* (pp. 115-28). Amsterdam: Rodolpi.

Yin, R.K. (2009). *Case Stuy Research. Design and Methods*. Thousand Oaks: Sage.

Zeidler, D.L., Osborne, J., Erduran, S., Simon, S., & Monk, M. (2006). The Role of Argument During Discourse About Socioscientific Issues. In Dana L.

Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 97-116). Dordrecht: Springer.

Zeidler, D.L., Sadler, T.D., Simmons, M.L., & Howes, E. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education, 89*(3), 357-77.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.

4

Paper III

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Science in Discussions:
An analysis of the use of science content in socio-scientific discussions

This paper presents a normative pragmatics analysis of students' use of science content in eight socio-scientific group discussions about human gene therapy. The specific focus of the paper is on the argumentative role that invocations of science had in the dialectics of the discussions. The analysis suggests that science content occasionally played an informative role in attempts to establish the factual background of parts of the deliberations, but that speakers often invoked science content creatively and selectively in argumentative strategies that aligned with an attempt to frame the issue of the discussion in ways that were favorable for the speaker. The paper aims at explaining how strategies that contained invocations of science worked pragmatically in the dialectical context of the discussions. The findings are discussed in relation to previous findings in the science education community as well as to more general questions pertaining to how science fits into socio-scientific discussions in which the arguers deliberate about what to do, not just what is true.
Keywords: socio-scientific issues, argumentation, science education, small group discussions, pragmatics

4.1 Introduction

Students' deliberations and discussions about socio-scientific issues (i.e. societal, ethical, and political issues that relate to science) are central research objects in science education (Albe, 2008; Kolstø, 2006; Sadler, 2004; Zeidler, Osborne, Erduran, Simon, & Monk, 2006). Socio-scientific activities have been documented to, among many things, grant students access to science content (Galvão, Reis, Freire, & Almeida, 2010) and to invite students to engage in argumentation (Walker & Zeidler, 2007). However, the most forceful justification for placing socio-scientific activities on the agenda is that they epitomize a key goal of science education: Enabling students to make decisions that are *informed by science* on real-life issues (Ryder, 2001). In this rhetoric, great value is placed on the use of science as 'evidence' and on 'evidence-based' decisions on such issues (Sadler, 2006; Zeidler, Sadler, Simmons, & Howes, 2005). It is difficult to disagree with this evaluation. As Kitcher (2010) has argued, "expert opinion" and "informed views" are necessary for tackling with the technical issues that societies face (p. 1231). It seems intuitive that an *informed* socio-*scientific* decision necessarily draws on scientific information. However, it is unclear (from a theoretical perspective) what it means to invoke scientific evidence *felicitously* in socio-scientific deliberations (Author, in press a). Further, it is unclear how teachers should best assess the manner in which students invoke scientific evidence, beyond assessing the quality of the invoked science content. From an *a priori* perspective, socio-scientific deliberations (e.g. about whether human gene therapy should be allowed) are deliberations about what to *do*, not just what is *true*. In other words, socio-scientific argumentation is primarily *practical* argumentation (Kock, 2009): Socio-scientific decisions are not simply inferred from a range of factual premises; they will always reflect the ideological and personal principles to which the deciding party adheres. Thus, socio-scientific decisions are essentially *political* products – this is, at least, the *de facto* nature of socio-scientific decisions within the present bifurcation of society. [1] So the key challenge for science education researchers would be to conceptualize exactly which role scientific evidence could have in socio-scientific discussions. By parity, the community lacks a clear conceptualization of what the goals of socio-scientific activities are (from an argumentative perspective) and of how such activities should be assessed.

While this paper does not aspire to present such an ambitious account, it does take the modest first step of inviting, and possibly informing, future accounts. The study presented here investigated how 16-19-year old students invoked science content in eight group discussions about whether human gene therapy should be allowed. The primary aim was to interpret the argumentative role of talk turns that featured science content and how such invocations of science played into the dialectics of the discussions.

[1] For the idea of a bifurcation of society into science and politics see Latour (2004)

4.1.1 Socio-scientific Deliberations and Science Content

Coarsely put, studies of science content in socio-scientific deliberations have fallen into one of two categories. On the one hand, some studies have focused on the *presence and quality* of science content *in* socio-scientific deliberations (e.g. Albe, 2007; Dawson & Taylor, 1999; Fleming, 1986; Grace & Ratcliffe, 2002; Levinson, 2004; Ratcliffe, 1997; Sadler & Donnelly, 2006; Sadler & Fowler, 2006; Sadler & Zeidler, 2003; Simon & Amos, 2011). On the other hand, some studies have focused on the extent to which students' science knowledge, or knowledge about science, *determines the quality* of their socio-scientific deliberations (e.g. Bell & Lederman, 2003; Lewis & Leach, 2006; Ryder, 2001; Sadler & Fowler, 2006; Sadler & Zeidler, 2005b).

It is a resilient finding that students rarely invoke science content in socio-scientific deliberation, and that students generally rely more heavily on societal, ethical, or economical factors, than on scientific evidence. For example, Ratcliffe (1997) found that 15-year old boys only applied school science "with modest frequency" in socio-scientific discussions, and that science information played an even lesser role in written reports. The use of scientific information was scarce, even though the students were directed deliberately and explicitly to clarify the scientific information that could be salient to their decision-making. Ratcliffe's (1997) findings may suggest that it is difficult for students to thematise and apply previously constructed science knowledge in other contexts, or, at least, that students tend to opt for a focus on value laden societal aspects of socio-scientific issues. In a later study, Grace and Ratcliffe (2002) found that the usage of science might increase in contexts where the primary issue is more transparently linked to school science content (cf. p. 1165). But they also found that students placed significantly more weight on criteria that stem from values in their socio-scientific decision-making.

Albe (2007) investigated the content of socio-scientific arguments – and how they were elaborated – in two groups of 16- to 18-year old students, who were engaged in a role-play. Her findings indicate that it was a challenging task for students to partake in such an activity. First, while one group managed to articulate their disagreement they did not manage to resolve it – in part because "the objective of the activity for some students clearly [was] to win the case" (p. 394) – the other group predominantly "co-elaborated" their arguments and rarely articulated their disagreement. Second, while the students were both motivated and focused on the elaboration of arguments, it was demanding for them to adopt a critically reflective stance towards scientific evidence and apply that in the elaboration of socio-scientific arguments. Indeed, the students' arguments "rarely implied" scientific knowledge (p. 399).

Walker and Zeidler (2007) found that while a web-based inquiry-focused scaffold may encourage students from grade 9-12 to elicit factual evidence in socio-scientific deliberations, these students did not do so in a critical reflective manner. This fact "ultimately led into numerous instances of fallacious reasoning and personal attacks" (p. 1403). And though "the majority of the students' answers reflected recognition of the tentative, creative, subjective, and social aspects of science" (p. 1404), they did not apply that understanding in their socio-scientific deliberations.

Simon and Amos (2011) investigated how 14-15-year old students interacted with background scientific information in socio-scientific discussions, and how the students argumentatively managed the decision-making process. They found that the students' arguments featured much more environmental evidence than scientific evidence, and that the students "diluted the scientific content" by using "less precise terms" in their argumentation (p. 181). Further, the students tended not to question the scientific information they had been given, and they tended not to consider positions that were alternative to their own. In general, Simon and Amos (2011) found that "[s]tudents' abilities to use and understand scientific concepts and terms during discussion activities were questionable" (p. 190).

Thus, the studies that have focused on presence and quality of science content in socio-scientific deliberations generally indicate that students tend to rely on other factors than scientific information and that the quality of the science content, which is used, is problematic.

The second category of studies is related to a more general focus on how the construction of an appropriate understanding of a scientific concept influences how a student articulates or manages that concept in various activities (e.g. Hogan, 2002; Tytler, 2001; Zeidler & Schafer, 1984). For example, Sadler and Zeidler (2005b) and Lewis and Leach (2006) documented that students' level of conceptual understanding predetermines the quality of their socio-scientific reasoning. Lewis and Leach (2006) argued that the conceptual science knowledge of students determines the range of aspects or factors they identify in a socio-scientific issue, and that this, in turn, determines the attitudes they express. In particular, they found that students who had not constructed an understanding of the difference between germ-line and somatic gene therapy would not have access to a wide range of potential issues concerning gene therapy. Further, Lewis and Leach (2006) argued that if students understood even a limited number of very basic science concepts and facts, it would be beneficial for the quality of socio-scientific deliberations.

Other studies suggest that content knowledge is not the only determining factor. For example, Ryder (2001) analyzed of a range of contexts in which laypersons interacted with issues related to science; and he concluded that the quality of such interactions relied on not only the laypersons' understanding and application of the basic science content involved, but also on the laypersons' understanding of the epistemology of science. Sadler and Fowler (2006) investigated how high school students, non-science majors, and science majors invoked genetics knowledge as evidence in socio-scientific argumentation. Among other things, they found that "[w]hile the use of content knowledge varied among the groups, the basic arguments offered by all three groups tended to focus on sociomoral aspects of [socio-scientific issues]" (p. 997). Further, there was a significant difference in terms of argument quality across groups, which according to Sadler and Fowler (2006) was a result both of students' understanding of basic genetics content as well as of the appropriation of a "schema" that allows students to "transfer knowledge" (p. 1001).

Thus the investigations that have focused on how science knowledge or knowledge about science influences socio-scientific deliberations indicate that content knowledge, knowledge of the epistemology of science, and generic transfer schemas may predetermine the quality of socio-scientific decision-making. But the two categories of studies carve out a niche, which is yet to be explored in detail: When students *do* use scientific content, what role do such usages have *in the dialectical process* of socio-scientific deliberations?

In a recent study, Orlander Arvola and Lundegård (2011) broached that issue by investigating how 15-year old students create *displacements* – i.e. how students "interfere and expand upon meanings" of science concepts in new and possibly unexpected ways (p. 5) – in socio-scientific classroom argumentation about abortion. While they found that there was a paucity of science in the classroom discussions, they were able to interpret that, *when* students use science, they did so because they deemed it necessary to "clarify their own standpoint" (p. 21). Such findings indicate that while students may not use much science in socio-scientific argumentation, they *can* engage in socio-scientific argumentation in ways that are meaningful for them and they *can* use science in specific ways that suits their argumentative goals. This is resonant with previous preliminary reports from the present project were it was argued that students can and do interweave science factual statements and evaluative judgments to feather their own argumentative nests (Author, in press a). However, a general investigation of the dialectical role of science in socio-scientific deliberation is needed. In particular, Orlander Arvola and Lundgård's (2011) study of classroom interaction needs to be paralleled with investigations of socio-scientific deliberations in small group discussions. The research question of this study is therefore the following: *What argumentative roles do invocations of science content have* *in students' group discussions about a controversial socio-scientific issue, and what effects on the dialectics of the discussion do such invocations have*?

4.2 Theoretical Background

4.2.1 Socio-scientific argumentation

Researchers have predominantly investigated students' socio-scientific discussions through the lens of (informal) argumentation (e.g. Kolstø, 2001, 2006; Patronis, Potari, & Spiliotopoulou, 1999; Sadler, 2004; Zeidler, et al., 2006). The rationale has been that the science content in many socio-scientific contexts is so complex (Ryder, 2001) and tentative (Millar, 1997) that it is best implemented through a focus on informal argumentation, allowing students to "formulate positions, and provide supporting evidence" (Sadler, 2004, p. 515).

Until recently, most studies have applied adjustments of Toulmin's (1958) framework for arguments (e.g. Kolstø, 2006; Osborne, Erduran, & Simon, 2004; Sadler, 2004; Sadler & Donnelly, 2006; Sadler & Zeidler, 2005a; Shea, Duncan, & Stephenson, 2011; Simon & Amos, 2011; Wishart, Green, Joubert, & Triggs, 2011) – drawing on applications of Toulmin's model within psychology (Kuhn, 1991; Pontecorvo & Girardet, 1993). Thus, the focus has primarily been on the (informal) *logical function* of statements in argument patterns – for example, the different functions of data, claim, or rebuttal. As has been argued, the focus on the logical function of statements in argument patterns may be too narrow: Important discursive aspects seem to become lost in translation when analysts use Toulminian frameworks to ascertain the logical function of a given statement (e.g. Duschl, 2007; Hofstein, Kipnis, & Kind, 2008; Naylor, Keogh, & Downing, 2007; Walker & Zeidler, 2007). Indeed there is a trade-off between logical function and dialectical situation. While the Toulmin model explicitly focuses on how "arguments sentence by sentence" justify conclusions (Toulmin, 1958, p. 88), the model has no means to conceptualize the practical process through which persons reach conclusions, make decisions, or resolve disagreements (e.g. Fulkerson, 1996; Johnson, 1995; Walton & Godden, 2007; Willard, 1976; Wohlrapp, 1987). In particular, Toulminian analysis of discussions necessarily reduces the dialectical interactive discussion process to monological chains of reasoning (Habermas, 1984; Johnson, 2002; Lynch, 1982; Smith, 1995; van Eemeren, Grootendorst, & Kruiger, 1987). The criticism of the Toulmin model has, of coursed, been noticed in science education (see e.g. Erduran, 2007; Duschl, 2007; Author, in press c).

There are ample *a priori* as well as contingent reasons for investigating the dialectical features of students' socio-scientific deliberations. Dating back to Aristotle (*Topics*, 1997), dialectical argumentation has been understood as a type of arguing for and against a standpoint, which arguers resort to when that standpoint cannot be *inferred* from a range of premises (cf. Beard, 2003; van Eemeren, et al., 1987; Walton, 2000). Socio-scientific deliberations – as deliberations about what to *do* – would *ipso facto* have to be categorized under dialectical argumentation. Further, the science education community has given overwhelming attention to student argumentation. That attention is solidly rooted in the notion that it can enable students to collaboratively argue for and against forwarded claims, and that this can have positive educational effects (e.g. Clark & Sampson, 2008; Driver, Newton, & Osborne, 2000; Duschl, 2007; Erduran, 2007; Munneke, van Amelsvoort, & Andriessen, 2003; Osborne, et al., 2004). Consequently, this study adopted an approach to argumentation – *normative pragmatics* – that explicitly afforded a dialectical lens.

4.2.2 Normative Pragmatics

Normative pragmatics – or 'design theory' – is a generic framework within argumentation theory and philosophy (Goodwin, 2000; Jacobs, 2000; van Eemeren & Houtlosser, 2007). In its most general form, normative pragmatics is the study of the *practical significance* of linguistic performances in argumentative interactions – where such performances have a normative dimension (Blair, 2006; Brandom, 1994). In normative pragmatics, argumentation is understood as a way of managing disagreement, in which arguers use language in order to influence each other's decisions (Goodwin, 2001). Arguers attempt to make their interlocutors *do* something (e.g. acknowledge their standpoint, provide more reasons, clarify what they said before etc.) through the design of messages that have specific contents (what is being said?) and designs (how is it being said?). Both aspects must be taken into account in the analysis (Jacobs, 2000), because design choices can have argumentative effects: Content that is delivered in the form of a question, for example, can affect the dialectics by shifting the burden of proof (van Eemeren, Houtlosser, & Snoeck Henkemans, 2007), and emotive adjectives can steer the argumentation in specific directions (Gilbert, 1997).

The distinction between content and design is roughly similar to Searle's (1969) distinction between the propositional content of an utterance and the act in which that content is elicited (Jackson & Jacobs, 1980). Some versions of normative pragmatics – such as pragma-dialectics – hold that a speaker's argumentation must have the illocutionary effect of bringing about that the interlocutor realizes that the speaker is presenting argumentation, and that argumentation always involves the speaker's attempt to bring about the perlocutionary effect of influencing the decisions of her interlocutor (van Eemeren & Grootendorst, 1982).

An arguer faces a number of "practical difficulties" – such as "[securing] the adequacy of her premises" (Goodwin, 2005, p. 100). In order to cope with these difficulties, she will have to use *strategies* that potentially have the practical significance to make it explicit to her interlocutor that she has, for example, adequately justified her standpoint (see also Brandom, 1994; van Eemeren & Houtlosser, 2002). While some strategies are rudimental – such as the strategy of providing reasons for a standpoint – others are more complex – such as the strategy of accusing: By accusing an interlocutor the speaker not only requests that the accused explain her position, but also implies that her position is wrong (Kauffeld, 1998). The key is that arguers can construct messages in ways that create *pragmatic reasons*. In such cases, the very act of eliciting a message creates a reason for the interlocutor to do something (e.g. acknowledge the adequacy of a premise) (Innocenti, 2006). The goal of normative pragmatics analysis is to identify such "strategies as strategies [and] explain how an arguer's utterance of some words can be expected to accomplish things like the imposition of probative burdens" (Goodwin, 2001, p. 9).

Framing or *designing* the issue is an important tool for influencing the decisions of others (Goodwin, 2002). The notion of framing the issue is commonly defined as a speaker's attempt to

> select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described (Entman, 1993, p. 52).

The abortion debate is a well-known case in which the original issue of whether to allow abortion has been framed either as whether to be pro-life or as whether to be pro-choice (Craig & Tracy, 2005). Framing issues in such ways can have argumentative effects on the decisions of one's interlocutors – "(often small) changes in the presentation of an issue or an event produce (sometimes large) changes of opinion" (Chong & Druckman, 2007, p. 104).

4.3 Methods

4.3.1 Research Design and Context

This study was a multiple case study (Stake, 2006; Yin, 2009) with a singular (universal) research question. It involved eight socio-scientific group discussions among four or five students (age 16-19) who discussed for 35-60 minutes about whether human gene therapy should be allowed. The groups discussed in isolation and they were interrupted by their teacher only towards the end of the discussion activity. The groups were formed based on the students' answers to an online questionnaire regarding general bioethical issues to increase the possibility of heterogeneous standpoints (Clark, D'angelo, & Menekse, 2009; Leitão, 2000).

Immediately before the activity the students received, a written material entitled "Gene Therapy – A Dilemma for the Future?" – an adjusted version of a teaching materials developed by Sadler and Zeidler (2004). The material gave a short systematic description of gene therapy research and its history. As such, the material is highly flexible in the sense that it can be applied in many contexts across groups with varying prior knowledge. Further, the material projects four archetypical positions towards gene therapy based on authentic statements from participants in the public debate in the US. The students were to decide on future legislation regarding human gene therapy (see also Author, 2010; in press a). To recall, *gene therapy on germ-line cells involves engineered changes that are heritable and persist throughout the lifespan of the beneficiary, whereas gene therapy on somatic (bodily) cells involves engineered changes that are not heritable and disappear with the affected cells.* This was the concrete task description:

> You must collaboratively try to reach an agreement about what you would advice the section [for bio-medicine and human rights in EU] to do. This means that you must try to reach a decision that all of you can vouch for. […] Remember to make it clear how your decision can be supported and be sufficiently detailed in your decision.

The discussion activity did not aim at *teaching* genetics. Rather, the aim was to allow students to *apply* already constructed knowledge on a controversial issue. Thus the written material was purely intended as a scaffolding device for the discussion process.

The study involved students from three biology classes from two Danish upper secondary schools – one rural and one urban. The activity was implemented in the context of mid-level biology (Biology B). This is a course which (among other things) "contributes to the human's understanding of it self as biological organism and as societal citizen – and which provides the disciplinary background for the development of responsibility, decision-making, and action with respect to present societal conditions with a biological content" (Danish Ministry of Education, 2010). The three teachers treated the discussion activity as a conclusion to their standard course on genetics – thus, the course, which led up to the discussion activity, was not explicitly socio-scientific. Within the context of this study, preliminary reports have been given on more specific aspects of the students' discussion (Nielsen, 2010; To appear a [Paper II]; To appear b [Paper I]).

4.3.2 Analysis Process

Elements of normative pragmatics have been applied on cases of scientific experts' interactions with laypersons (Goodwin & Honeycutt, 2009), seminal historical speeches (Innocenti, 2006), the argumentative effects of advertisements (Jacobs, 2000), and public participations at school board meetings (Craig & Tracy, 2005). In all these reports, a thorough analysis of the case adopted center stage. However, there is no universally formulated procedure for conducting normative pragmatics analysis.

The analysis of the transcribed discussions was done in four steps. This scaffolded and regimented the analysis process. First, talk turns in which the speaker expressed, alluded to, or in other ways represented science content were indexed as *science talk turns*. Second, multiple iterations of open (inductive) coding (Denzin & Lincoln, 1994; Thomas, 2003) led to the identification of *thematic issues* for each discussion. In this step, sequences of talk turns were identified and demarcated in terms of what the issues or object of contentions were. The issues that emerged recurrently and that were discussed at length, were interpreted as thematic issues. For example, in all groups it became a thematic issue to discuss whether parents should be allowed to design their babies (labeled ‘ the designer baby issue’; see also the next section). The first two analytical steps did not aim at elaborating the research question *per* se. They, rather, served as scaffolds for the ensuing normative pragmatics analysis.

Third, sequences that contained science talk turns were analyzed from a normative pragmatics perspective in order to establish an interpretation of what local argumentative role a given science talk turn had in the dialectics of the sequence. The normative pragmatics analysis was guided by the identification of a number of possibly salient aspects:

(1) The type of argumentative *speech act* that the speaker performed (van Eemeren & Grootendorst, 1989). For example, questions (directives) and assertives usually have different argumentative functions (van Eemeren & Grootendorst, 2004).

(2) The types of *argumentative indicators* used by the speaker (cf. Katriel & Dascal, 1984; Snoeck Henkemans, 1996; van Eemeren & Grootendorst, 1982; van Eemeren, et al., 2007; Walton & Krabbe, 1995). For example, while ‘yes, but…’ and ‘I don’t think so’ could indicate doubt or disagreement of different strength, locutions such as ‘how do you mean?’ and ‘why is that so?’ could indicate requests for clarification or justification.

(3) Other design choices made by the speaker such as the use of *pronouns* (Goodwin & Honeycutt, 2009), *adjectives* (Gilbert, 1997), *stance adverbs* (Tseronis, 2009), and *interjections* (Blakemore, 1987; Fraser, 1990; Jaszczolt, 2002).

(4) Scorekeeping of the *commitments* and *entitlements* of the participants as a function of their overtly elicited messages (Brandom, 1994). This involves comparing

> what a student says to what she has previously said. For example, if a student at one point asserts that she thinks that we should do everything in our power to alleviate diseases –regardless of our moral scruples – she would commit herself to a certain extend; in particular, at a later stage she would not be able to coherently assert that some forms of treatment should never be allowed.

These aspects formed the basis of a normative pragmatics interpretation of the local *dialectical relevance* of a science talk turn. A distinction was made between two forms of relevance. On the one hand, a science talk turn could have "information-relevance" in the sense that it conveyed scientific information that *potentially* could be used for, for example, establishing the acceptability of a standpoint. On the other hand, it could have "pragmatic relevance" in the sense that scientific information was *used* in order to "justify or refute a contested standpoint" (Jacobs & Jackson, 1992, p. 162).

The normative pragmatics analysis was conducted in a hermeneutical manner. Since the first step provided an overview of which talk turns featured science content, and since the second step provided a dialectical overview of the discussions, it was possible to identify candidate sequences that could be of interest. These sequences were the first to be subjected to normative pragmatics analysis. Subsequently, attempts were made to identify similar sequences in the discussions. The analysis of these sequences, in turn, could reveal different dialectical roles of science, which resulted in a new search for sequences (in all discussions) with similar features and so on. In the preliminary stages of the analysis, parts of the normative pragmatics analysis were shared with and critiqued by an argumentation scholar who had extensive experience with normative pragmatics analysis (see Author, in press a).

In the fourth, and final, analytical step the normative pragmatics interpretation of the local role of a given science talk turn was understood and interpreted against the background of the overall thematic dialectic of the discussion. Often the fourth and third analytical steps were made in parallel.

4.4 Analysis and Findings

While all groups eventually decided to take a positive stance towards somatic gene therapy (albeit with caveats that generally concerned which diseases the treatment should be applied on), there was much disagreement about germ-line gene therapy. Four groups (A1, A3, B1, and C3) eventually agreed to allow germ-line gene therapy with substantial caveats; the remaining groups (A2, B2, C1, and C2) agreed to reject it. In two of the groups that decided not to allow germ-line gene therapy (C1 and C2), all participants appeared to agree during much of the discussion. In these two groups, the participants often spent time reinforcing their shared arguments against allowing germ-line gene therapy and co-elaborating their arguments against a fictitious opponent. Occasionally some participants briefly adopted a 'devil's advocate'-role. In the remaining six groups, the final decisions meant that at least one person needed to make considerable compromises.

Four issues were coded as *thematic* issues: These issues emerged recurrently and typically required substantial discussion real estate (in terms of talk turns and time):

- The '*designer baby*'-issue issue corresponded to the perennial concern in bioethics that allowing germ-line gene therapy could be a slippery slope towards a scenario in which parents purposefully engineer multifarious traits of their future child (e.g. Holm & Takala, 2007; Post, 1993). The primary concern was that engineered changes would eventually not just target severe hereditary disease; and whether such a scenario would be ethically permissible.

- The '*genetic elite*'-issue pertained to whether allowing germ-line gene therapy would be a slippery slope towards a scenario in which a powerful elite can reproduce and amplify their status as an elite. As in the scholarly debate in bioethics (Harris, 1993; Reindal, 2000), this issue often involved considerations about eugenics and vicious attempts to create a perfect race.

- The '*closed future*'-issue pertained to whether it would be ethically permissible to decide on behalf of beneficiaries of germ-line gene therapy – that is, a person's right to an "open future" (Feinberg, 1980) may be violated. The concern was that autonomous choices of, for example, parents or societal institutions might severely limit the autonomy of the beneficiary (e.g. Davies, 2006; Takala, 2005).

- The '*legitimate disease*'-issue corresponded to the perennial issue in bioethics about the legitimate targets of germ-line gene therapy and somatic gene therapy (e.g. Rabino, 2003). While some diseases may in the future be cured, or removed completely, using gene therapy, some conditions, such as minor discomforts, should maybe not be legitimate targets of gene therapy.

Thus, the participants reproduced what bioethics scholars consider the core bioethical concerns about human genetics research (Holland, 2003; Wilkinson, 2010). While the thematic issues are formulated as potential arguments against germ-line gene therapy, they also contained arguments – from some participants – in favor of germ-line gene therapy. The thematic issues were forums for a dialectical pro- and contra-argumentation about germ-line gene therapy (and in some cases gene therapy, in general). However, this is an important point: Arguments in favor for germ-line gene therapy were usually made in response to someone voicing concerns about germ-line gene therapy. In other words, while many participants did express that germ-line gene therapy has considerable benefits, these expressions rarely occurred outside of a context in which the potential negative aspects of allowing germ-line gene therapy were discussed. This is resonant with Harris's (1993) argument that even if one holds that gene therapy is ethically sound, it is still necessary to discuss the thematic issues outlined above.

The *global primary issue* for all discussions – as set by the task description – was to which extent human gene therapy should be allowed as a treatment. In order to make a decision on that issue, the participants raised a number of issues that were *subordinate* to the global primary issue. While issues such as the '*designer baby*'-issue were subordinate to the global primary issue, they themselves became primary issues *in the local context*; and just like the global primary issue, the local primary issues involved the introduction of local subordinate issues. For example, in group A3's discussion of the 'designer baby'-issue the participants began to discuss whether extensive control of a future child's appearances would go against human evolution in the sense that the beneficiary would not be able to "live within [it's] surroundings" (Angelica, 194 A3). This, in turn, led the participants to raise a further local subordinate issue about the effect of human evolution on appearance features. Elliot, in particular, questioned whether the scenario of unfit beneficiaries of germ-line gene therapy would be relevant, because these beneficiaries would "just have to mutate again" to fit into their environment (200 A3). Thus negotiating the factual background of human evolution became instrumental for managing potential disagreement about the 'designer baby'-issue in group A3.

4.4.1 Different Ways of Representing Science Content

Roughly put, science content was represented in either of three ways: (i) *explicit expressions* of science content; (ii) *assertive expressions* of science content; and (iii) expressions with *implicit science content*. (This sub-section focuses on science content that was subordinate to a local primary issue of a non-science character; the next sub-section focuses on science content in local primary issues.)

4.4.1.1 Explicit expressions of science

An example of a talk turn that explicitly contained a science factual claim or statement is Blanche's turn 88-90 C1:

85 C1 April:	Because in the extreme then it just ends with humanity being similar, you see … a reproduction of some perfect human=
86 C1 Blanche:	Yes
87 C1 April:	=and that everyone suddenly looks like each other
88 C1 Blanche:	But for example that about the two girls who were treated because they overproduced that there amino acid … if it went in and helped them, well, then I just think that one should be allowed to=
89 C1 Chahna:	to do it
90 C1 Blanche:	=to do that gene therapy on them because they were cured by it, you see

Here Blanche expressed a science content: That gene therapy has had positive effects on two patients who produced too much amino acid. This science content had relevance beyond that of conveying information: It had local *pragmatic relevance* because Blanche immediately *used* that stated fact as a support for the acceptability of her position that somatic gene therapy should be allowed in some cases or contexts (a position she held continuously in the discussion). This interpretation is warranted by the fact that Blanche began her talk turn with the discourse connective 'but' (Danish: 'men'), which typically indicates that the speaker minimally withholds endorsement of the previous claim of the interlocutor; further Blanche's second use of 'because' (Danish: 'fordi') provides indications of the structure of her argument (Snoeck Henkemans, 1992; van Eemeren, et al., 2007). A key observation about the case of Blanche is that the science content that she explicitly expressed played a supporting role in her attempt to divert or steer the discussion. April's attempt to frame or *design* the issue in terms of eugenics – of whether or not to allow a scenario of creating a "perfect human" (85 C1) – was effectively obstructed by Blanche's attempt to frame or design the issue in terms of helping specific patients. The strength of Blanche's move in 88-90 C1 was very much an effect of her explicit expression of science factual knowledge. For, at face value, April would now have to either argue against the validity of the scientific statement of Blanche's or somehow answer exactly why it should be permissible to reject gene therapy – keeping in mind that this would be tantamount to reject to help the patients in question.

Occasionally explicit expressions of science content appeared to have only information-relevance:

119 A3 Angelica:	I know that they have found a new vaccine that cures against nine viruses against cervical cancer where one before only had four and the new that they are about to find out whether it works am I actually participating in as a research subject. There one goes in and looks whether it gives better results than the first one, so they have went in and looked at different … what do they call it … well viruses that go in and change the structure of cells in the ovaries or the cervix […]

Here Angelica provided an account of medical trials on cervical cancer vaccines. The issue about cervical cancer vaccines was introduced as a subordinate issue to a local primary issue about how potential medical trials on gene therapy ought to be regulated. As such, the science content that Angelica expressed in 119 A3 played an informative role in the sense that she *locally* elaborated upon the factual background for the issue about regulating medical research. However, a closer look on the ensuing part of the sequence reveals that Angelica's turn 119 A3 may also have had pragmatic relevance:

127 A3 Angelica:	[…] but there is something about the new vaccine that is damned good that maybe can go in and prevent cancer well that is completely great, see
128 A3 Elliot:	It would be damned great if one could…
129 A3 Angelica:	Yes it would be damned great well, but that is exactly why I don't think that gene therapy should be sneezed at, I think it is okay in some cases especially in these serious diseases. But one must be careful, there are consequence with it, you see

Notice how Angelica, in turn 129 A3, effectively used the preventive potential of cervical cancer vaccines to establish support for her position that careful research in gene therapy ought to be allowed "in specific cases" – note the argumentative premise indicator 'therefore' (Danish: 'derfor'). In addition, Angelica could be interpreted as enticing potential opponents ("I don't think that gene therapy should be sneezed at" (Danish: 'kimse af genterapi')), this could suggest an attempt to shift the burden of proof: Potential opponents would now have to positively argue for why gene therapy research should be sneezed at.

Of course, the cases of Blanche and Angelica are just two concrete examples of explicit expressions of science knowledge. Other cases of explicit expressions of science content can, and did, play slightly different argumentative roles. However, the two cases do denote general observations about explicit expressions of science content. First, trough analytical attention to the overall dialectical context of a given explicit expression of science content it was typically possible to directly trace how that expression had pragmatic relevance for a speaker's attempt to justify or refute a standpoint. Second, explicit expressions of science content would typically not just play a strong role in supporting the adequacy of a position adopted by the speaker, but also – more broadly – for the introduction or framing of an issue in a way that would challenge the interlocutor with an increased burden of proof. In many cases, it was manifest that the students were able to strategically express a science content that appeared to purely have information-relevance at first; but that this information was subsequently used (after a number of turns) to construct an argument that led to an attempted shift in the burden of proof (this is explored further below.)

A particularly forceful move that speakers made in the course of introducing or framing the issue was to invoke science knowledge in order to present the issue as *analogous* to something that the opponent would otherwise accept or reject. For example, when group A2 negotiated whether allowing germ-line gene therapy would result in the 'designer baby'-scenario, Cadence (who was open to germ-line gene therapy in the initial part of the discussion) said:

55 A2	Cadence:	Well, I think the difference … there is a huge difference … well, see, I think that precisely that about seeing a child that has Down's syndrome… well if you get the opportunity to see it … that, I think is super good, because I don't think that has a damned thing to do with making designer children […]

Cadence used the science knowledge that it is possible to detect whether a fetus suffers from Down's syndrome. By now, this scanning procedure has gained much currency in Denmark and it is far less controversial than it has been. In that sense, Cadence's move could be interpreted as an assimilation of germ-line gene therapy and fetal scanning. Presumably, her opponents would be inclined to endorse fetal scanning. Cadence substantiated her position that fetal scanning affords a "super good" opportunity with the further claim that such scans do not have "a damned thing to do with making designer children". Thus, she invoked science in order to indicate that some other pre-natal interventions (just like germ-line gene therapy) exist, and that they (*ceteris paribus*) are morally unproblematic; and this pragmatically implies that germ-line gene therapy, by parity and in principle, is morally unproblematic. This, then, is a form of *argument from analogy* (Govier, 2010; Walton, 1996) in which science was used (i.e. had pragmatic relevance) to dismantle the notion that germ-line gene therapy would lead to morally problematic design of babies.

4.4.1.2 Assertive expressions of science

A second way of representing science content was to explicitly assert a science content *as* a fact. Dwight did this in turn B318:

255 B1	Dwight:	Why do you not want somatic?
256 B1	Betsy:	There I just have something… when they have become people … when they have become … come out and they are as they are supposed to be, that you should damned not fiddle more

		with them. No, that, I can't… That, I can't have
[…]		
312 B1	Dwight:	But Betsy, you forget that our cells are constantly being changed […]
[…]		
318 B1	Dwight:	[…] cancer comes from mutations in the cells, that do that there is a change in genes. Why are we then not allowed to do the same? When people actually agree that cancer mutations are not natural, but for example can happen because you smoke then your chance for mutations increase. Why can't we do it the other way around? And try to treat it in the same way as it comes

The key indicator here is Dwight's usage of the stance adverb 'actually' (Danish: 'faktisk'). This indicates that he insisted that it is an indisputable fact that cell mutation related to cancer can be a result of human conduct; further, the stance adverb 'actually' typically indicates that the speaker anticipates that the indisputable fact is incompatible with the argumentation of the interlocutor (Tseronis, 2009, pp. 70-1). The installation of this indisputable fact played a key role in Dwight's attempt to frame the issue of somatic gene therapy as an issue about whether it is morally permissible to simply reverse perfectly natural processes.

Often such explicitly assertive expressions of science functioned pragmatically like *appeals to expert authority*. When Dwight used the pronoun 'people' (Danish: 'man'; could also be translated as 'they') – in "people actually agree" – he hardly referred to laypersons; he, rather, referred to there being a consensus between (medical) experts that cancer can be a result of human conduct (cf. Goodwin & Honeycutt, 2009). Dwight's appeal to expert authority substantiates the notion that human conduct can result in cancer as an indisputable fact. However, it *also* had a pragmatic effect of supporting his refutation of Betsy's commitment (such as in B256) – thus undermining her credibility by 'demonstrating' that her argumentation is in disagreement with the "indisputable" facts. In addition, Dwight committed the straw man fallacy because he misrepresented Betsy's reason (from 256 B1) for being opposed to somatic gene therapy (Talisse & Aikin, 2006).

Other indicators of assertive expressions of science were interjections or discourse connectives such as 'you see', 'see?' 'right?', or 'after all':

153 C1 Blanche:	[…] of course it is easier to go into an embryo, there are much less cells, you see… well it is surely a much small operation … and that with somatic … then one has to do it every few months because cells die, you see, and new cells come […]

Usages of 'you see' (Danish: "jo") like this indicate that the speaker attempts to bring her interlocutor to make a pragmatic inference – the pragmatic function being that it appears that a claim (or explanandum) has been, or will now become, sufficiently justified (or explained) (Blakemore, 1987; Fraser, 1990; Jaszczolt, 2002).

Assertive expressions of science always had pragmatic relevance for the given argument (they did *more* than convey information). They were often used in argumentation about what to do (not just what is true) and were often contextualised in the speakers' attempt to present an increased burden of proof to her interlocutor in connection with framing the issue in a specific way.

4.4.1.3 Implicit science content

Science content could also be represented *implicitly*. For example, Anita (group C3) pointed to a potential ethical problem concerning germ-line gene therapy "because one goes in and fiddles with some life without the beneficiary being able to choose" (Anita, 214 C3). Similarly, Donna (group A2) pointed to a possible concern that "it [i.e. germ-line gene therapy] will be misused… that one will go and fiddle with something that isn't just something health related" (Donna, 17 A2).

In such cases, the speaker would be semantically committed to a science factual proposition. Donna, for example, would have to be committed to a proposition to the effect of 'germ-line gene therapy affords engineered changes to more than just traits that affect the overall health of the person'. In other words, Donna's message is semantically assertible *only if* she is prepared to assert the background science proposition also; and though this science content may be rudimentary, it did indirectly play a role in the production of that turn.

Talk turns that contained implicit science content – such as the examples above – were often made in a context were an issue was raised or introduced. Note how the turns cited above can be interpreted as raising issues: Anita raised the issue that the beneficiaries of germ-line gene therapy cannot choose freely whether they want to be beneficiaries; and Donna introduced an issue about potential misuse of germ-line gene therapy, if allowed. This suggests, unsurprisingly, that the background science content was integral in the process by which a participant identifies a particular issue *as* a relevant issue. For example, if Donna had been oblivious to the full potential of germ-line gene therapy, then she would not have been able to raise the issue about misuses of the technology for purposes beyond curing diseases.

Occasionally, however, implicit invocations of science did more than simply introduce an issue. Donna and Anita's message above are examples of the argumentative effect of a particular way of representing the background science knowledge. They involved the same proxy for gene therapeutic procedures: The verb "fiddle" (Danish: 'pille'). Opponents of gene therapy regularly used the term 'fiddle' as a proxy for the process of gene therapy. Using 'fiddle' is a noteworthy design choice. It has negative connotations (in some contexts the Danish term 'pille' could even be translated to mean physically *tamper* or *toy* with something). To say that someone fiddles, already seems to suggests that someone does more than she is supposed to do – for example, like the phrase "stop fiddling with the outlet, it is dangerous". This further indicates that Anita and Donna attempted to paint a specific picture of the *manner* in which scientists or doctors would administer gene therapeutic treatments. To 'fiddle' stands in stark contrast to a controlled procedure made by a trained professional.

These considerations emphasize the powerful potential of implicit invocations of science. Compare, for example, Donna's message above (17 A2) with this talk turn:

8 B2 Christian:	I don't think that one can … that they can control it if one begins to do gene therapy and then at the end it will be about whether we can change … the genes so that we get a better appearance or something like that

Donna and Christian's messages conveyed roughly the same science content – that gene therapy may prove to be difficult to regulate because of the technology's ability to alter a variety of traits. In other words, the same science knowledge about gene therapy was used to introduce an issue that could be relevant to the deliberation about the primary issue of whether to allow gene therapy. However, the different ways in which this science knowledge was articulated suggest different argumentative effects. For Christian the problem about germ-line gene therapy was explicitly that it opens a path to genetic changes that target the beneficiary's appearance. While this may also have been Donna's concern, it appears that the very act of fiddling (conducting germ-line gene therapy) is itself represented as the problem. In particular, while Christian's strategy was to provide a scientifically based reason for his position, Donna's move was similar to an emotive appeal; she could accomplish to steer the discussion in a specific direction (Gilbert, 1997), and she could create a pragmatic reason for her interlocutors to accept her position as being adequately supported (cf. Innocenti, 2006)

Thus, implicit invocations of science knowledge, such as the above, can have an argumentative effect beyond that of simply identifying an issue as relevant for the decision making process. The manner in which the background science knowledge is being represented can also suggest to the interlocutor that there should be an intuitive answer to the raised issue. After all, condoning research in germ-line gene therapy is one thing, condoning that a doctor fiddles with the genetic material of one's future child is quite another.

4.4.2 Science as local primary issue versus science as a subordinate issue

34 sequences (with varying length between 3 and 37 turns) were identified as *science sub-discussions* in the sense that a particular science content was the local primary issue. Most of these were sparked by a *question* that pertained to some science content; and in many cases, the science content was directly related to gene therapy (or genetics, more broadly). Here is an illustrative example from the beginning of discussion A2:

1 A2	Cadence:	Okay I have to inquire … the difference is just that they want … well they have tried it just with this somatic gene therapy … and that worked and now they want to try this with germ-line cells because they want to prevent to have to do it that often, do we agree on that?
2 A2	Donna:	Yes
3 A2	Adriane:	Yes
4 A2	Cadence:	So it is that, which we have to decide upon
5 A2	Adriane:	Somatic gene therapy that is that ((about)) developed cells that make out organs and tissue of the human body
6 A2	Cadence:	Yes and germ-line cells, there you go in and, like, change the offspring that comes and then it will be inherited, the new material
7 A2	Adriane:	Oh? I understood it as that where one goes in and changes the bodily
8 A2	Cadence:	Yes but it is also that … the offspring, you see, and then ((it)) is inherited … you change the entire fetus, you also change the grandchildren and the great grandchildren, okay
9 A2	Adriane:	Yes

The local primary issue in sequence 1-9 A2 was the difference between germ-line gene therapy and somatic gene therapy. This sequence is strictly speaking not an argumentative sequence. Adriane and Cadence were explicating what germ-line gene therapy and somatic gene therapy is. Adriane's turn 5 A2, in particular, is a *usage declarative* which analysts typically ascribe an indirect role in argumentation (van Eemeren & Grootendorst, 2004): The turn attempts to define and delimit the usage of the term 'somatic gene therapy.' In this light, the turns in 1-9 A2 appear to have had only information relevance: Adriane, Cadence and Donna established a shared factual background, which outlined the domain of the ensuing discussion. So, in the local context of this sequence, science was not directly used to support positions or to frame the issue. Rather, science was used in a way that afforded *multiple* possible issues to be carved out as relevant for the participants.

We can appreciate how sequence 1-9 A2 outlined potential issues by contrasting it with the following sequence from group C1:

17 C1	April:	It is also there that it arises, the problem about doing germ-line gene therapy, you see, there one hasn't included the child, you see
18 C1	Blanche:	No, one has no choice
[…]		
22 C1	Chahna:	But there lies also a bigger problem in it because one looks at all the cells in a child just like when one makes a completely new human
23 C1	Blanche:	Yes where if one with somatic gene therapy …
24 C1	Chahna:	There it is only individual cells that there are problems with

The sequences from group A2 and C1 involved roughly similar science content, and both sequences were the first articulations of the difference between germ-line and somatic gene therapy in their respective discussions. However, in sequence 17-24 C1 the local primary issue was *not* the science content pertaining to why and how germ-line gene therapy and somatic gene therapy differ. Rather, the science content was used to establish a local primary issue about potential ethical problems concerning germ-line gene therapy: April and Blanche foregrounded that the beneficiaries of germ-line gene therapy may have a closed future and that that is a "problem" (April, 17 C2); and Chahna foregrounded that an even "bigger problem" would be that beneficiaries of germ-line gene therapy are fundamentally different beings than if germ-line gene therapy had not been administered (Chahna, 22 C1). These potential problems were the primary issue in sequence 17-24 C1, and the science content was used subordinately in the introduction of those problems as salient issues.

Further, April and Chahna, in particular, did more that just broach these issues: They also argued for taking a specific position on the respective issues. Indeed, Chahna's usage of the connective "because" indicates that she used the science content as a premise in an argument (Govier, 2010; van Eemeren, et al., 2007). So, the science content in sequence 17-24 C1 was used to activate specific issues in a manner that made it appear that these issues have an intuitive answer. In any event, the sequence 17-24 C1 clouds the fact that it would be relevant and legitimate to discuss whether administering germ-line gene therapy is ethically problematic. Thus, the strategic potential of sequence 17-24 C1 was not just that some ethical concerns were foregrounded; it also had the potential to putatively remove the need to argue *why* these ethical concerns are salient.

While sequences – such as 1-9 A2 – that had a science content as a local primary issue seem to have only information relevance, they typically formed a point of departure for future attempts to argue for a specific position on a specific issue. As mentioned above, students were generally able to elicit a specific science content in a way that initially endows that science content with information-relevance only. However, later on that science content could be co-opted in order to 'demonstrate' that a position to an issue is adequately supported. Here is an illustrative example:

78 A1	Despina:	What do they mean with germ-line cells? Well, is it a girl or a boy? Isn't it just that one outright goes in and changes the genes?
79 A1	Allan:	Well, but if they discover that there is a disease. What disease is it that they talk about?
80 A1	Connie:	Isn't it cancer?
81 A1	Allan:	It's that there SCID.

82 A1	Connie:	It is something about when the immune system lacks blood corpuscles
83 A1	Allan:	Yes a gene is simply lacking, which must … but it is the question where one goes in and directly changes in the individual. That I can better relate to than the other, I think. Because I think that it is a little frightening that about … because then it is that one goes in and changes and makes an elite due to that one changes a human group entirely

The primary issue in sequence 78-83 A1, as sparked by Despina's question was what germ-line gene therapy is. Note how Allan, in turn 79 A1, signaled that he was now about to answer Despina's science question – and even that he will somehow exemplify it using a specific disease. However, instead of merely providing an answer, his account (in turn 83 A1) was essentially an argument against allowing germ-line gene therapy. In particular his use of "because" (Danish: "for") indicated that he was about to provide a premise – namely that creating an "elite" is "frightening" – for the position that it is more difficult to "relate" to germ-line gene therapy than to somatic gene therapy. Therefore, instead of providing a comprehensive answer to Despina's science question, Allan co-opted the question in order to make a case against germ-line gene therapy. Now this sort of slippery slope argument ought to involve premises that shed light on exactly why the slope is slippery (why would allowing germ-line gene therapy lead to these specific social consequences?) (Govier, 2010).

In general, science sub-discussions straddled the border between argument and explanation (or explication). A case in point is a prolonged sequence from group B1. Betsy held that germ-line gene therapy should be allowed as a treatment of human heritable diseases because "it would be great if you could remove those diseases like for example cystic fibrosis, so that there are not people who go around and die when they are 17" (Betsy, B1, 91). Dwight was opposed to allowing germ-line gene therapy, because "it is a big crisis [and] ethically totally irresponsible that the offspring one gets is not genetically identical to oneself" (Dwight, B1, 97-9). In the end of the sequence, Dwight elaborated his argument (144-146 B1), and that prompted Andrea to pose a question pertaining to how germ-line gene therapy is performed:

143 B1	Betsy:	But isn't it also a human even though gene therapy has been administered?
144 B1	Dwight:	Yes but it is no longer a natural human. I don't feel it is because when one has went in to fiddle=
145 B1	Andrea:	Well, it is...
146 B1	Dwight:	=when one has went in to fiddle with the germ-line cells then one removes the natural of the human
147 B1	Andrea:	Well, but it surely are … it surely are the germ-line cells from another human
148 B1	Dwight:	No, no, you go in and make a treatment on…
149 B1	Betsy:	It is the germ-line cell of a mother and a father. Then you go in and mate them and then you say okay there is a disease here that might kill them when they are 17 so that if there is one can maybe remove that disease and they can live without dying when they are 17.
150 B1	Dwight:	Then one goes in and changes…
151 B1	Betsy:	And that's what he ((points to Dwight)) thinks that one is not allowed to do

Betsy's account in turn 149 B1 pertained to how (and consequently why) gene therapy on zygotes could work to alter genetic traits that may be connected to certain diseases which, in turn, may "kill" patients "when they are 17". In that sense, Betsy *made* germ-line gene therapy *plain* to Andrea (Osborne & Patterson, 2011). However, in Betsy's next talk turn she pointed to Dwight and said: "And that's what he ((points to Dwight)) thinks that one is not allowed to do" (Betsy, B1, 151). At this point Betsy's account becomes an *argumentative device*, for it is on the basis of that explanation or explication that Betsy can muster something similar to an *accusation* against Dwight; thus making it appear that he is obliged to answer her charge (cf. Kauffeld, 1998). In doing so, Betsy framed the issue so that Dwight appears to be obliged to argue for why he would allow certain people to die when they are 17 – an obligation which is very different from the one of 'just' having to argue against germ-line gene therapy.

Betsy's explanation or explication became instrumental for the persuasiveness of her refutation of Dwight's standpoint (i.e. that germ-line gene therapy should not be allowed). The crux of the matter is that her strategy works precisely because she chose to account for germ-line gene therapy *in a particular way*, and because she *blended* her explanatory account *into* her argumentation in the way that she did.

Co-option attempts such as those exemplified by Allan and Betsy are undoubtedly part of political reality; but they can carry unfortunate consequences. Allan and Betsy's interlocutors who sparked the science sub-discussions by asking science questions received more than they bargained for. In fact, there are clear signs towards the end of each of the two discussions that neither Despina, in Allan's group, nor Andrea, in Betsy's group, appeared to come to a greater understanding of germ-line gene therapy, even towards the end of their respective discussions:

231 A1	Despina:	was it [germ-line gene therapy] whether one wanted a disabled child or…?
[…]		
324 A1	Despina:	Hello! I don't understand that about germ-line gene therapy would violate future generations' rights to inherit a genetic build-up which is not specifically adapted

and

449 B1	Andrea:	Well, I know that one can't answer this question, but how the hell did they imagine that while one is alive that the genes could be changed?
[…]		
487 B1	Andrea:	Well, I just have to hear… that germ-line thingy that was … that was so that one could change…

To co-opt a science sub-discussion for one's own argumentative purpose is a potential violation of one's dialectical obligations of transparently showing the adequacy of the premises in one's argumentation (Kock, 2007). But, more importantly, it also potentially clouds the factual background for the interlocutor – a clouding which in the worst case renders the interlocutors incapable of making an informed decision.

4.4.3 On the Role of Science in the Discussion of Thematic Issues

Though science played multifarious roles within each of the thematic issues, it is possible to make some general observations. In connection to the '*closed future*'-issue the primary science content that opponents of germ-line gene therapy elicited was the fact that germ-line gene therapy has hereditary effects. This science content played a role in the articulation or introduction of the 'closed future'-issue. But in many cases that science content had direct pragmatic relevance: The hereditary effects of germ-line gene therapy were invoked in order to make a value-laden challenge about the sanctity of the beneficiary's autonomy to those who were positive or neutral towards germ-line gene therapy. So when a speaker conveyed that germ-line gene therapy has hereditary effects it was rarely just a matter of conveying information and introducing a potentially salient issue; it was to introduce an issue together with an invitation to a adopt a specific position on that issue.

The '*designer baby*'- and the '*genetic elite*'-issues could only be raised on the basis of the science knowledge that germ-line gene therapy theoretically can be used to alter genetic traits beyond removing traits related to severe hereditary diseases. But beyond this distant background these issues primarily involved macro-social or socio-economic concerns, they rarely featured the invocation of science content; and when science was invoked, it was usually invoked implicitly. Nevertheless there were a few instances in which science was used in order to make it appear that there is a natural and causal link between, for example, allowing germ-line gene therapy and macro-social consequences such the creation of a genetic elite (recall the case of Allan in sequence 78-83 A1 above).

The '*legitimate disease*'-issue was fundamentally different from the other thematic issues because it did not directly imply concerns towards allowing gene therapy. However, it did play a central role in all discussions. First, it was often instrumental (and sometimes subordinate) to, for example, the '*designer baby*'-issue. Second, the '*legitimate disease*'-issue was an important strategic forum for both proponents and opponents of germ-line gene therapy (or somatic gene therapy). For example, opponents could challenge potential proponents by making it appear as if it is impossible to demarcate legitimate diseases from minor discomforts or that any demarcation would ostracize a group of persons. Esry, for example, stated that "but I also just think that it is a mega bad idea if we name a particular disease […] because then we just make [the patients] odd" (Esry, 169-71 A2). Proponents, on the other hand, could name specific diseases and thereby make it apparent that the opponents of gene therapy would also be opponents of curing these diseases. Dwight, for example, made such a challenge to Betsy when he asked her "you wouldn't want that one in the future could prevent that people get cancer?" (Dwight, 257 B1). In the '*legitimate disease*'-issue, science was predominantly used in attempts to establish which diseases are genetic diseases, which diseases are life threatening, or which disease could be tolerably treated using conventional treatments. This relates back to the mentioned role of science in the construction of analogies between the contested issue and a different but apparently similar issue that has an intuitive answer.

4.5 Discussion and Implications

On the one hand, the students in this study *drew* on science in the process of articulating and identifying issues that they deemed salient for their discussion about human gene therapy. Such usages of science had the function of establishing the factual background for the ensuing socio-scientific negotiations. In such cases, factual information about a subject (such as the fact that germ-line gene therapy has hereditary effects) were used to signal to interlocutors that that the subject (germ-line gene therapy) may potentially be an object of moral discussion. The science content could be conveyed implicitly (e.g. the case of Donna, 17 A2), but often it was explicitly expressed and occasionally a particular science content was even the local primary issue (e.g. the sequence 1-9 A2). In such cases, the science content played a role of delimiting a series of possible issues that would have potential relevance for the global primary issue. Though sequences of this character could later be co-opted by an individual student (e.g. the case of Allan, 83 A1), they represented the factual background in a way that was transparent enough for others to draw on them as well. The critical quality of discussions could only benefit from such transparent and pseudo-neutral exchanges.

On the other hand, science content played a strong role in responses to previous lines of arguing by introducing, or directly framing, an issue as well as providing argumentative support for a specific position towards that (framed) issue. The argumentative force of this general usage of science is a result of the potential of such expressions (explicit as well as implicit) to establish a shared starting point (a statement to which all arguers could agree), which did more than inform the discussion. The matter-of-factual lens afforded by invoking science could be harnessed to make it appear that there is an intuitive position to the issue, or it at least challenges the interlocutor with an increased burden of proof (recall, at this point, the case of Blanche 88-90 C1 above.) This can be, and was indeed, an effective argumentative strategy. The speaker who uses science in this way was likely to achieve not only to frame the issue in a way that was favorable for her position, but also to cloud that it could be important for the group to deliberate whether that specific way of framing the issue was important. Note that the fact that patients who produce too much amino acid can be treated using gene therapy does not intrinsically signal that it is *the* salient point in a deliberation of whether gene therapy should be allowed. Ideally, however, a socio-scientific discussion should contain considerations about why such points are important or not. Also from an educational perspective, a student who has not yet constructed a solid understanding of, for example, what germ-line gene therapy is, would undoubtedly be better off if the sub-discussion about what germ-line gene therapy is was not immediately co-opted by one of her peer's. But many invocations of science seemed to directly hinder such considerations (cf. the cases of Despina and Andrea).

The interpretive findings of this study can be related to, and possibly elaborate on, a number of findings from previous research and general concerns of the science education community. First, the interpretations are resonant with what seems to be a general tendency: Students are reluctant to consider alternative positions and reflect on the provided scientific information to socio-scientific issues (Sadler, 2004; Simon & Amos, 2011). Berland and Reiser (2009; 2011) observed that students have manifest difficulties in balancing between "sensemaking" and "persuasion" and that if students focus primarily on persuading peers they will focus their energy on defending their own position or confronting positions that stand in contrast to their own. This attitude may even be "unwitting", as Nickerson (1998) has argued: The "natural tendency" of rational agents "seems to be to look for evidence that is directly supportive of hypotheses we favor" (p. 211). Mercier and Sperber (2011), have extended these ideas to argue that arguers "who have an opinion to defend" rarely engage properly with the argumentation of their interlocutors, but, rather, initially "consider" the moves of their interlocutors "as counterarguments to be rebutted" (Mercier & Sperber, 2011, p. 72). Whether this is indeed the case in all types of argumentative situation is an open question. But it is certainly resonant with Kock's (2007) argument that political argumentation, in particular, is not directed at *resolving* a disagreement.

The interpretive findings of this study may elaborate such previous observations by clarifying a general way in which students can co-opt science for persuasive purposes: Namely by invoking science as a scaffolding device in attempts to frame the issue. This information, in turn, may guide educators and researchers in their attempts to train students to adopt dialectically open stances towards real-life issues and include confirmative as well as disconfirmative information in their decision-making.

Second, the interpretative findings of this study also elaborate on Lewis and Leach's (2006) observation that a student's disciplinary knowledge partly determines what that student is capable of discussing in a socio-scientific discussion. Now, it must be true that if a student does not know that, for example, germ-line gene therapy has hereditary effects, she would not be able to raise certain issues in a discussion about gene therapy. Indeed, as this study has demonstrated it is often possible to trace the introduction of an issue back to a particular episode of science knowledge, even when the particular science content was represented implicitly. But this is only part of the story. The students in this study were generally able to invoke science in creative and selective ways that played directly into their persuasive attempts. Thus, while it is necessary that a student knows that germ-line gene therapy has hereditary effect if that student is to deliberate certain issues concerning gene therapy, it by no means implies that that student will use that knowledge in such deliberations. Indeed, Kelly, Druker, and Chen (1998) have demonstrated that students (who discussed an issue pertaining to electricity) primarily used scientific evidence in a warranting manner when prompted by a question or a forwarded claim. The students in the present study primarily invoked science to feather their own argumentative nests both in response to prompts – such as questions, bids for elaborations, or value-laden positions of others – as well as in anticipation of future moves of their opponents so as to challenge that opponent with an increased burden of proof.

Recently, a number of scholars have resourced to strengthen the conceptual landscape concerning key terms like ‘argument’ and ‘explanation’ (Braaten & Windschitl, 2011; Osborne & Patterson, 2011). Osborne and Patterson (2011) argued that it is crucial to clearly distinguish between scientific explanation and argument – two linguistic moves that often have been concatenated: While explanations work towards making plain an already agreed on fact (the explanandum); arguments work towards justifying the acceptability of a claim (which may still be in dispute) (cf. also Govier, 2010). In other words, analysts who investigate students’ discourse would have to establish whether a given student at a given point is in the midst of arguing or explaining. The interpretations of the present study indicate that in the context of *socio*-scientific deliberations it will be more difficult for the analyst to adhere to this distinction. In most cases when a student elaborated a given science content in response to an interlocutors’ science question, the student would move to *explain* or *explicate* that science content. But while such explanations or explications can appear to be part of an unbiased account that provides more information on, or even make plain, a statement that appears to be something that is generally agreed upon, they occasionally played into the speaker's argumentative project. In other words, a speakers' particular *choice* of how to explicate or make plain a science concept or phenomena can be, and was indeed, a part of her longer-term argument. In order for an analyst to be able to identify explanations from argumentation in authentic socio-scientific discussion activities, the analyst would have to pay particular attention to the dialectical features of students' argumentation.

Future empirical studies of socio-scientific deliberations may benefit from, and elaborate on, Braaten and Windschitl's (2011) distinction between 'explication' and 'explanation', according to which explications are not full explanations in the sense that "explanations that account for natural phenomena involves more than explications of meaning" (p. 651). The students in this study seem to explicate more often than they explained but further investigations are needed to corroborate this on a larger scale.

Previous research has paid overwhelming attention to how students manage scientific information *as evidence* in socio-scientific decision-making, and to which extent such decision are *evidence-based* (e.g. Acar, Turkmen, & Roychoudhury, 2010; Dawson & Venville, 2009; Eastwood, Schlegel, & Cook, 2011; Evagorou, 2011; Fowler, Zeidler, & Sadler, 2009; Halverson, Siegel, & Freyermuth, 2009; Kolstø, 2001, 2006; Kolstø, et al., 2006; Levinson, 2006; Ratcliffe, 1997; Sadler & Zeidler, 2005b; Simon & Amos, 2011; Wu & Tsai, 2007). But it may be misleading to emphasize 'evidence' in the context of socio-scientific deliberations. The interpretation of the argumentative role of invocations of science in this study suggest that science was largely invoked in attempts to demarcate certain aspects of the global primary issue as *the* salient aspects of that issue, and subsequently to provide support for a specific way attitude towards these aspects. While speakers occasionally attempted to make it *appear* that a personal standpoint on the global primary issue was directly based on scientific evidence (see also Author, in press), they did not use evidence, strictly speaking. Formally, 'evidence' is a type of reason for adopting a standpoint, but not all reasons are evidence. For example, the possibility of talking to friends and colleagues across the Atlantic could be a reason for me to attend a conference in the US, but that possibility is not evidence. The same is true about the scientific fact that germ-line gene therapy has hereditary effects; it could be a reason for someone to hold that germ-line gene therapy should not be allowed, but it is not evidence for holding that position. As Walton (2002) argued, evidence is used in *inferences* – evidence, that is, is a set of propositions from which an "*inference is drawn* to support some claim or conclusion" (p. 225; emphases added). This is an important point, because it has become standard in argumentation theory to define dialectical arguments over and against inferences. Agents resort to dialectical argumentation by eliciting arguments *for and against a point of view*; and they do so, in cases where the point of view or conclusion *cannot* be inferred from the premises (cf. Beard, 2003; Johnson, 2002; van Eemeren, et al., 1987; Walton, 2000). A decision on a socio-scientific issue is precisely a conclusion that cannot be inferred from a range of premises.

Now, there must be a logically felicitous role for science evidence in socio-scientific deliberations. Spelling out that role would be a project that touches the very core of the science education community's reflections on what it means to ask of students to make scientifically informed decisions on socio-scientific issues. Of course, others have raised this issue in slightly different forms before (Albe, 2008; Sadler & Zeidler, 2005a). But this has not yet prompted a thorough theoretical exposition within our field. A preliminary suggestion could be that scientific evidence could felicitously enter socio-scientific deliberations in collaborative attempts to establish the factual background of the ensuing value-laden decision-making process. The evidence would then play two felicitous roles. First, it would predicate of a subject (e.g. germ-line gene therapy) that it has certain causal qualities (e.g. hereditary effects). Second, *in doing so*, the asserted evidence would signal that a number of ethical concerns that may pertain to the causal qualities would *a fortiori* pertain to the subject of the predication. In other words, while value-laden criteria for decision-making are reasons for socio-scientific decisions about what to *do*, scientific evidence about what is *true* establishes which phenomena or causal processes may be salient subjects for the value-laden criteria. While this seems to suggest a sharp ontological distinction between facts and values, it is merely an attempt to emphasize that it would – *pragmatically speaking* – be beneficial if students' socio-scientific discourse is more *transparent* in sense of making explicit their decision criteria.

Some students in this study did struggle with science content – as predicted by previous research (e.g. Simon & Amos, 2011). But most of them appeared to understand enough to at least selectively and creatively invoke their science knowledge in ways that should give science educators pause. Science was occasionally invoked in ways that appeared to endow the speaker's utterance with a certain authority, or to endow a specious quality to the argument. Among other things, such invocations of science can create the pragmatic effect that the selection of aspects of the about human gene therapy that are salient for discussing that issue is a no-brainer. Using science in order to cloud this selection of aspects and criteria for decision-making is probably not what most science educators have in mind when they advocate for the use of science. After all, it is questionable whether a deliberation is informed if the reasons for framing an issue in a particular way, or if the reasons for selecting particular decision criteria are clouded for persuasive purposes.

It is important for science teachers to secure the quality of the science content that students elicit in discussion activities. To this end, some have argued that a group's negotiation of science concepts could be stabilized through cogent teacher interventions (e.g. Levinson, 2004). But the findings of this study suggest that it is equally important to secure the *manner* in which science content is invoked in discussions. In fact, if a teacher is unaware of the specific dialectics and the on-going strategic argumentation in a particular group, then the interventions of that teacher could have adverse effects on the dialectics of the discussion (see also Naylor, et al., 2007). In particular, the teacher could inadvertently become a source that mandates a students' framing attempt in the eyes of her peers. Thus, teachers would need to be sensitive to the particular dialectics within a specific group in order to contribute to the group's sensemaking processes. Future research is needed in order to formulate best practices that have a formative role of strengthening the factual correctness as well as the dialectical felicitousness of invoked science content. But it may prove to be beneficial if teachers directed attention to whether and *how* a given invocation of science content has pragmatic relevance or even relevance in a student's attempt to frame the issue.

While the elaborate framing attempts that this study has thematised are part of political reality they could potentially obstruct critical and reflective decision-making on the side of some students. As has been argued by Ratcliffe (1997) it is crucial that students become able to recognize the set of values that form the basis of socio-scientific arguments. This point can be elaborated. One could speculate that if students were able to identify the framing attempts of their interlocutors they would be better equipped to react to such attempts. It could, thus, be beneficial to introduce students to the archetypical and generic lines of argumentation within bioethics – hereunder making explicit that archetypical ways of framing the issue are exactly that: Ways of framing the issue. In other words, if students are to become able to critically engage with socio-scientific issues, then they must become aware of framing attempts and learn to identify situations in which their interlocutors co-opt science in order to support such attempts.

So while the interpretive findings of this study appear to paint a rather bleak picture of socio-scientific discussions, it could be argued that socio-scientific discussion activities become even more important in light of the existence of argumentative strategies of the sort identified here. To my mind, the interpretive findings suggest that students could only benefit from learning to identify and probe argumentative strategies that are archetypical in the context of bioethics. To put such generic argumentative strategies on the teaching agenda would be a natural extension of the numerous efforts that are being made to teach students to argue in science contexts.

4.6 Limitations

Since this was a multiple case study, the aim was not to establish generalizable findings that exhaust the data. The explicit aim of this study was to afford an interpretation of the data in great detail. The small-scale and exploratory nature of this qualitative study follows a growing tradition of conducting research on socio-scientific activities that does not aim at being generalizable, but, rather, aim at providing concrete empirical examples in order to raise issues for discussion in the science education community (Albe, 2008; Barrett & Nieswandt, 2010; Lindahl, 2009; Marttunen, 1997; Orlander Arvola & Lundegård, 2011; Pouliot, 2008; Sadler, 2006; Sadler & Zeidler, 2005a). On a level of finer detail, science will undoubtedly play other argumentative roles in the dialectics of students' discussions that the ones reflected upon here. If the amount of science used changes across different issue (Grace & Ratcliffe, 2002), then the way in which the invocations of science play into the discussion could also change. Future studies are needed for analyzing other strategies in which science content is invoked in order to explain how these strategies work. In addition, this study only considered students' overt articulations. Thus, students' background knowledge and the group dynamics have not been part of the data. Abstracting from such factors was necessary from a practical perspective, but a long-term research agenda ought to make interpretations based on such factors as well. In contrast, this study has been a modest attempt to illustrate that the strategies in which students invoke science can be viewed *as* strategies, and that it is possible to make interpretations about how they work pragmatically in the dialectics of the discussions in which they are used.

4.7 Conclusions

The students in this study were generally able to draw on science information in their socio-scientific deliberations. But, in addition, they were also able to creatively and selectively use science pragmatically in elaborate attempts to (i) demarcate specific aspects of gene therapy as *the* salient aspects (framing), and to (ii) make it appear that the demarcated aspects call for intuitive positions to be taken on the overall issue about human gene therapy.

This paper began with a concern that more knowledge is needed about what it means to use science in socio-scientific discussions and, in particular, about how such activities can be assessed by teachers. While this paper has modestly refrained from providing such accounts, it has provided a window into the complexity of socio-scientific discussion that may inform future studies in this area. The findings reported here do indicate that it will be difficult to appropriately assess students' socio-scientific discourse. It is one thing to assess the correctness of invoked science content, quite another to assess the argumentative legitimacy of such invocations in the dialectical context.

For science education researchers, the findings of this study provide *a posteriori* flesh to the *a priori* concern that it may not be appropriate to parse the use of science information in socio-scientific discussions as *evidence*. Science education needs both descriptive accounts of the dialectical roles of specific science contents across different socio-scientific issues, as well as normative accounts of what the felicitous roles of science content are in such contexts. This paper invites further discussion in the community about exactly what it means to ask of students to discuss socio-scientific issues.

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4.9 References

Acar, O., Turkmen, L., & Roychoudhury, A. (2010). Student Difficulties in Socio-scientific Argumentation and Decision-making Research Findings: Crossing the borders of two research lines. *International Journal of Science Education, 32*(9), 1191-206.

Albe, V. (2007). Students' Argumentation in Group Discussions on a Socio-Scientific Issue. In Roser Pintó & Digna Couso (Eds.), *Contributions from Science Education Research* (pp. 389-401). Dordrecht: Springer Netherlands.

Albe, V. (2008). Students' positions and considerations of scientific evidence about a controversial socioscientific issue. *Science & Education, 17*(8-9), 805-27.

Aristotle. (1997). *Topics. Books I and VIII, with excerpts from related texts* (Robin Smith, Trans.). Oxford: Clarendon Press.

Barrett, S.E., & Nieswandt, M. (2010). Teaching about ethics through socioscientific issues in physics and chemistry: Teacher candidates' beliefs. *Journal of Research in Science Teaching, 47*(4), 380-401.

Beard, D. (2003). Informal Logic. *Review of Communication, 3*(3), 254-9.

Bell, R.L., & Lederman, N.G. (2003). Understandings of the nature of science and decision making on science and technology based issues. *Science Education, 87*(3), 352-77.

Berland, L.K., & Reiser, B.J. (2009). Making sense of argumentation and explanation. *Science Education, 93*(1), 26-55.

Berland, L.K., & Reiser, B.J. (2011). Classroom communities' adaptations of the practice of scientific argumentation. *Science Education, 95*(2), 191-216.

Blair, J.A. (2006). Pragma-Dialectics and pragma-dialectics. In P Houtlosser & A van Rees (Eds.), *Considering Pragma-Dialectics* (pp. 11-21). Mahwah (NJ): Lawrence Erlbaum Associates.

Blakemore, D. (1987). *Semantic constraints on relevance*. Oxford: Blackwell Publishers Ltd.

Braaten, M., & Windschitl, M. (2011). Working toward a stronger conceptualization of scientific explanation for science education. *Science Education, 95*(4), 639-69.

Brandom, R.B. (1994). *Making It Explicit: Reasoning, Representing, and Discursive Commitment*. Cambridge (MA): Harvard University Press.

Chong, D., & Druckman, J.N. (2007). Framing Theory. *Annual Review of Political Science, 10*(1), 103-26.

Clark, D., D'angelo, C.M., & Menekse, M. (2009). Initial Structuring of Online Discussions to Improve Learning and Argumentation: Incorporating Students' Own Explanations as Seed Comments Versus an Augmented-Preset Approach to Seeding Discussions. *Journal of Science Education and Technology*, *18*(4), 321-333.

Clark, D., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. *Journal of Research in Science Teaching, 45*(3), 293-321.

Craig, R., & Tracy, K. (2005). "The issue" in argumentation practice and theory. In F.H. van Eemeren & P. Houtlosser (Eds.), *Argumentation in Practice* (pp. 11-28). Amsterdam: John Benjamins.

Danish Ministry of Education. (2010). *Bekendtgørelse om uddannelsen til studentereksamen. Nr 692 af 23/06/2010 (Executive Order nr. 692 of 23/06/2010).*

Davies, D.S. (2006). Genetic Dilemmas and the Child's Right to an Open Future. In Helga Kuhse & Peter Singer (Eds.), *Bioethics: An Anthology* (pp. 246-56). Oxford: Blackwell Publishing Ltd.

Dawson, V., & Taylor, P. (1999). Teaching bioethics in science: Does it make a difference? *Australian Science Teachers Journal, 45*(1), 59-65.

Dawson, V., & Venville, G. (2009). High-school Students' Informal Reasoning and Argumentation about Biotechnology: An indicator of scientific literacy? *International Journal of Science Education, 31*(11), 1421-45.

Denzin, N.K., & Lincoln, Y. (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Duschl, R.A. (2007). Quality Argumentation and Epistemic Criteria. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 159-75). Dordrecht: Springer Netherlands.

Eastwood, J.L., Schlegel, W.M., & Cook, K.L. (2011). Effects of an Interdisciplinary Program on Students' Reasoning with Socioscientific Issues and Perceptions of Their Learning Experiences. In Troy D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 89-126). Dordrecht: Springer Netherlands.

Entman, R.M. (1993). Framing: Toward clarification of a fractured paradigm. *Journal of Communication, 43*(4), 51-8.

Erduran, S. (2007). Methodological Foundations in the Study of Argumentation in Science Classrooms. In Sibel Erduran & María Pilar Jiménez-Aleixandre (Eds.), *Argumentation in Science Education* (pp. 47-69). Dordrecht: Springer Netherlands.

Evagorou, M. (2011). Discussing a Socioscientific Issue in a Primary School Classroom: The Case of Using a Technology-Supported Environment in Formal and Nonformal Settings. In Troy D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 133-59). Dordrecht: Springer Netherlands.

Feinberg, J. (1980). The Child's Right to an Open Future. In W. Aiken & H. LaFollette (Eds.), *Whose Child? Children's Rights, Parental Authority and State Power* (pp. 124-53). Totowa (NJ): Littlefield, Admas & Co.

Fleming, R. (1986). Adolescent reasoning in socio-scientific issues, part I: Social cognition. *Journal of Research in Science Teaching, 23*(8), 677-87.

Fowler, S.R., Zeidler, D.L., & Sadler, T.D. (2009). Moral sensitivity in the context of socioscientific issues in high school science students. *International Journal of Science Education, 31*(2), 279-96.

Fraser, B. (1990). An approach to discourse markers. *Journal of Pragmatics, 14*(3), 383-98.

Fulkerson, R. (1996). *Teaching the Argument in Writing*. Urbana, IL: National Council of Teachers of English.

Galvão, C., Reis, P., Freire, S., & Almeida, P. (2010). Enhancing the Popularity and the Relevance of Science Teaching in Portuguese Science Classes. *Research in Science Education*, (Advance online publication), 1-16. Retrieved from http://dx.doi.org/10.1007/s11165-010-9184-3

Gilbert, M.A. (1997). *Prolegomenon to a Pragmatics of Emotion.* Paper presented at the Ontario Society for the Study of Argumentation, Brock University, St. Catherine's, ON. Retrieved from http://www.yorku.ca/gilbert/argthry/argthry/arg-papers/mag1997-prol-emo.pdf.

Goodwin, J. (2000). Comments on 'Rhetoric and Dialectic from the Standpoint of Normative Pragmatics'. *Argumentation, 14*(3), 287-92.

Goodwin, J. (2002). Designing issues. In F.H. van Eemeren & P. Houtlosser (Eds.), *Dialectic and rhetoric: The warp and woof of argumentation analysis* (pp. 81-96). Amsterdam: Kluwer.

Goodwin, J. (2005). Designing premises. In F.H. van Eemeren & P. Houtlosser (Eds.), *Argumentation in Practice* (pp. 99-114). Amsterdam: John Benjamins.

Goodwin, J., & Honeycutt, L. (2009). When Science goes Public: From Technical Arguments to Appeals to Authority. *Studies in Communication Sciences, 9*(2), 19--30.

Govier, T. (2010). *A Practical Study of Argument* (7th ed.). Belmont: Wadsworth Cengage Learning.

Grace, M.M., & Ratcliffe, M. (2002). The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24*(11), 1157 - 69.

Habermas, J. (1984). *The Theory of Communicative Action: Reason and the rationalization of society* (T. McCarthy, Trans.). Boston: Beacon Press.

Halverson, K.L., Siegel, M.A., & Freyermuth, S.K. (2009). Lenses for Framing Decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education, 31*(9), 1249 - 68.

Harris, J. (1993). Is Gene therapy a Form of Eugenics? *Bioethics, 7*(2-3), 178-87.

Hofstein, A., Kipnis, M., & Kind, P. (2008). Learning in and from Science Laboratories: Enhancing Students' Meta-Cognition and Argumentation Skills. In C.L. Petroselli (Ed.), *Science Education Issues and Developments ((*pp. 59-94). New York: Nova Science Publishers.

Hogan, K. (2002). Small groups' ecological reasoning while making an environmental management decision. *Journal of Research in Science Teaching, 39*(4), 341-68.

Holland, S. (2003). *Bioethics. A philosophical Introduction*. Cambridge: Polity.

Holm, S., & Takala, T. (2007). High hopes and automatic escalators: a critique of some new arguments in bioethics. *Journal of Medical Ethics, 33*, 1-4.

Innocenti, B. (2006). A normative pragmatic perspective on appealing to emotions in argumentation. *Argumentation, 20*(3), 327-43.

Jackson, S., & Jacobs, S. (1980). Structure of conversational argument: Pragmatic bases for the enthymeme. *Quarterly Journal of Speech, 66*(3), 251-65.

Jacobs, S. (2000). Rhetoric and dialectic from the standpoint of normative pragmatics. *Argumentation, 14*(3), 261-86.

Jacobs, S., & Jackson, S. (1992). Relevance and digressions in argumentative discussion: A pragmatic approach. *Argumentation, 6*(2), 161-76.

Jaszczolt, K. (2002). *Semantics and pragmatics: meaning in language and discourse*. Harlow: Pearson Education.

Johnson, R.H. (1995). Informal logic and pragma-dialectics: Some differences. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C. Willard (Eds.), *Proceedings of the Third ISSA Conference on Argumentation, Volume I: Perspectives and Approaches* (pp. 237- 45). Amsterdam: SicSat.

Johnson, R.H. (2002). Manifest rationality reconsidered: Reply to my fellow symposiasts. *Argumentation, 16*(3), 311-31.

Katriel, T., & Dascal, M. (1984). What do indicating devices indicate? *Philosophy and Rhetoric, 17*, 1-15.

Kauffeld, F.J. (1998). Presumptions and the distribution of argumentative burdens in acts of proposing and accusing. *Argumentation, 12*(2), 245-66.

Kelly, G., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education, 20*(7), 849-71.

Kitcher, P. (2010). The Climate Change Debates. *Science, 328*(5983), 1230-4.

Kock, C. (2007). Norms of legitimate dissensus. *Informal Logic, 27*(2), 179-96.

Kock, C. (2009). Choice is Not True or False: The Domain of Rhetorical Argumentation. *Argumentation, 23*(1), 61-80.

Kolstø, S.D. (2001). 'To trust or not to trust, . . .'- pupils' ways of judging information encountered in a socio-scientific issue. *International Journal of Science Education, 23*(9), 877-901.

Kolstø, S.D. (2006). Patterns in Students' Argumentation Confronted with a Risk ‐ focused Socio ‐ scientific Issue. *International Journal of Science Education, 28*(14), 1689-716.

Kolstø, S.D., Bungum, B., Arnesen, E., Isnes, A., Kristensen, T., Mathiassen, K., et al. (2006). Science students' critical examination of scientific information related to socioscientific issues. *Science Education, 90*(4), 632-55.

Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.

Latour, B. (2004). *Politics of nature: how to bring the sciences into democracy*. Cambridge (MA): Harvard University Press.

Leitão, S. (2000). The potential of argument in knowledge building. *Human Development, 43*(6), 332-60.

Levinson, R. (2004). Teaching bioethics in science: Crossing a bridge too far? *Canadian Journal of Science, Mathematics and Technology Education, 4*(3), 353 - 69.

Levinson, R. (2006). Teachers' perceptions of the role of evidence in teaching controversial socio-scientific issues. *Curriculum Journal, 17*(3), 247-62.

Lewis, J., & Leach, J. (2006). Discussion of Socio-scientific Issues: The role of science knowledge. *International Journal of Science Education, 28*(11), 1267 -- 87.

Lindahl, M.G. (2009). Ethics or Morals: Understanding Students' Values Related to Genetic Tests on Humans. *Science & Education, 18*(10), 1285-311.

Lynch, M. (1982). Closure and disclosure in pre-trial argument. *Human studies, 5*(1), 285-318.

Marttunen, M. (1997). Electronic Mail as a Pedagogical Delivery System: An Analysis of the Learning of Argumentation. *Research in Higher Education, 38*(3), 345-63.

Mercier, H. & Sperber, D. (2011). Why do Humans Reason? Arguments for an Argumentative Theory. *Behavioral and Brain Sciences*, 34, 57-111.

Millar, R. (1997). Science education for democracy. In R. Levinson & J. Thomas (Eds.), *Science Today: Problem or Crisis?* (pp. 87-101). London: Routledge.

Munneke, L., van Amelsvoort, M., & Andriessen, J. (2003). The role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research, 39*(1-2), 113-31.

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education, 37*(1), 17-39.

Nickerson, R.S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology, 2*(2), 175-220.

Nielsen, J.A. (2010), Functional roles of science in socio-scientific discussions. In Ingo Eilks & Bernd Ralle (Eds.) *Contemporary Science Education – Implications from Science Education Research about Orientations, Strategies and Assessment* (pp. 83-96). Aachen: Shaker.

Nielsen, J.A., (To appear a), Co-opting Science: A preliminary study of how students invoke science in value-laden discussions. *International Journal of Science Education.*

Nielsen, J.A., (To appear b), Dialectical Features of Students' Argumentation: A critical review of argumentation studies in science education. *Research in Science Education*

Orlander Arvola, A., & Lundegård, I. (2011). 'It's Her Body'. When Students' Argumentation Shows Displacement of Content in a Science Classroom. *Research in Science Education,* (Advance online publication), 1-25. Retrieved from http://dx.doi.org/10.1007/s11165-011-9237-2

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020.

Osborne, J., & Patterson, A. (2011). Scientific argument and explanation: A necessary distinction? *Science Education, 95*(4), 627-38.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: implications for teaching. *International Journal of Science Education*.

Pontecorvo, C., & Girardet, H. (1993). Arguing and Reasoning in Understanding Historical Topics. *Cognition & Instruction, 11*(3/4), 365.

Post, S.G. (1993). *Inquiries in bioethics*. Washington, D.C.: Georgetown University Press.

Pouliot, C. (2008). Students' inventory of social actors concerned by the controversy surrounding cellular telephones: A case study. *Science Education, 92*(3), 543-59.

Rabino, I. (2003). Gene Therapy: Ethical Issues. *Theoretical Medicine and Bioethics, 24*(1), 31-58.

Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. *International Journal of Science Education, 19*(2), 167-82.

Reindal, S.M. (2000). Disability, gene therapy and eugenics - a challenge to John Harris. *Journal of Medical Ethics, 26*(2), 89-94.

Ryder, J. (2001). Identifying Science Understanding for Functional Scientific Literacy. *Studies in Science Education, 36*(1), 1-44.

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-36.

Sadler, T.D. (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education, 17*(4), 323-46.

Sadler, T.D., & Donnelly, L. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463-88.

Sadler, T.D., & Fowler, S.R. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education, 90*(6), 986-1004.

Sadler, T.D., & Zeidler, D.L. (2003). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education, 88*(1), 4-27.

Sadler, T.D., & Zeidler, D.L. (2004). Negotiating Gene Therapy Controversies. *The American Biology Teacher, 66*(6), 428-33.

Sadler, T.D., & Zeidler, D.L. (2005a). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Resarch in Science Teaching, 42*(1), 112-38.

Sadler, T.D., & Zeidler, D.L. (2005b). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education, 89*(1), 71-93.

Searle, J.R. (1969). *Speech Acts: An Essay in the Philosophy of Language*. Cambridge: Cambridge University Press.

Shea, N., Duncan, R.G., & Stephenson, C. (2011). *Exploring Genetic Literacy: How Undergraduate Science Majors Reason About Authentic Genetic Dilemma*. Paper presented at the *Annual Conference of the National Association for Research in Science Teaching (NARST),* Orlando (FL), April 3-6.

Simon, S., & Amos, R. (2011). Decision Making and Use of Evidence in a Socio-scientific Problem on Air Quality. In Troy D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 167-92). Dordrecht: Springer Netherlands.

Smith, P.C. (1995). Towards a Discursive Logic: Gadamer and Toulmin on Inquiry and Argument. In L. K. Schmidt (Ed.), *The Specter of Relativsm* (pp. 159-77). Evanston: Northwestern University Press.

Snoeck Henkemans, A. (1992). *Analysing complex argumentation. The reconstruction of multiple and coordinatively compound argumentation in a critical discussion.* Amsterdam: Sic Sat.

Snoeck Henkemans, A. (1996). Indicators of independent and interdependent arguments: 'anyway' and 'even'. In J. van Benthem, F.H. van Eemeren, R.

Grootendorst & F. Veltman (Eds.), *Logic and argumentation* (pp. 77-87). Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen.

Stake, R.E. (2006). *Multiple case study analysis*. New York: The Guilford Press.

Takala, T. (2005). The Many Wrongs of human Reproductive Cloning. In M. Häyry, T. Takala & P. Herissone-Kelly (Eds.), *Bioethics and Social Reality* (pp. 53-66). Amsterdam: Rodolpi.

Talisse, R., & Aikin, S. (2006). Two Forms of the Straw Man. *Argumentation, 20*(3), 345-52.

Thomas, D.R. (2003). A General Inductive Approach for Qualitative Data Analysis. Retrieved from http://www.health.auckland.ac.nz/hrmas/Inductive2003.pdf

Toulmin, S.E. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Tseronis, A. (2009). *Qualifying standpoints. Stance adverbs as a presentational device for managing the burden of proof.* Utrecht: Netherlands Graduate School of Linguistics.

Tytler, R. (2001). Dimensions of evidence, the public understanding of science and science education. *International Journal of Science Education, 23*(8), 815 - 32.

van Eemeren, F.H., & Grootendorst, R. (1982). The speech acts of arguing and convincing in externalized discussions. *Journal of Pragmatics, 6*(1), 1-24.

van Eemeren, F.H., & Grootendorst, R. (1989). Speech act conditions as tools for reconstructing argumentative discourse. *Argumentation, 3*(4), 367-83.

van Eemeren, F.H., & Grootendorst, R. (2004). *A systematic theory of argumentation: The pragma-dialectical approach*. Cambridge: Cambridge University Press.

van Eemeren, F.H., Grootendorst, R., & Kruiger, T. (1987). *Handbook of Argumentation Theory: a Critical Survey of Classical Backgrounds and Modern Studies*. Dordrecht: Foris.

van Eemeren, F.H., & Houtlosser, P. (2002). Strategic maneuvering with the burden of proof. In F.H. van Eemeren (Ed.), *Advances in pragma-dialectics* (pp. 13-28). New Port News (VA): Vale Press.

van Eemeren, F.H., & Houtlosser, P. (2007). The study of argumentation as normative pragmatics. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 15*(1), 161-77.

van Eemeren, F.H., Houtlosser, P., & Snoeck Henkemans, A. (2007). *Argumentative indicators in discourse: a pragma-dialectical study*. Dordrecht: Springer.

Walker, K., & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-410.

Walton, D.N. (1996). *Argumentation schemes for presumptive reasoning*. Mahwah (NJ): Lawrence Erlbaum Associates.

Walton, D.N. (2000). The place of dialogue theory in logic, computer science and communication studies. *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science, 123*(3), 327-46.

Walton, D.N. (2002). *Legal argumentation and evidence*. University Park (PA): Pennsylvania State University Press.

Walton, D.N., & Godden, D.M. (2007). Informal Logic and the Dialectical Approach to Argument. In H.V. Hansen & R.C. Pinto (Eds.), *Reason Reclaimed* (pp. 3-17). Newport News (VA): Vale Press.

Walton, D.N., & Krabbe, E. (1995). *Commitment in dialogue. Basic concepts of interpersonal reasoning*. Albany (NY): State University of New York Press.

Wilkinson, S. (2010). On the distinction between positive and negative eugenics. In M Häyry, T Takala & P Herissone-Kelly (Eds.), *Arguments and Analysis in Bioethics* (pp. 115-28). Amsterdam: Rodolpi.

Willard, C. (1976). On the utility of descriptive diagrams for the analysis and criticism of arguments. *Communication Monographs, 43*(4), 308-19.

Wishart, J., Green, D., Joubert, M., & Triggs, P. (2011). Discussing Ethical Issues in School Science: An investigation into the opportunities to practise and develop arguments offered by online and face-to-face discussions. *International Journal of Science Education, Part B, 1*(1), 47-69.

Wohlrapp, H. (1987). Toulmin's Theory and the Dynamics of Argumentation. In F.H. van Eemeren, R. Grootendorst, J.A. Blair & C. Willard (Eds.), *Argumentation: Perspectives and Approaches* (pp. 327-35). Dordrecht: Foris.

Wu, Y., & Tsai, C. (2007). High School Students' Informal Reasoning on a Socio-scientific Issue: Qualitative and quantitative analyses. *International Journal of Science Education, 29*(9), 1163-87.

Yin, R.K. (2009). *Case Stuy Research. Design and Methods*. Thousand Oaks: Sage.

Zeidler, D.L., Osborne, J., Erduran, S., Simon, S., & Monk, M. (2006). The Role of Argument During Discourse About Socioscientific Issues. In Dana L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 97-116). Dordrecht: Springer.

Zeidler, D.L., Sadler, T.D., Simmons, M.L., & Howes, E. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education, 89*(3), 357-77.

Zeidler, D.L., & Schafer, L.E. (1984). Identifying mediating factors of moral reasoning in science education. *Journal of Research in Science Teaching, 21*(1), 1-15.

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Paper IV

Nielsen, J.A., (To appear), Arguing from Nature: The role of 'nature' in students' argumentations on a socio-scientific issue. *International Journal of Science Education*.

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Arguing from Nature:
The role of 'nature' in students' argumentations on a socio-scientific issue

This paper explores how students invoked different conceptions of 'nature' in eight socio-scientific group discussions about human gene therapy. The paper illustrates and discusses how the students articulated nature and to what extent they elicited science factual content in the process. While the students in this study invoked nature at key places in a variety of dialectical contexts in the discussions, these invocations were often uncritical appeals and rarely involved science factual content. Even when an argument from nature was challenged the author of that argument would often shift the sense of nature rather than elaborate upon the argumentation. It is argued that if students were more properly introduced to the evaluative character of the term 'nature' it would not just be conducive to the quality of their argumentation, but also invite them to foreground science factual content at key places in their discussion.
Keywords: Argumentation, biology education, nature, socio-scientific issues

5.1 Introduction

Science education seeks to enable students to make informed decisions about societal issues that relate to science (e.g., Danish Ministry of Education, 2010; EU-Commision, 2004; OECD, 2006). To this end, science educators have touted the introduction of *socio-scientific issues* – issues that have a conceptual basis in science, but arise *as issues* in the societal, political, and ethical realm of human lives (Ekborg, Ideland, & Malmberg, 2009; Kolstø, 2001, 2006; Sadler & Zeidler, 2003).

Socio-scientific issues afford many educational benefits. Students can, for example, take multiple positions towards such issues since there are no 'right answers' (Ekborg, et al., 2009, p. 37). And this, in turn, can have a positive effect on students' learning in terms of both opening science content up to students (Galvão, Reis, Freire, & Almeida, 2010) and enabling students' critical engagement through the use of argumentation (Sadler, 2004; Walker & Zeidler, 2007).

But socio-scientific issues present a number of challenges to teachers and researchers. Socio-scientific argumentation is typically *practical* because socio-scientific issues are often about what to *do* – not just what is true (Kock, 2009). Thus assessments of socio-scientific discourse are complicated by the fact that students – like other arguers – can opt to use science content strategically in their argumentation. (Nielsen, To appear [Paper II]). Further, socio-scientific issues straddle the nature-society interface. Therefore socio-scientific discourse is poised to be fraught with invocations of *nature* (Sherlock, 2002; Sousa, 1980). But there is a lack of knowledge of how students invoke nature in socio-scientific discussions. This paper explores how groups of students invoked, and argued from, nature in socio-scientific discussions.

5.2 The Concept of Nature

The concept of nature is notoriously vague (Andersson, 1993; Crawford, 2008; Soper, 1995); and it is almost always invoked in an evaluative way (Sousa, 1980). In the contemporary Western world, 'nature' has one of two different *referents*: On the one hand, 'nature' can be used to denote an 'existential domain' (such as the opposition of 'culture' or 'society'); on the other hand, 'nature' or 'natural' can be used to denote an 'essential character' of something, (such as in the expression 'the nature of science') (Crawford, 2008, p. 313).

It has been common to distinguish nature from the domain of human intervention or society (Soper, 1995; Sousa, 1980) – a distinction that students reproduce (Haluza-Delay, 2001). Thus any attempt to define nature is typically also an attempt to define the nature-society interface (Castree, 2005) or even to dispel that interface as a myth (Latour, 2004; Soper, 1995). Most notions of the nature-society interface implicitly elicit one of a number of different normative stances – such as anthropocentrism, biocentrism, and ecocentrism – regarding how human interventions in nature ought to be evaluated (Bourdeau, 2004; Minteer, 2009; Preston, 2007).

One of the most pervasive themes in contemporary bioethics is to discuss the role and value of arguments from nature and how or whether they can derive action-guiding principles from nature (Boshammer, 1998; Holland, 2003; Sherlock & Morrey, 2002; Singer, 2006). In this context, arguments from nature have the general positive form 'X ought to be done, because X is natural', or the general negative form 'X ought not to be done, because X is unnatural' (Sousa, 1980, p. 169).

Arguments from nature must be scrutinized critically. Govier (2010) has argued that invocations of nature exhibit 'vagueness' and 'emotional overtones' to the extent that they have a powerful persuasive potential (p. 80). Depending on what one's concept of nature is, one could derive just about any conclusion from nature. For example, the argument from genetic 'trespassing', which is a dominant genre of arguments *against* genetic engineering, essentially stipulates 'that there are fixed lines that demarcate a 'natural' way of genetic existence as distinct from, and preferable to, deliberately manufactured existence' (Sherlock, 2002, p. 150). But arguments from nature can also be applied in argumentation *for* genetic engineering. For example, Glass (1971) argued that 'every child' is naturally endowed with an 'unalienable right' to be 'born with a sound physical and mental constitution based on a sound genotype' (p. 28).

In order to critically evaluate a given argument from nature, one must identify both the *referent* (i.e., existential domain or essential character) as well as the *sense* of 'nature' or 'natural' that was used in the argument. Govier (2010) illustrated four different senses of nature, as it occurs in everyday argumentative discourse (p. 81):[1]

Nature$_1$: 'What is natural is what is not a result of human intervention'.

[1] Govier (2010) does not distinguish between 'nature' and 'natural'. In her treatment, the different usages of the adjective 'natural' appear to correspond to different usages of the noun 'nature' a similar approach is taken here.

Nature$_2$: 'What is natural is what is required for the proper biological functioning and survival of an entity'.

Nature$_3$: 'What is natural is what is best for an entity according to standards that are not biological but derive from some other set of values'.

Nature$_4$: 'What is natural is whatever is compatible with the principle of science that describes and explains our world'. This could be a misleading formulation. Better would be: What is natural is that which is currently and potentially compatible with scientific explanations. So the thrust of this sense is the notion that what is natural is that, and only that, which science can or may one day be able to account for. This is slightly similar to philosophical scientism (cf. Sorell 1994).

This taxonomy enables analysts to better understand a particular argument from nature. So when a speaker argues that 'X ought to be done because X is natural' she could elaborate her argument as, for example, 'X ought to be done because X contributes to the biological functioning of humans'. While the revision is not more cogent, it is more transparent. Thus it will be clearer what the speaker's argumentative commitments and entitlements are. This is critical information for every analysis of argumentation (Brandom, 1994; Goodwin, 2005). The key point is succinctly explained by Govier (2010): '[t]here are problems and anomalies about the natural, no matter in which of these senses we use the term' (p. 81).

European science textbooks predominantly portray nature as distinct from human intervention and as an object for human interests (Carvalho, Tracana, Skujiene, & Turcinaviciene, 2011; Korfiatis, Stamou, & Paraskevopoulos, 2004; Östman, 1998, 2010). Thus it has been documented how textbooks mainly present a picture in which 'nature was in oscillating balance' and in which 'humans had the absolute control over a nature whose only value was its usefulness as a resource' (Korfiatis, et al., 2004, p. 85). And while the textbooks did present multifarious stances towards the nature-society interface, the portrayal of these stances was fragmented and lacked critical evaluation (Korfiatis, et al., 2004).

Such findings are resonant with the apparent trend that while students often exhibit a 'strong belief in an extremely resilient 'Balance of Nature'' (Ergazaki & Ampatzidis, 2011, p. 1) their reasoning behind this view is often riddled with fragmented and contradictory views of nature (Engestöm, 1981; Ergazaki & Ampatzidis, 2011; Zimmerman & Cuddington, 2007). Also Cobern, Gibson, and Underwood (1999) found that individual students exhibited a 'rich breadth of perspectives' such as 'religious, aesthetic, scientific, conservationist' when explaining what nature is (p. 541). The authors also found that the students rarely used science content in their elucidations (Cobern, et al., 1999, p. 550).

5.3 Research Questions

Thus, students do regularly adopt multifarious and contradictory concepts of nature, and not enough effort has been put into enabling students to critically evaluate different normative stances towards the nature-society interface by invoking science content. This is a less-than-ideal vantage point for socio-scientific decision-making. But a futile scholarly discussion requires more direct empirical knowledge of how students invoke nature in socio-scientific discourse. This study is designed to explore how students articulate 'nature' argumentatively in socio-scientific discussions. This is operationalized in two research questions:

(1) What argumentative roles do students' arguments from nature have in the context of small-group discussions about human gene therapy?

(2) To what extent do students invoke science content in their articulations of nature?

This is important: This report does not subscribe to any particular concept nature/natural or to any particular usage of these terms, the key objective is to understand how students conspicuously use these terms and to interpret how such usages can have argumentative effects in the context of a discussion. The primary aim of this report is not just to present findings; it is, rather, to carefully depict the analysis of individual articulations of nature.

5.4 Methods

5.4.1 Research Design

In order to elucidate the research question, eight socio-scientific group discussions were analysed. In each group, 4-5 Danish biology students from upper secondary school (age 16-19) discussed for 40-60 minutes whether human gene therapy should be allowed. 36 students participated in total. The study involved three biology-B classes (students can choose between three different levels of Biology; B-level being the midlevel). The discussions were the conclusion to what the three teachers individually deemed as their standard course on genetics. The groups were formed on the basis of the students' answers to an online questionnaire regarding overall bioethical issues so as to increase the possibility of heterogeneous standpoints within each group (Clark, D'angelo, & Menekse, 2009). The groups were only interrupted towards the end of the activity.

A written material entitled 'Gene Therapy – A Dilemma for the Future?', which is based on teaching materials developed by Sadler and Zeidler (2004), was given to the students when they sat down in groups. It described the difference between somatic and germ-line genetic therapy, and how these technologies work, and depicted some of the real-life positions that debaters have taken towards the issue. The students were to decide on future legislation regarding human gene therapy (see also Nielsen, 2010; To appear [Paper II]).

The discussions were recorded by video cameras that captured all members in a group as well as by voice recorders that could be used both as a back-up recording and as a secondary source to consult in the transcription. Two persons (one being the author) transcribed the discussions; the two sets of transcriptions were collected, cross-examined, and adjusted – at places of discrepancy – by the author.

5.4.2 Analytical Framework

The framework for argumentation used in this study was *normative pragmatics* (Goodwin, 2000; Jacobs, 2000; van Eemeren & Houtlosser, 2007; for the use of normative pragmatics in science education see Nielsen, To appear [Paper II]). Normative pragmatics studies the *practical significance* of language use in argumentative interactions (Blair, 2006; Brandom, 1994). From the perspective of normative pragmatics, argumentation is a process in which two or more people use language to influence the decisions of their interlocutors (cf. Goodwin, 2001, p. 14). In other words, arguers design messages that can have specific effects on the recipients. Such messages have a *content* dimension (what is being said?) as well as a *design* dimension (how is it being said?); and both aspects must be taken into account in the analysis (Jacobs, 2000). Conspicuous design choices such as posing a question instead of asserting can have practical effects – such as affect the balance of the burden of proof. By taking both design and content into account, normative pragmatics builds a bridge between traditional rhetorical analysis and dialectics (Jacobs, 2000). A central tenet of normative pragmatics is the conviction that arguers can construct messages in ways that create *pragmatic reasons*: The very act of eliciting a message can create a reason for the interlocutor to do something (e.g. acknowledge the adequacy of a premise) (Innocenti, 2006).

The goal of the normative pragmatics analysis, which this study applied, is to come to a greater understanding of the *strategies* that arguers in given situation resort to. This involves identifying such 'strategies as strategies [and] explain how an arguer's utterance of some words can be expected to accomplish things like the imposition of probative burdens' (Goodwin, 2001, p. 9). Rudimentary strategies include providing reasons for one's claim, challenging the reasons given by others; but beyond that, arguers can also implement other strategies such as proposing or accusing (Kauffeld, 1998), or appeals to emotions (Innocenti, 2006) or authority (Goodwin & Honeycutt, 2009).

5.4.3 Analysis Process

The normative pragmatics analysis was embedded in a four-step procedure. First, in order to index talk turns of interest, the talk turns that featured the terms 'nature' and '(un)natural' were marked. Talk turns in which the speaker expressed, alluded to, or in other ways represented science content were marked as well. Second, the thematic issues (i.e., the issues that were discussed recurrently and at length) of the discussions were identified. This was done through two iterations of open coding (Denzin & Lincoln, 1994) in which the discussions were split into sequences according to the issue that the participants discussed in that sequence. This created two basic analytical tiers that acted as guidelines for the ensuing normative pragmatics analysis.

Third, the normative pragmatics analysis of sequences in which students invoked nature was guided by the identification of:

(1) the argumentative *speech act* that the speaker performed (van Eemeren & Grootendorst, 1989);
(2) the *argumentative indicators* that were used by the speaker – such as 'because', 'therefore', 'but', 'you see', 'why?' (van Eemeren, et al., 2007);
(3) the speaker's additional *design choices* – such as pronouns (Goodwin & Honeycutt, 2009), adjectives (Gilbert, 1997), and stance adverbs (Tseronis, 2009)
(4) the *commitments* and *entitlements* of the speakers (Brandom, 1994).[2]

[2] This amounts to a sort of scorekeeping: If a speaker at one point says that 'all kinds of genetic engineering should be banned' then that speaker would

In the fourth and final step, the normative pragmatics interpretation of the local role of a given talk turn was interpreted against the background of the overall thematic dialectic of the discussion. This study was part of a larger study on the general roles that science content played in the discussions (Nielsen, 2010, To appear [Paper II]). The analysis conveyed here was embedded in the more general and wider analysis of the overall study. Since the overall study was largely explorative, and aimed to raise debate rather than firm results, the normative pragmatics analysis was conducted in a *hermeneutical* manner (Nielsen, To appear [Paper II]). Initial local sequences were selected on the basis of information from the first two analytical steps. The initial sequences were subjected to normative pragmatics analysis and then attempts were made to identify similar sequences across other discussions. The analysis of these sequences, in turn, could reveal different dialectical roles of invocations of nature, which resulted in a new search for sequences across all discussions with similar features and so on.

5.5 Analysis

5.5.1 General Observations

Out of a total of 3333 talk turns from all eight discussions, there were only 70 explicit mentions of 'nature', 'natural', or 'unnatural' (in 60 different talk turns). These articulations were embedded in 32 distinct sequences of argumentation. These quantitative measures could imply that 'nature' merely played a marginal role in the discussions. But it will be argued in the remainder of this report that while the invocations of nature where few in numbers, they regularly played key roles not just in the argumentation sequences in which they were contextualised but also in the overall dialectics of the discussions.

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also be committed to hold that 'genetic engineering on plants should be banned'. If the speaker later would state that 'genetic engineering on plants could be allowed', then that would be interpreted as a concession.

For practical reasons it has not been possible to present in detail the analysis of all 32 sequences in which nature was invoked. This analysis section will analyse in detail eight sequences on the basis of which a number of interpretational claims will be made. As mentioned above, the analysis was hermeneutical in the sense that one sequence was analysed initially; subsequently other, apparently similar, sequences were analysed in order to see similarities and differences in terms of how nature was invoked and how science content was used in these invocations. The selected cases – that are analysed here – represent *the different argumentative strategies found through this hermeneutical process*. Of course, this type of study could never aim for completeness, there will undoubtedly be other argumentative strategies available to argues than those discussed here.

It is possible, however, to state some general remarks about the arguments from nature in the data set. Such arguments were predominantly used in argumentation *against* gene therapy. Overt mentions of nature were, in particular, often aimed to castigate germ-line gene therapy as somehow being unnatural. Some invocations were not very complex and were never elaborated. For example, Allan – in discussion A1 – argued that there has to be '*a more natural alternative*' to germ-line gene therapy, an alternative which does not '*change anything lasting*' – that is, has no hereditary effects (Allan, 215 A1); thus Allan indicated that germ-line therapy is comparatively less natural than other possibilities because its effects are hereditary. But Allan did not elaborate why there is a logical connection between being unnatural and having hereditary effects. There were, however more subtle and complex invocations of nature; the main part of this section will illustrate and discuss some of these in detail.

In the entire dataset only one student, Dwight from discussion B1, invoked nature in order to argue *for* somatic gene therapy. From his perspective, somatic gene therapy '*is not unnatural to the same degree than*' germ-line gene therapy (399 B1), and he argued at length that somatic gene therapy is just the reverse of a naturally occurring process and therefore morally unproblematic (see also Nielsen, To appear [Paper II]).

5.5.2 Castigating Germ-line Gene Therapy by Appealing to Evolution

A number of arguments from nature against germ-line gene therapy involved *evolution* as the connection between germ-line gene therapy and violations of nature. The following example from discussion A2 is particularly illuminating. Donna argued against germ-line gene therapy (her opponent, Cadence, was at this early stage positive towards germ-line gene therapy):

30 A2	Donna:	I also just think that something which is really dangerous […] ((is)) that one fiddles a little with the order of nature … well, that about survival of the fittest … Darwinism and stuff like that … that just goes completely lost, you see, if one can take all diseases away
31 A2	Cadence:	But, you see, it [(i.e. survival of the fittest)] also does that […] by the means of medicine […] =
[…]		
33 A2	Cadence:	= one could say that medicine also goes in and changes survival of the blah blah blah

Donna's argument in turn 30 A2 involves a slippery slope (Govier, 2010; van Eemeren, Grootendorst, & Snoeck Henkemans, 2002), where the removal of all diseases putatively acts as the causal linkage between allowing germ-line gene therapy and bypassing evolution. Her design choices reveal two notable points. First, the phrase '*fiddle* […] *with the order of nature*' was reiterated a few turns later when Donna stated that:

48 A2	Donna:	[how one makes up one's mind] depends on how much one wants to go in and fiddle with the order of nature

This indicates that Donna articulated an existential domain, which is distinct from the domain of human intervention, but which has an internal order that can be disrupted – Nature$_1$ in Govier's taxonomy.

Second, the term 'fiddle' (Danish: *pille*) is a noteworthy design choice. It has negative connotations (in some contexts the Danish term 'pille' could even be translated to mean physically *tamper* or *toy* with something). To say that someone fiddles, already seems to suggests that someone does more than she is supposed to do as in the phrase 'stop fiddling with the outlet, it is dangerous'. This further indicates that Donna attempted to paint a specific picture of the *manner* in which scientists or doctors would administer gene therapeutic treatments. To 'fiddle' has a haphazard ring to it; at least it is in stark contrast to a controlled procedure made by a trained professional.

The design choices that Donna made in turn 30 could potentially give Cadence, Donna's opponent, an unacceptable burden of proof – namely to argue why she thought that it would be permissible to haphazardly intervene with the order of nature. In that sense Donna's message has the potential to *frame* the issue of gene therapy as being an issue about intervening with the order of nature. She resorted to the same strategy a few talk turns later (in turn 48, see above).

In turn 30, Donna gave a tentative reason for why gene therapy, in its extreme, could be intervening with the order of nature: '*survival of the fittest … Darwinism and stuff like that … that just goes completely lost, you see, if one can take all diseases away*'. So according to Donna, the essential character of '*the order of nature*' that would potentially be disrupted is '*survival of the fittest*' or '*Darwinism*'. Further, Donna argues that the aspect of '*survival of the fittest*' will be '*completely lost*' if all human '*diseases*' are removed – possibly she means a scenario where no humans are carriers of hereditary diseases. This last argumentative move stands out quite clearly: Interjections or discourse connectives such as 'you see' (Danish: 'jo') – as well as 'see?', or 'after all' – indicate that the speaker attempts to bring her interlocutor to make a pragmatic inference – the pragmatic function being that it appears that a claim (or explanandum) has been, or will now become, sufficiently justified (or explained) (Blakemore, 1987; Fraser, 1990; Jaszczolt, 2002).

Thus Donna interwove science factual content (information about '*survival of the fittest*' and how it can be bypassed) with a value-laden challenge (of fiddling with '*the order of nature*') – a strategy that has the potential to make it appear that her way of framing the issue is more mandated by science than other ways of framing (cf. Nielsen, To appear [Paper II]). But articulations of nature such as Donna's can and should be critically engaged with. In particular two aspects are missing in order for Donna's line of reasoning to be cogent.

First, the claim that gene therapy fiddles with the order of nature ought to be substantiated with more science content. The somewhat superficial reference to evolution is unclear at best. Donna made no other mention of evolution in the discussion so it is difficult to ascertain exactly what notion she was eliciting. One interpretation could be that her message is close to one of the standard, yet debatable, objections to gene therapy (cf. Willgoos, 2001) that germ-line gene therapy eventually would let individuals – who would otherwise not be fit enough – contribute to the human gene pool, thus diluting the human gene pool. But even if this were so, her move would still be an eligible subject of critical scrutiny from her opponent – possibly in the form of elaborating the apparent factual linkage between allowing gene therapy and bypassing '*survival of the fittest*'.

Second, Donna's appeal to nature in turn 30 (and its repetition in turn 48) lacked an explication of why it is wrong to '*fiddle* […] *with the order of nature*' in the sense of acting so that '*survival of the fittest* […] *is completely lost*'. As it stands, Donna's turn 30 simply stipulates that '*survival of the fittest*' is an essential part of the order of nature, and that it is self-evident that intervening with that essential character is wrong. But that would be an evaluative statement, which should be substantiated by (among other reasons) a value principle (such as '*ceteris paribus* humans ought to minimize intervening with natural selection'). But rather than giving such an account, Donna presented her evaluative statement as if it was a part of a factual account.

Now, Cadence confronted Donna (in turn 31 33, see above). Cadence stipulated that conventional human medical treatments by the same token could intervene 'survival of the fittest'. She also made use of the interjection '*you see*' which indicates that she wanted to invite Donna to make the inference that since humans regularly intervene with 'survival of the fittest' without moral scruples, that intervention could not be a reason against germ-line gene therapy. Cadence's challenge could act as a request for Donna to provide a reason for her evaluative statement where this would involve an account of why evolution is essential to nature to the extent that humans ought not intervene with it. Thus Cadence's move in turns 31 and 33 shifted the burden of proof back to Donna. But unfortunately Donna did not directly discharge her dialectical obligations (Johnson, 2000; Kock, 2007) by elaborating her argumentation or engage with Cadence's challenge.

5.5.3 Science-related Challenge as a Prompt for Revisions of the Sense of Nature

A speaker in some cases be prompted to elaborate her invocation of nature in light of a science factual challenge from an interlocutor. For example, Angelica – in discussion A3 – argued against germ-line gene therapy due to the risk of misuses of the technology to design babies:

12 A3	Angelica:	[…] one shouldn't go in and directly design one's children […] because we at some point would go in and want to steer or control what we get and how our children should look, and then it is exactly the case that one goes against the right of nature, and that, I think, is wrong

A few turns later, Angelica elaborated that germ-line therapy '*stops the human evolution*' (24 A3). This was Angelica's argument: Germ-line gene therapy potentially leads to parents designing their babies, this may bypass (or stop) evolution, which means that germ-line gene therapy goes against nature, and since it is wrong to go against nature, germ-line gene therapy ought not be allowed. On this reconstruction, Angelica articulates nature as Nature_1 in Govier's taxonomy.[3]

Similar to the case of Donna, Angelica's argument involves a slippery slope. In Angelica's case it was the design of babies that acted as the causal linkage between allowing germ-line gene therapy and stopping evolution. Contrary to the case of Donna, however, Angelica interwove factual and evaluative statements in a more transparent fashion ('*that, I think, is wrong*').

Later in discussion A3, Elliot challenged Angelica's slippery slope argument. While he agreed that germ-line gene therapy ought to not be allowed, he did not find Angelica's argumentation convincing. This led Angelica to revisit her initial usage of nature:

185 A3	Angelica:	[…] at some point one just gets to resemble one another too much. Well, I think it will go awry
[…]		
188 A3	Elliot:	I think there is a long way before one can do that
[…]		
191 A3	Angelica:	[…] we have to think about that the human being, like, conforms to its nature and the environment it is born into … you see, I am for good reasons not dark skinned because I am not born under 45 degrees heat […]
[…]		
193 A3	Elliot:	No, you see, that is because one has mutated

[3] It is unclear what Angelica referred to by '*right of nature*' (Danish: *naturens ret*). She may have referred to the right of the potential beneficiaries of germ-line gene therapy; but since her interlocutors did not at that early stage ask her to elaborate, her initial reference is unclear at best.

194 A3	Angelica:	Yes exactly we are mutated, you see, to be able to conform to our nature and if one for example in Africa begins to be able to change one's genetic pattern so that one is to have light skin then one can't live under these surroundings, you see
[…]		
200 A3	Elliot:	No but I just think that that would not be doable because if humans … then they would also just have to mutate again […]
201 A3	Angelica:	Yes […] but the thought alone is, I think, really scary […]
[…]		
219 A3	Angelica:	One is not allowed to change nature so drastically […]

This was Angelica's revisited argumentation (in turns 191 and 194): Human beings have to be able to '*conform to* [their] *nature*' in order to live under the conditions of their nature, therefore human beings have '*mutated*' to be able to conform in that sense; and if germ-line gene therapy were allowed in the extreme, it would be possible to alter traits (such as '*light skin*') that would render the beneficiaries unfit to '*live under* [their] *surroundings*' (194 A3).

On the face of it, Angelica's revision could be just an elaboration of her previous commitment that germ-line gene therapy '*goes against* […] *nature*' because it '*stops the human evolution*'. So germ-line gene therapy obstructs evolution because it potentially alters traits that are products of evolution (such as skin pigmentation and eye coloration), and such traits are products of evolution because they have been beneficial for humans under local living conditions.

But Angelica did more than just elaborate. Angelica changed the source of normativity (i.e., of why germ-line gene therapy is wrong). In the initial account it was just plain wrong to go against nature and stop evolution. In her revised account it is wrong to change traits that could render the beneficiary unfit to live under specific environmental conditions. Correspondingly Angelica's revised articulation of nature was as Nature_2 in Govier's (2010) taxonomy.

Further, Angelica invoked nature in two different ways in her revised argumentation. On the one hand, she used '*nature*' equivalent to '*environment*' (191 A3) – nature, that is, as an existential domain that present conditions and obstacles for humans to conform to. On this account, nature is outside humans in the sense that nature poses external constraints. On the other hand, she later stipulated that engineered changes to human genetic material would be to '*change nature*' (222 A3). This is a very different articulation of the nature-society interface. Here humans, and in particular the genetic material of humans, are a part of nature as a systemic whole – humans do not simply stand on the receiving end of nature's external constraints.

It is noteworthy that both Angelica's revision, and her second revised articulation of nature as a systemic whole were prompted by Elliot's science factual confrontations – i.e. whether it would be possible, in the short-term, to use germ-line gene therapy to create a uniform society (cf. 188 A3) and whether human beings would not simply '*mutate again*' in order to be able to live under their local conditions (200 A3), respectively.

Now, Angelica's move in turn 194 A3 appears to aim at creating a factual backdrop against which germ-line gene therapy can be identified as being unnatural in the sense of potentially harming the biological functioning of humans. Thus, Elliot's confrontation to Angelica in turn 200 A3 should be interpreted as an attempt to cry down the unnaturalness of germ-line gene therapy. Elliot's point, on this interpretation, was that allowing germ-line gene therapy would not be unnatural for in the long run the affected humans would simply '*mutate again*'. As such, Elliot and Angelica's exchange was (at least a precursor to) negotiation of what is (un)natural on the basis of a potential disagreement about the factual account of the relation between human beings and their environment.

The conceptual quality of Elliot and Angelica's invocations of science content was slightly problematic (e.g., the idea that evolution primarily revolves around mutation is a quite common misconception, see

Ferrari & Chi, 1998). But for the purpose of this paper it is noteworthy that Elliot's repeated attempts to confront Angelica's argument from nature on a science factual basis prompted her not just to elaborate her argumentation, but also to change the sense of nature. Indeed, Angelica's final invocation of nature no longer carried any factual content that could warrant her argument from nature. In her final move she acknowledged the factual information provided by Elliot, but resorted to a strategy of simply stipulating that germ-line gene therapy would '*change nature*' more '*drastically*' than '*allowed*' (222 A3).

5.5.4 Appeals to an Essential Character of Human Beings

So far the focus has been on how students articulated nature as an existential domain with an ordered principle that was parsed as evolution. But this was not the only type of invocation of nature. For example, in discussion B1, Dwight and Betsy disagreed as to whether germ-line gene therapy should be allowed as a treatment. Betsy was continuously in favour of germ-line gene therapy, her main reason was that it would '*be great if one could remove the diseases like for example cystic fibrosis so that there aren't people who go around and die from it when they are 17*' (91 B1). Dwight disagreed:

97 B1	Dwight:	[...] I think when ... the moment one makes a germ-line cell treatment [...] then the offspring that two people get is not genetically identical with them ... that, I think, is a big crisis=

A charitable interpretation of the quality of being '*genetic identical*' could be that Dwight had in mind that the beneficiaries of germ-line gene therapy might carry genetic material which is not purely the result of the genetic material of the two parents. A few turns later Dwight talks about this quality as the '*genetic ties between humans*' (107 B1). Indeed, Dwight held that it is '*ethically completely irresponsible*' (99 B1) that germ-line gene therapy potentially cuts the genetic ties between humans. And immediately afterwards he elaborated by referring to nature: '*I am just saying that it breaks with some principles of nature*' (103 B1). Betsy, however, challenged this: '*I must honestly admit that I do not think about* [the genetic ties] *that much*' (108 B1). She was, rather, concerned with the fact that germ-line gene therapy could be used so that '*there would not come anyone who got that disease … so that they don't have to lie and writhe in pain every day*' (115 B1). There is a lot to be said about Betsy's attempt to foreground the suffering of patients. But here it suffices to observe that she attempted to give Dwight the burden of proof. Dwight's response came over a number of turns:

128 B1	Dwight:	[…] surely one deselects to have one's own offspring if one makes gene therapy on germ-line cells… then it is no longer one's own offspring
[…]		
144 B1	Dwight:	[…] it is no longer a natural human … I don't feel it is any longer when one has been in and fiddled =
[…]		
146 B1	Dwight:	=when one has been in and fiddled with the germ-line cells … then one removes the natural of the human

Dwight did not commit himself in a way that would dialectically preclude him from agreeing with Betsy that it is a problem that some patients have to '*writhe in pain every day*'. His primary new commitment was that germ-line gene therapy, the positive aspects notwithstanding, essentially changes the beneficiary, and that such a change '*removes the natural of the human*' (Dwight, 146 B1).

While it is straightforward to identify the referent of nature in Dwight's argumentation as an essential character of human beings, his invocation of nature shifted from Nature_3 to Nature_1 in Govier's (2010) taxonomy. His initial appeal to the '*genetic ties between humans*' indicates that such ties have an intrinsic value (note that he did not provide a biological account of why such ties are beneficial) – as such, that would be an articulation of Nature_3. Dwight's appeal failed to persuade Betsy, and he was prompted to make a second attempt in which he implied that there are '*some principles of nature*' with which humans can intervene on pain of loosing the quality of being natural humans – that would be an articulation of Nature_1.

It might be possible to consistently combine the two senses of nature. For example, it is conceivable that Nature_1 could be invoked to elaborate on a previous invocation of Nature_3. In such cases it should be possible to identify the connection between the two different articulations. But this connection was not clear in Dwight's argumentation. What was missing was an argument that it is natural (Nature_3) to have unaltered genetic ties *because* it is natural (Nature_1) to have one's own offspring. Regardless of whether Dwight was aware of it or not, his second articulation of nature seems to be an attempt to steer the discussion on to a more principled level, rather than an elaboration of his initial argumentation.

5.5.5 Dissociation as a Confrontational Device

Occasionally, some students referred to nature when they wanted to define which diseases could be legitimate targets for germ-line gene therapy. The issue about whether it is possible to define legitimate diseases was a central strategic forum in all discussions: For example, an opponent of gene therapy would be able to make a case against gene therapy by making a case that it would be impossible to cogently demarcate legitimate diseases from minor discomforts (Nielsen, in review). For example, Diana – in discussion C3 – continuously doubted that it would be possible to distinguish between legitimate and illegitimate diseases:

160 C3	Diana:	If first one allows it [(i.e. gene therapy)] […] where is the line? […] If one has already has said yes to that one may cure diseases then it becomes really difficult to draw the next line. If one can draw one more at all

While Christina acknowledged the difficulty of deciding which diseases are legitimate, she made attempts to draw the line in terms of nature:

171 C3 Christina: […] but, well, […] it will just revolve around how far one removes oneself from … from, like, our, well, nature, well, from our species. Because one could say that cancer and stuff like that, in some way that isn't natural either, you see. Well, it […] yes maybe it is in evolution that it is something natural because, well, it has come about in some way, you see. Well but, I just think … precisely such […] hard-core diseases if we could call them that… those that do that, for example, a child can only live very few years […] well, [(those diseases)] that completely limit the human being. That isn't natural for the human being, you see

Cristina suggested that the line could be drawn in terms of '*how far one removes oneself from* […] *nature*'. She then used nature to dissociate legitimate diseases from other diseases. Dissociation is an argumentative move in which 'something which is regarded by the audience as a conceptual whole or unity is split up by the speaker into distinct elements'; and which 'imposes a value hierarchy on the different aspects of the original notion that are separated' (Rees, 2009, pp. 3-4; original italics removed). Christina dissociated the concept 'disease' into, on the one hand, '*hard-core*' diseases, which '*completely limit the human being*' and which are not '*natural for the human being*' and, on the other hand, disease that (we presume) are not hard-core, will not completely limit the person, and are natural for humans to have. So from her perspective there are diseases that would be legitimate candidates for gene therapeutic treatment because they obstruct the functioning of the patient, and such diseases are unnatural to have.

Christina's four articulations of nature point to different directions. The first mention suggests that she assimilated a being's nature with that being's species. This suggests a sense of nature as the essential character of humans that insulates the human species from others. Further, it draws on aspects of Nature_1 in Govier's (2010) taxonomy; for nature is something we can remove ourselves from. Her second and fourth articulation of nature also seem to pertain to the essential character of human beings, for here she stipulated that cancer and other diseases that limit the human being are unnatural. This comes closest to an articulation of an anthropocentric version of Nature$_2$. Her third mention of 'nature' pertains to how cancer – as a phenomenon – has originated. In that usage, 'nature' denotes the fact that the existence of cancer can be given a scientific explanation (i.e., cancer does not have supernatural origins). This could indicate that she articulated nature as Nature$_4$. But that would be in stark contrast to her three other usages of 'nature'. For even though she explicitly acknowledges that cancer has a natural explanation it appears that cancer is still one of the hard-core diseases that are unnatural to human beings.

One interpretation of Christina's move could be that she articulated nature in a sense similar to Aristotelian *essence*: The '*hard-core diseases*' severely '*limit*' the process with which the human being actualises its essential potential (Witt, 1989). On this line of reasoning, it would be natural to remove the genetic disposition to have such diseases because such diseases go against the essential nature of human beings. Thus Christina's key argument from nature for the claim that it is possible to distinguish between legitimate and illegitimate diseases involved an articulation of nature as Nature$_3$ in Govier's (2010) taxonomy – which would also be in line with the Aristotelian idea of essence.

Now, Diana immediately challenged the yardstick that Christina proposed: '*It isn't natural only to have four fingers either, you see*' (172 C3); and she elaborated further that

175 C3	Diana:	'I don't know … you see, one can, both become ill by for example radiation … well, then it is not something natural in that sense, you see … but one's cells can also, you see =
[…]		
177 C3	Diana:	= […] well, it depends on what one means by natural … the body can destroy itself, you see … in some way, without there being, in that sense, any extraneous factors
178 C3	Christina:	Yes … Yes

Diana's phrase '*it depends on what one means by natural'* indicate that Diana took issue with Christina's dissociation, by making her own dissociation – namely between different aspects of nature to form a hierarchical distinction between two different senses of nature (implying that the concept of nature that Christina uses was different from concept of nature that she herself thought one ought to use). At the same time Diana provided a factual account that may render her concept of nature more cogent than Christina's. Thus Diana pointed to how some diseases may not be the result of some external cause (such as '*radiation*'), and she treated this information as a reason against the validity of Christina's claim that suffering '*hard-core diseases*' is unnatural for humans. Thus, this was Diana's challenge: Some diseases originate in the human body and therefore these diseases are natural for humans (in the sense that they are native to the human body), regardless of how obstructing they appear to persons who experience them.

The exchange between Diana and Christina indicates the potential of dissociations in socio-scientific discussions, in particular concerning the concept of nature. The two students had to discuss the concept of nature as a subordinate issue in order to manage their disagreement about which diseases would be legitimate targets for gene therapy. This in turn, prompted them to entertain a dissociation, which prompted the invocation of science content. Diana and Christina should arguably have elicited more science content. Nevertheless, the structure of their exchange suggests – similar to the exchange between Angelica and Elliot – that situations in which an interlocutor questions a particular conceptualisation of nature could become a fulcrum for a more detailed scientific debate in which science factual claims can become primary issues.

5.6 Summarising Discussion

The students in this study invoked nature at key places in a variety of dialectical contexts in the discussions. But most often these invocations were, at least initially, uncritical appeals and involved little or no science factual content. The students almost exclusively invoked nature at the subordinate level of argumentation. Thus, in the majority of cases, when a student argued from nature, her interlocutors would either critique her argumentations on *other* grounds than the concept of nature she entertained, or simply accept her argumentation. But while articulations of nature, or of what is natural, seldom were primary issues, these articulations occurred in key dialectical junctions in the discussion about thematic issues.

The finding that appeals to nature were a key part of the students' argumentative arsenal resonate with recent findings that appeals permeate the argumentation of scientific experts in discussions with laypersons (Goodwin & Honeycutt, 2009). Further, the finding that nature was articulated in a variety of ways across dialectical contexts within one discussion – and even within the argumentation of individual students – resonate well with the findings by Cobern, Gibson, and Underwood (1999) about how students conceptualize nature.

This study elaborates on these previous findings and one finding, in particular, should give science educators reason to pause: *Students would typically shift the sense of nature when they were argumentatively challenged, rather than discharging their dialectical obligation to elaborate their argument from nature*. This could indicate that the students did not necessarily subscribe to one particular conceptualisation of nature from which their position or standpoint originated, but rather that a concept of nature was co-opted to fit their argumentative goal in the situation. So 'nature' was occasionally used as the 'jack-of-all-trades' as proposed by the German writer Friedrich Nicolai (cited in Crawford, 2008, p. 322).

In many cases it could be argued that a speaker's argument from nature took shape as her last argumentative resort in the local dialectics of the discussions. It was regularly the case that the arguments from nature involved invocations of nature that, initially at least, were not elaborated. In most cases, the opponents of germ-line gene therapy simply stipulated that this form of treatment would go against a principle of nature or remove the naturalness of the beneficiaries. In such cases, nature was articulated as the highest court of appeals or as the final arbiter of what is wrong and what is right. Pragmatically this makes sense. After all, every arguer faces 'practical difficulties' (such as '[securing] the adequacy of her premises') by having to create 'expeditiously the unchallengeable adequate premises she needs' (Goodwin, 2005, p. 100). Pragmatically speaking, it could appear – *in situ* – that an appeal to nature *as a principle* is more unchallengeable than an appeal to some intrinsic values of unaltered genetic ties. Of course, not every appeal to a higher arbiter is a sign that the arguer has reached the end of the argumentative tethers. In the case of Dwight (see above), he could be interpreted as steering the discussion on to a more principled level on which the issue would be the trade-off between the long-term ethical responsibilities of human agents and the short-term alleviations of patients in pain. But Dwight did not just steer the discussion on to a more principled level, he also stipulated *as a given truth* that one ought not alter the genetic material of germ-line cells on pain of breaking with some principles of nature.

The students rarely elaborated on their invocation of nature, and the interlocutors also rarely confronted a given invocation of nature directly. In most cases the interlocutors either accepted the argument from nature or challenged the cogency of the argument on other aspects than the invocation of nature. This meant that it was all too often unclear what a given invocation of nature signified. And although it was possible *post factum* to piece together an interpretation of a given invocation of nature as an articulation of nature in a specific sense or with a specific referent, such information seems to have been unavailable to the interlocutors *in situ*. This is unfortunate because it seems that it is exactly such argumentative moves that interlocutors critically engage with in socio-scientific discourse (e.g. Sadler & Zeidler, 2006; Zeidler, Osborne, Erduran, Simon, & Monk, 2006).

A major interpretive claim is that confrontations of invocations of nature can potentially spark the introduction of science content. The apparent lack of science content in students' socio-scientific discussions has been a thematic issue in science education (e.g., Albe, 2008; Lewis & Leach, 2006; Ratcliffe, 1997; Sadler & Donnelly, 2006). Cases such as the exchanges between Angelica and Elliot and between Christina and Diana suggest that it would be a good investment for teachers to thematise the problematic character of arguments from nature. In both these cases there are indications that the participants had competing conceptions of what is natural, or at least how to argue from what is natural, and this prompted the invocation of science factual content in the argumentation. Thus if students are encouraged to probe others' invocation of nature more critically, it could potentially spark argumentative exchanges in which science factual content becomes the primary issue. Further such dialectical probing is generally conducive to the construction of more complex disciplinary knowledge (e.g., Leitão, 2000).

A final overall interpretive finding of this study concerns the complexity of the students' argumentation. Parsing the practical significance of a given articulation of nature is a delicate affair that has to take into account the dialectical context of that articulation. This could be a fundamental obstacle for teachers who aspire to evaluate such discourse on the fly. If, however, teachers are sensitive to the fact that 'nature' is most often a flexible placeholder for sets of personal values, they would be better equipped to critically engage with students' elaborate appeals to nature.

While this study has focussed on invocations of nature, it may be well worth to consider invocations of *religion* in future normative pragmatics studies of socio-scientific discourse. Incidentally, religious questions and references to religion, in general, only played a marginal role in the present data set. Mentions of religion occurred in two forms. First, when students mention 'God' it happened in a discussion of James Watson's statement in the written material – namely, 'if scientists don't play God, who will?' (Watson, quoted in Sadler & Zeidler, 2004, p. 432). In those cases, the issue was the role of science in society; religion did not as such enter into the discussion. Second, in the cases in which the terms 'religion' or 'religious' are mentioned it seems that the students want to signal that the issue of gene therapy may be *more controversial in more religious regions of the world.* For example, Donna suggested that 'one may be somewhat flexible in Denmark because we are not so religious' (89 A2). And while some participants did perceive themselves as religious, it does not appear that they *conspicuously used* references to religion in argumentative strategies. But more studies in this area are needed.

5.6.1 Limitations

This study was exploratory and did not aim to be exhaustive or generalisable. Thus this study belongs to an emerging trend among qualitative studies on discursive aspects of socio-scientific issues (e.g., Albe, 2008; Barrett & Nieswandt, 2010; Lindahl, 2009; Pouliot, 2008). It is plausible that students in other contexts will invoke nature in different ways and within different argumentative strategies. Indeed, this paper has only presented eight sequences in which nature was invoked. Other students also invoked nature beyond what was represented here. And while other sequences resemble one or more of the sequences presented here, there will always be slight differences. The sequences presented here were chosen because they do represent *different generic features* of argumentative strategies involving the invocation of nature; and because they do indicate that while references to nature are few in numbers, such references *can potentially* play an important role in the dialectics of socio-scientific discussions. So the purpose of this study was *not* to enumerate *all* different strategies that involve invocations of nature. Rather, the aim of this study was to demonstrate that such strategies exist, describe how they work, and critically assess how they are put to use.

5.7 Conclusion and Implications

Researchers, policymakers, and other stakeholders harbour a strong conviction that socio-scientific issues in everyday life call for scientifically informed decisions. Though the students in this study *did* invoke science in their arguing, it is clear that they utilized (occasionally elaborate) strategies of appealing to nature and that they only to a little extent invoked science in order to ground such appeals. The students in this study generally used nature as a normative arbiter in the discussion, and the discussions mostly lacked direct attempts to probe the cogency of a particular reference to nature. This is unfortunate because it appears that this would be a futile forum for invocations science content in order to dialectically sort out the *factual background* against which an evaluative judgement can be made. For example, invoking science in order to deliberate whether the participants should agree that natural selection is a key principle that ought not be disrupted. Indeed *if* bioethical scholars are correct in holding that the appraisal of the cogency of arguments from nature is a key aspect of bioethical discussions, *then* the interpretive findings of this study suggest that science educators need to be more attentive to how students elicit and engage with such arguments in socio-scientific discussions (at least in cases of bioethical socio-scientific issues).

Just as it has been argued that teachers need to thematise the fact-value distinction when introducing socio-scientific issues (Albe, 2008; Kolstø, 2001; Sadler & Zeidler, 2006; Zeidler, et al., 2006), this study suggests that it is futile for teachers to thematise the equivocality and evaluative character of invocations of nature. It seems that students would not need many argumentative tools in their arsenal to begin to engage more critically with their peers' invocations of nature. If students were introduced to, for example, Govier's (2010) taxonomy and the problems that pertain to the four different senses of nature, it might not just have a positive impact on their argumentation but also indirectly spark more fruitful discussions about the factual background of a given appeal to nature, thus enabling students to make more informed decisions about societal issues that relate to science.

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5.9 References

Albe, V. (2008). Students' positions and considerations of scientific evidence about a controversial socioscientific issue. *Science & Education, 17*(8-9), 805-27.

Andersson, T. (1993). Views on Nature in Metaphorical Discourse. Retrieved from http://www.lucs.lu.se/LUCS/006/LUCS.006.pdf

Barrett, S.E., & Nieswandt, M. (2010). Teaching about ethics through socioscientific issues in physics and chemistry: Teacher candidates' beliefs. *Journal of Research in Science Teaching, 47*(4), 380-401.

Blakemore, D. (1987). *Semantic constraints on relavance*. Oxford: Blackwell Publishers Ltd.

Boshammer, S. (1998). Discussing HUGO: The German Debate on the Ethical Implications of the Human Genome Project. *Journal of Medicine and Philosophy, 23*(3), 324-33.

Bourdeau, P. (2004). The man–nature relationship and environmental ethics. *Journal of Environmental Radioactivity, 72*, 9-15.

Brandom, R.B. (1994). *Making It Explicit: Reasoning, Representing, and Discursive Commitment*: Harvard University Press.

Carvalho, G.S., Tracana, R.B., Skujiene, G., & Turcinaviciene, J. (2011). Trends in Environmental Education Images of Textbooks from Western and Eastern European Countries and Non-European Countries. *International Journal of Science Education*, (Advance online publication). Retrieved from http://dx.doi.org/10.1080/09500693.2011.556831

Castree, N. (2005). *Nature*. London ; New York: Routledge.

Clark, D.B., D'angelo, C.M., & Menekse, M. (2009). Initial Structuring of Online Discussions to Improve Learning and Argumentation: Incorporating Students' Own Explanations as Seed Comments Versus an Augmented-Preset Approach to Seeding Discussions. J Sci Educ Technol, 1-13.

Cobern, W.W., Gibson, A.T., & Underwood, S.A. (1999). Conceptualizations of nature: An interpretive study of 16 ninth graders' everyday thinking. *J. Res. Sci. Teach., 36*(5), 541-64.

Crawford, D.W. (2008). The Aesthetics of Nature and the Environment. In Peter Kivy (Ed.), *The Blackwell Guide to Aesthetics* (pp. 306-24). Oxford: Blackwell Publishing Ltd.

Danish Ministry of Education. (2010). *Bekendtgørelse om uddannelsen til studentereksamen. Nr 692 af 23/06/2010 (Executive Order nr. 692 of 23/06/2010).*

Denzin, N.K., & Lincoln, Y. (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.

Ekborg, M., Ideland, M., & Malmberg, C. (2009). Science for life – a conceptual framework for construction and analysis of socio-scientific cases. *NorDiNa, 5*(1), 35-46.

Engestöm, Y. (1981). The laws of nature and the origin of life in pupils' conciousness: a study of contradictory modes of thought. *Scandinavian Journal of Ecucational Research, 25*(82), 39-61.

Ergazaki, M., & Ampatzidis, G. (2011). Students' Reasoning about the Future of Disturbed or Protected Ecosystems & the Idea of the 'Balance of Nature'. *Research in Science Education,* (Advance online publication). Retrieved from http://dx.doi.org/10.1007/s11165-011-9208-7. doi:10.1007/s11165-011-9208-7

EU-Commision. (2004). Europe needs more scientists. *Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe*, 1-215.

Ferrari, M., & Chi, M.T.H. (1998). The nature of naive explanations of natural selection. *International Journal of Science Education, 20*(10), 1231-56.

Fraser, B. (1990). An approach to discourse markers. *Journal of Pragmatics, 14*(3), 383-98.

Galvão, C., Reis, P., Freire, S., & Almeida, P. (2010). Enhancing the Popularity and the Relevance of Science Teaching in Portuguese Science Classes. *Research in Science Education*, 1-16.

Gilbert, M.A. (1997). *Prolegomenon to a Pragmatics of Emotion.* Paper presented at the Ontario Society for the Study of Argumentation, Brock University, St. Catherine's, ON. Retrieved from http://www.yorku.ca/gilbert/argthry/argthry/arg-papers/mag1997-prol-emo.pdf.

Glass, B. (1971). Science: Endless Horizons or Golden Age? *Science, 171*(3966), 23-9.

Goodwin, J. (2000). Comments on 'Rhetoric and Dialectic from the Standpoint of Normative Pragmatics'. *Argumentation, 14*(3), 287-92.

Goodwin, J. (2001). One Question, Two Answers. *Argumentation and Its Implications*, 1-17.

Goodwin, J. (2005). Designing premises. In F.H. van Eemeren & P. Houtlosser (Eds.), *Argumentation in Practice* (pp. 99-114). Amsterdam: John Benjamins.

Goodwin, J., & Honeycutt, L. (2009). When Science goes Public: From Technical Arguments to Appeals to Authority. *Studies in Communication Sciences, 9*(2), 19--30.

Govier, T. (2010). *A Practical Study of Argument* (7th ed.). Belmont: Wadsworth Cengage Learning.

Haluza-Delay, R. (2001). Nothing Here to Care About: Participant Constructions of Nature Following a 12-Day Wilderness Program. *The Journal of Environmental Education, 32*(4), 43-8.

Holland, S. (2003). *Bioethics. A philosophical Introduction*. Cambridge: Polity.

Innocenti, B. (2006). A normative pragmatic perspective on appealing to emotions in argumentation. *Argumentation, 20*(3), 327-43.

Jacobs, S. (2000). Rhetoric and dialectic from the standpoint of normative pragmatics. *Argumentation, 14*(3), 261-86.

Jaszczolt, K. (2002). *Semantics and pragmatics: meaning in language and discourse*. Harlow: Pearson Education.

Johnson, R.H. (2000). *Manifest rationality: a pragmatic theory of argument*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Kauffeld, F.J. (1998). Presumptions and the distribution of argumentative burdens in acts of proposing and accusing. *Argumentation, 12*(2), 245-66.

Kock, C. (2007). Norms of legitimate dissensus. *Informal Logic, 27*(2), 179-96.

Kock, C. (2009). Choice is Not True or False: The Domain of Rhetorical Argumentation. *Argumentation, 23*(1), 61-80.

Kolstø, S.D. (2001). 'To trust or not to trust, . . .'- pupils' ways of judging information encountered in a socio-scientific issue. *International Journal of Science Education, 23*(9), 877-901.

Kolstø, S.D. (2006). Patterns in Students' Argumentation Confronted with a Risk ‑ focused Socio ‑ scientific Issue. *International Journal of Science Education, 28*(14), 1689-716.

Korfiatis, K.J., Stamou, A.G., & Paraskevopoulos, S. (2004). Images of nature in greek primary school textbooks. *Science Education, 88*(1), 72-89.

Latour, B. (2004). *Politics of nature: how to bring the sciences into democracy*. Cambridge, Mass.: Harvard University Press.

Leitão, S. (2000). The potential of argument in knowledge building. *Human Development, 43*(6), 332-60.

Lewis, J., & Leach, J. (2006). Discussion of Socio-scientific Issues: The role of science knowledge. *International Journal of Science Education, 28*(11), 1267 -- 87.

Lindahl, M.G. (2009). Ethics or Morals: Understanding Students' Values Related to Genetic Tests on Humans. *Science & Education, 18*(10), 1285-311.

Minteer, B.A. (2009). *Nature in common? Environmental ethics and the contested foundations of environmental policy*. Philadelphia: Temple University Press.

Nielsen, J.A. (2010), Functional roles of science in socio-scientific discussions. In Ingo Eilks & Bernd Ralle (Eds.) *Contemporary Science Education – Implications from Science Education Research about Orientations, Strategies and Assessment* (pp. 83-96). Aachen: Shaker.

Nielsen, J.A. (To appear), Co-opting Science: A preliminary study of how students invoke science in value-laden discussions. *International Journal of Science Education*.

Nielsen, J.A. (in review). Science in Discussions: An analysis of the use of science content in socio-scientific discussions, 48p. Manuscript submitted for publication.

OECD. (2006). *Assessing, Scientific, Reading and Mathematical Literacy - A Framework for PISA 2006*. Paris: OECD.

Östman, L. (1998). How companion meanings are expressed bys cience education discourse. In D.A. Roberts & Leif Östman (Eds.), *Problems of meaning in science curriculum* (pp. 54-70). New York: Teachers College Press.

Östman, L. (2010). Education for sustainable development and normativity: a transactional analysis of moral meaning-making and companion meanings in classroom communication. *Environmental Education Research, 16*(1), 75 - 93.

Pouliot, C. (2008). Students' inventory of social actors concerned by the controversy surrounding cellular telephones: A case study. *Science Education, 92*(3), 543-59.

Preston, N. (2007). *Understanding ethics* (3rd ed.). Leichhardt: Federation Press.

Ratcliffe, M. (1997). Pupil decision-making about socio-scientific issues within the science curriculum. *International Journal of Science Education, 19*(2), 167-82.

Rees, M.V. (2009). Dissociation in Argumentative Discussions: A Pragma-dialectical Perspective.

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-36.

Sadler, T.D., & Donnelly, L. (2006). Socioscientific Argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463-88.

Sadler, T.D., & Zeidler, D.L. (2003). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education, 88*(1), 4-27.

Sadler, T.D., & Zeidler, D.L. (2004). Negotiating Gene Therapy Controversies. *The American Biology Teacher, 66*(6), 428-33.

Sadler, T.D., & Zeidler, D.L. (2006). Scientific Errors, Atrocities and Blunders. In Dana L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 261-85). Dordrecht: Springer.

Sherlock, R. (2002). Three Concepts of Genetic Trespassing. In Richard Sherlock & John D. Morrey (Eds.), *Ethical issues in biotechnology* (pp. 149-60). Lanham: Rowman & Littlefield.

Sherlock, R., & Morrey, J.D. (2002). Introduction. In Richard Sherlock & John D. Morrey (Eds.), *Ethical issues in biotechnology* (pp. 1-29). Lanham: Rowman & Littlefield.

Singer, P. (2006). New Assisted Reproductive Technology. In Helga Kuhse & Peter Singer (Eds.), *Bioethics: an anthology* (2nd ed., pp. 99-102). Oxford: Blackwell Pub.

Soper, K. (1995). *What is Nature?* Oxford: Blackwell Publishers Ltd.

Sorell, T. (1994). *Scientism: Philosophy and the Infatuation with Science.* London: Routledge.

Sousa, R.d. (1980). Arguments from nature. *Zygon, 15*(2), 169-91.

Tseronis, A. (2009). *Qualifying standpoints. Stance adverbs as a presentational device for managing the burden of proof.* Utrecht: Netherlands Graduate School of Linguistics.

van Eemeren, F.H., & Grootendorst, R. (1989). Speech act conditions as tools for reconstructing argumentative discourse. *Argumentation, 3*(4), 367-83.

van Eemeren, F.H., Grootendorst, R., & Snoeck Henkemans, F. (2002). *Argumentation: analysis, evaluation, presentation*. Mahwah, N.J.: L. Erlbaum Associates.

van Eemeren, F.H., & Houtlosser, P. (2007). The study of argumentation as normative pragmatics. *Pragmatics: Quarterly Publication of the International Pragmatics Association, 15*(1), 161-77.

van Eemeren, F.H., Houtlosser, P., & Snoeck Henkemans, A. (2007). *Argumentative indicators in discourse: a pragma-dialectical study*. Dordrecht: Springer.

Walker, K., & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-410.

Willgoos, C. (2001). FDA Regulation: An Answer to the Questions of Human Cloning and Germline Gene Therapy. *American Journal of Law & Medicine, 27*, 101-24.

Witt, C. (1989). *Substance and essence in Aristotle: an interpretation of Metaphysics VII-IX*. Ithaca: Cornell University Press.

Yin, R.K. (2009). *Case Stuy Research. Design and Methods*. Thousand Oaks: Sage.

Zeidler, D.L., Osborne, J., Erduran, S., Simon, S., & Monk, M. (2006). The Role of Argument During Discourse About Socioscientific Issues. In Dana L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education* (pp. 97-116). Dordrecht: Springer.

Zimmerman, C., & Cuddington, K. (2007). Ambiguous, circular and polysemous: students' definitions of the 'balance of nature' metaphor. *Public Understanding of Science, 16*, 393-406.

6

General Discussion

6.1 Overview

This final section discusses the interpretive findings that were presented in Papers II through IV. While each paper contained an individual discussion, this section discusses the interpretive findings from a more general perspective and it envisages some general implications for research and teaching. The rest of this subsection briefly reiterates the empirical papers. Subsection 6.2 presents the general discussion of the interpretive findings. Subsection 6.3 discusses the methodological considerations that arise from conducting qualitative interpretivist research that purely investigates dialogical argumentation; and it presents a number of limitations that consumers of this study's findings should be aware of. Finally, subsection 6.4 presents some final conclusions and remarks.

6.1.1 Paper II: *Co-opting Science*

This paper presented the initial preliminary analysis of three discussions – one from each class. The paper took a specific focus on how the students in the study interweaved science content and evaluative statements: *How and for what purpose do students interweave factual and evaluative statements in group discussions about a controversial socio-scientific issue*?

The interpretive findings of this study suggest that the students regularly *co-opted* science factual knowledge claims *to feather their own argumentative nests*. Further, it was possible to identify a certain pattern of such co-option strategies: The speaker would interweave science facts an evaluative claims by presenting science factual content *alongside* a value-laden challenge to her interlocutor. This strategy, it is argued, has palpable pragmatic effects in the discussion situation. In particular, this strategy acts as a scaffold for the speaker's attempt to *frame* the issue in a way that beneficial for her project of asserting influence on her interlocutors' decisions.

6.1.2 Paper III: *Science in Discussions*

This paper presented an analysis of all eight discussions. Unlike Paper II, the research question of this paper was more akin to the general research questions (RQ 1 and 2; see Section 1.3): *What argumentative roles do invocations of science content have in students' group discussions about a controversial socio-scientific issue, and what effects on the dialectics of the discussion do such invocations have*?

On the one hand, the students *drew* on science in the process of articulating and identifying issues that they deemed salient for their discussion about human gene therapy. Pragmatically, such usages of science established the factual background for an ensuing socio-scientific negotiations: The science content delimited a series of possible issues that would have potential relevance for the making a decision on whether gene therapy should be allowed. On the other hand, science content played a strong role in responses to previous lines of arguing by introducing, or directly *framing*, an issue as well as providing argumentative support for a specific position towards that (framed) issue. The argumentative force of this general usage of science is a result of the potential of such expressions (explicit as well as implicit) to establish a shared starting point (a statement to which all arguers could agree) which did more than inform the discussion: The matter-of-factual lens afforded by invoking science could be harnessed to make it appear that there is an intuitive position to the issue, or it at least challenges the interlocutor with an increased burden of proof.

6.1.3 Paper IV: *Arguing from Nature*

The final paper presented an analysis of the eight discussions with a more specific focus – the invocation of the concept of Nature, or of what is natural: *What argumentative roles do students' arguments from nature have in the context of small-group discussions about human gene therapy; and to what extent do students invoke science content in their articulations of nature*?

While invocations of nature (or of what is natural) where few in number, the normative pragmatics analysis of these invocations does suggest that the invocations of nature played a key role in the respective discussions. Most often these invocations were, at least initially, uncritical appeals and involved little or no science factual content. Further, the students would typically shift the sense of nature when they were argumentatively challenged, rather than discharging their dialectical obligation to elaborate their argument from nature. The students rarely elaborated on their invocation of nature, and the interlocutors also rarely confronted a given invocation of nature directly. Though the students *did* invoke science in their arguing, it is clear that they utilized (occasionally elaborate) strategies of appealing to nature and that they only to a little extent invoked science in order to ground such appeals. Nevertheless, confrontations of invocations of nature could potentially spark the introduction of science content.

6.2 Summarising Discussion

This dissertation has sought to thematise how students use science content in socio-scientific discussions. As discussed in the General Introduction, this issue was operationalized in terms of argumentation: The goal has been to elucidate the argumentative roles that invocations of science content can have in students' group discussions about a socio-scientific issue (cf. Section 1.3).

Concretely, this dissertation has been guided by the attempt to accomplish three research aims (cf. Section 1.3.1):

(1) To review the relevant literature in order to establish a foundation for a viable framework for analysing students' socio-scientific argumentation;
(2) to conduct a suitable empirical study that can be used to elaborate on the general research question;
(3) to indicate the empirical applicability of normative pragmatics.

The ground covered in the General Introduction (Sections 1.2, 1.4, and 1.6) as well as in Paper I are concrete attempts to meet the first research aim. It has been argued that socio-scientific argumentation is typically practical argumentation – about what to do, not just what is true – and that this argumentation among students should be understood as manifesting both *rhetorical* and *dialectical* features. As argued in Paper I, the dialectical features of students' argumentation constrains the analyst's choice of analytical framework. *If* researchers are interested in studying students' dialogic argumentation, *then* they have to go beyond frameworks such as the Toulmin model. This dissertation has argued that a potential framework is normative pragmatics and it has presented a series of applications of that framework in order to elaborate on both the general research questions, as well as a number of subordinate research questions. The viability of normative pragmatics (the third research aim) is based on the flexibility of normative pragmatics to elaborate on a number of different research questions.

In order to reach the second research aim this dissertation has presented an empirical study in which eight groups of students discussed whether to allow human gene therapy. The General Introduction (Sections 1.5 and 1.6) has presented in detail the design and methods of this study and the interpretive findings has been presented in Papers II through IV. The remainder of this section will focus primarily on what can be learned from the interpretive findings of the empirical part of this study.

6.2.1 On Two General Roles of Science Content

The interpretive findings suggest that invocations of science content can play multifarious roles in socio-scientific discussions. In other words, science can be invoked in a multitude of different argumentative strategies. While these strategies differ substantially in relation to their respective contexts, it has been possible to identify at least two general types of invocations.

On the one hand, science was invoked in an *informative* fashion. In such cases, a student (or a number of students) would present a science content in a way that established the factual background for the ensuing value-laden, socio-scientific deliberation. For example, the assertion that germ-line gene therapy has hereditary effects can – depending on the context, of course – can have the practical significance of, *signalling* that the subject (germ-line gene therapy) may *potentially* be an object of moral discussion. Indeed, in many cases such invocations affected the discussion by making the factual background *transparent* to the interlocutors, so that they could later *draw* on this information in their value-laden deliberation. This is the important point: Arguers can elicit or negotiate science factual knowledge about the causal properties of some object or phenomenon in order to propose – in a transparent fashion – *a range of possible issues may be considered in the deliberation*. In other words, science knowledge can open potential issues for the arguers and it can invite considerations about which issues are important in the deliberation. This should not be too surprising. After all, this role of science is quite possibly what most science educators have in mind.

On the other hand, science was often invoked creatively and selectively in ways that not only *framed* the issue, but also created (pragmatic) support for a specific standpoint towards the framed issue. In such cases, the speaker was conspicuously *not* concerned with merely opening a range of potential issues. Rather, this type of invocation affords a speaker to *hone in* on one aspect of a specific issue with the strategic potential to *close* the discussion in her favour. The schematics of such a general strategy is presented in more detail in Papers II and III (Sections 3.4 and 4.5). Roughly put, the strategy consists of *the presentation of science content in conjunction with a value-laden challenge to a previous line of arguing from the interlocutor*. The argumentative force of this strategy is a result of the potential of science factual knowledge to establish a shared starting point (a statement to which all arguers could agree) which accomplishes more than inform the discussion: The matter-of-factual lens afforded by invoking science could be harnessed to *make it appear* that there is an intuitive position to the issue, or it at least challenges the interlocutor with an increased burden of proof. So the speaker can use the relative determinacy and certainty of a science knowledge claim to create a pragmatic reason for her interlocutor to acknowledge her value-laden standpoint (or challenge).

The latter of these two ways of using science content has, through out this dissertation been labelled *co-opting science*. For this is exactly what happens. The speaker takes a science content and makes it fit her own argumentative purposes. As discussed in Papers II and III, the speaker who co-opts science in the above manner may very well fail to discharge her dialectical obligations. Indeed, the speaker can effectively cloud the fact that it may be relevant to deliberate whether the issue should be framed in this particular way, and, if so, whether the position she proposes to the framed issue is acceptable at all.

Again, science can easily be seen as playing multifarious roles in socio-scientific discussions; so there is possibly not a definitive list of roles to be made. Further*, it is entirely possible that other students would use other strategies and that other topics, or issues, would foster different types of strategies*. As discussed in Section 6.3 below, this study did not aim at making an exhaustive list of such strategies. Nor did this study seek to make generalised claims about such strategies. But on the basis of the analysis, it is possible to point to the existence of certain strategies in this data set and that, though individual usages of science differed across contexts; and it is possible to extrapolated the above two very general ways in which science was used.

Papers II and III connect, in detail, these interpretive findings concerning to previous research on socio-scientific issues (see Sections 3.4 and 4.5). This will not be reiterated at length here. It suffices to remark that the findings of this study indicate that there is a lot to learn about *how* students invoke science in socio-scientific discussions. Indeed, this study should signal the viability of a new research vista that complements the two predominant focal points in previous research on socio-scientific argumentation – namely, (a) the extent to which students use science in socio-scientific argumentation and (b) the affect that the level of disciplinary knowledge has on the quality of such argumentation (cf. Section 1.2). For on the basis of the interpretive findings of this study it seems clear that even few invocations of science may have wide-reaching effects on the ensuing deliberation, and that science content can be used in ways that make a questionable contribution to the critical quality of socio-scientific deliberations.

A notable feature of the use of science was the fact that such invocations were often contextually (or dialectically) complex in the sense that they involved subtle challenges to others and were executed in several talk turns at different places in the overall discussion sequence. This is a point that will be discussed further below.

When asking questions like 'How did students discuss this particular socio-scientific issue?', invocations of science content are not the only feature that could interest science educators. Paper IV presents an example of an auxiliary object of study – namely invocations of nature, or of what is natural. Initially the parallel study, which is presented in that paper, sprung out of an emerging hypothesis from the initial analysis: That the arguers seemed to make quite elaborate appeals to nature as a sort of arbiter in the discussions. Eventually the study afforded a window into the fascinating strategic processes involved when students articulate what is natural: Namely, (i) that the students articulated nature at key dialectical junctions in the discussion of thematic issues, (ii) that such articulation had the form of uncritical appeals to nature as an arbiter over what to do, and (iii) that *when* a student's articulation of nature was challenged, *then* that student would typically simply *shift* the sense of nature rather than elaborating her argumentation.

In the context of this dissertation, Paper IV provides an additional proof of concept of not just the viability of asking how students manage socio-scientific deliberations, about also – and more importantly – of using normative pragmatics in order to elaborate on a multitude of research questions in science education. This, then, goes in the direction of satisfying the third research aim of this dissertation (i.e. to indicate the empirical applicability of normative pragmatics; cf. Section 1.3).

6.2.2 Some Implications for Research and Teaching

As argued in Section 1.2.3.1, science education researchers ought to postpone any commitment to focus on science content *as evidence* in students' socio-scientific deliberations. To reiterate, this is not just a question of the finer details of socio-scientific discourse: Often (functional) scientific literacy is defined in a way that accentuates the ability to use scientific evidence in decision-making on societal problems (Cavagnetto, 2010; Kelly, 2011; Ryder, 2001). So any discussion about whet it means to use scientific evidence in socio-scientific argumentation is *ipso facto* a discussion about what it means to be scientifically literate. As argued earlier, this study did not presume that science content figures *only* as evidence in socio-scientific discourse. Rather, this study sought to explore what roles such content may have in actual socio-scientific deliberations among students.

As presented in Papers II and III, the students in this study occasionally made outright attempts to make it apparent that a personal standpoint was directly based on scientific evidence. In such cases, the speaker presented a science factual statement so as to provide pragmatic support for a particular way of framing the issue, and so as to provide pragmatic support for a particular standpoint towards that framed issue. But a decision would hardly be an evidence-based decision if the 'evidence' is used in a way that clouds the question of which factors or aspects are relevant to consider in making the decision. So it would be misleading to say that these students used science content as evidence in any usual sense of that term.

These interpretive findings raise an important issue: *Is there a different to be made between felicitous and non-felicitous usages of science content*? In the papers (Papers II and III), I have indicated that I think this difference exists when we are dealing with rhetorical-*cum*-dialectical argumentation about socio-scientific issues; and I have indicated that we could spell out the difference in terms of whether the speaker, who used science, did sufficiently discharge her *dialectical obligations* – such as transparently comparing pros and cons of a decision (Kock, 2008), presenting reasons for a specific way of interpreting an issue or aspects of an issue (Kock, 2007), and not misrepresenting the argumentation of her interlocutor (Johnson, 2002). On that basis, I proceeded to give tentative suggestion for how science content could felicitously enter socio-scientific deliberations: Namely*, in (truly) collaborative attempts to establish the factual background of the ensuing value-laden decision-making process*. We could hope that, in such cases, while the arguers' value-laden criteria for decision-making are their reasons for their socio-scientific decision about what to *do*, the scientific evidence that they cite is cited in order to delineate *which* phenomena or causal processes may relevant subjects of the value-laden criteria. For example, the science fact that 'germ-line gene therapy has hereditary effects' could felicitously enter into a socio-scientific discussion if it was cited in order to say something about the causal properties of germ-line gene therapy (as opposed to the case in which it was cited in order to *also* say something about a value-laden state of affair). In that case, the science fact is used merely to signal that there are some specific causal properties of germ-line gene therapy ('that it has hereditary effects') and that it is in light of these causal properties *in tandem* with a guiding value-principle ('that it *can* be morally contentious to engineer the genetic layout of future generations') that it ('germ-line gene therapy') candidates as relevant object of value-laden deliberation. The key here is to highlight the tandem of facts and value-principles: *Socio-scientific decision that rest on value-principles without science content are* (potentially) *non-informed* (yet logically consistent); *socio-scientific decision that rest on science content without* (explicit and transparent) *value-principles are dogmatic* (and logically contentious).

This proposal seems to suggest a sharp ontological distinction between facts and values. Indeed, the bulk of the feedback that I have received about this project so far has pertained to this point: Is it cogent to make the distinction between facts and values that I made in Paper I? Of course, this has been a perennial issue in philosophy, and it is correct that most pragmatists explicitly argue for the dismantling the sharp distinction. Most (in)famous is, of course, Searle's (1964) attempt to use speech act theory to argue that speaker can consistently derive moral statements from factual ones. Nevertheless, it is still an open question whether such attempts actually succeed (Hill, 2008; Samuels, 1973; Thomson & Thomson, 1964). Further, even Putnam (2002, 2004) – who has been one of the starkest opponents of an *ontological dichotomy* between facts and values – has argued for there being a clear need to make a *pragmatic distinction*:

> If we *disinflate* the fact/value dichotomy, what we get is this: there is a distinction to be drawn (one that is useful in some contexts) between ethical judgments and other sorts of judgments. This is undoubtedly the case, just as it is

> undoubtedly the case that there is a distinction to be drawn (and one that is useful in some contexts) between *chemical* judgments and judgments that do not belong to the field of chemistry. *But nothing metaphysical follows from the existence of a fact/value distinction in this (modest) sense* (Putnam, 2002, p. 19).

So even though we should not tolerate a sharp dichotomy, there must be a pragmatic distinction between ought-statements and is-statements. For the purpose of this dissertation that pragmatic distinction is enough. So while my proposal above, about the virtues of arguing transparently about what are the facts and what are the values that we – the deliberators – draw our decision on, may appear to smuggle in a very committing ontological stance, it is merely an attempt to emphasize that it would – *pragmatically speaking* – be beneficial if students' socio-scientific discourse is more *transparent* in sense of making explicit their decision criteria.

But, of course, my proposal is only a tentative bid. More reflections on, and discussions about, the question of whether science can be used non-felicitously are needed. But this much seems to be clear: *The focus could not just be on whether students use science correctly; we also need to consider whether students correctly use correct science*. And the challenge that meets science educators is the following: While the formal validity of co-option strategies – such as those that have been described in this dissertation – is questionable, *such strategies are a part of discursive reality*. Thus *if* one is to make informed decisions about socio-scientific issues, *then* one must be able to expeditiously identity such strategic attempts from one's interlocutor and to act accordingly. In short, part of what it means to be a *critical* language user is the ability to recognise such strategies *as* strategies and probe them as such.

It may be objected that science education research has been very attentive to the critical component of scientific literacy. But most often this critical component pertains to whether a student can critique evidence – in the sense of a "critical examination of scientific information related to socioscientific issues" (Kolstø, et al., 2006, p. 632). And while this type of critical examination of the validity of an evidence claim is a central part of what it means to do good science, it is not necessarily the same type of critical ability that is required to discuss socio-scientific issues. The ability to identify co-option strategies and to probe such strategies cannot be reduced to the ability to probe the validity of the invoked information.

Most scholars would agree that doing science is something different from reflecting upon socio-scientific issues. But do we really appreciate the radical nature of this difference? This study has thematised a number of aspects of students' socio-scientific discourse that puts further emphasis on this difference. And, as such, we touch upon the very core of the science education community's reflections on what it means to ask of students to make scientifically informed decisions on socio-scientific issues. And while I have tentatively proposed one way to talk about the complex discursive processes involved in socio-scientific discussions, there is probably more need than ever for a focused and detailed discussion about the conceptual underpinnings of what is to be expected when students discuss socio-scientific issues. Again, the importance of this discussion is emphasised by the fact that our notion of what it means to be scientifically literate hinges, to a large part, on what it means to use science on problems from outside science.

Now, even if the scholarly field accomplishes to settle on a fitting conceptualization of what it means to engage students in socio-scientific discussions there will still be a challenge of articulating how teacher ought to *assess* students' socio-scientific discourse. One of the concrete challenges is that reflections about arguers' argumentative strategies is not a part of most science teachers' repertoire. This is related to a general problem concerning socio-scientific issues, which was recently raised by Simmoneaux (2011): There is a real challenge when science teachers who are not used to teaching about values and philosophical issues become arbiters in socio-scientific activities.

One way of meeting this challenge could be to create a sand box in which prospective science teachers can design hypothetical socio-scientific activities in an interdisciplinary collaboration between the natural sciences and the humanities. In the Danish context, I have been involved in a new master-level course for prospective science and mathematics teachers, in which the prospective teachers are introduced to, apply, and reflect upon, various theoretical frameworks on *interdisciplinary teaching* with a focus also on interdisciplinary work between the humanities and the natural sciences (Jankvist, Nielsen, & Michelsen, 2011). But of course such approaches are still very tentative, and nothing can yet be said about the outcome in terms of how well these future teachers are equipped for socio-scientific activities.

A more disconcerting challenge for assessment is the *complexity* of socio-scientific discourse. The pragmatic mechanisms in socio-scientific discussions that have been portrayed in this study are so complex that it would simply not be possible for teachers to expeditiously identify all the subtle aspects and the complex dialectical moves in their students' argumentation. The interpretive findings suggest that students' argumentative strategies can develop over considerable discussion real-estate (in terms of turns and time) so even acute attention to individual statements or brief exchanges would not be enough for a teacher to disclose some strategic attempts. Further, while individual statements or exchanges can have a specific local role, these statements or exchanges can later in the process play into other, more complex, argumentative strategies.

These interpretive findings do suggest that comprehensive assessment of students' socio-scientific discourse will require detailed information about the dialectical processes in which that discourse occurred. And that poses a very real practical challenge for teachers: In daily teaching practice, the kind of deep analysis made in this study is not possible. It is safe to say that normative pragmatics – and the four-step analysis procedure – is a research tool, not a tool for assessment. There is then a serious need for a scholarly discussion about how teachers can best be equipped to assess their students' socio-scientific activities.

Finally, some of the interpretive findings of this study imply suggestions for future preparations for socio-scientific discussions. Concretely, since elaborate argumentative strategies were part of these students' repertoires, it would be advisable to consider direct attention to such strategies and how they could be probed. As argued in Papers II through IV, it would make sense to introduce students to archetypical themes in bioethical discussions – such as the different pragmatic roles of factual and evaluative statements, generic notions of what is natural, and archetypical forms of bioethical arguments. One could hope that students would be able to draw on this *argumentative* landscape in their socio-scientific discussions. But that would be the topic of future research.

6.3 Methodological Considerations

The empirical part of this study was a *qualitative interpretivist* study. More specifically, this study was a piece of applied argumentation theory or, *applied philosophy*. In such studies, it is notoriously difficult to define and assess traditional research virtues such as *reliability*, (internal) *validity*, and *generalizability* (external validity). Indeed, it does not necessarily make sense to gauge interpretivist studies according to these virtues, for "[r]eliability and validity are tools of an essentially positivist epistemology" (Watling cited in Simco & Warin, 1997, p. 670). The issue of whether these virtues should be reformulated or even abandoned in post-positivist epistemologies is, of course, perennial (Corbin & Strauss, 2008; Creswell, 1998; Creswell & Miller, 2000; Denzin & Lincoln, 1998; Lincoln & Guba, 1985; Maxwell, 1992; Patton, 2002; Strauss & Corbin, 1990). A number of theorists have long argued that the criteria for good qualitative research – in particular research on discourse – concern issues that pertain to "how our research can both be intellectually challenging and rigorous and critical" (Silverman, 1993, p. 144; see also Wodak & Meyer, 2009).

Finlay (2006; 2007) has, on the basis of the scholarly discussion, proposed that qualitative research should be gauged in terms of its "*clarity*" – is the research articulated in a clear and systematic fashion? – its "*credibility*" – are the interpretations rigorously justified in a way that allows the reader to audit the argumentation? – its "*contribution*" – does the research have a potential impact? – and, finally, its "*communicative resonance*" – were the interpretations tried in dialogues with others and did they fit with their experience?

In Section 1.6 I stated that the ultimate aim of the analysis in this study was transparency in how the interpretive decisions were arrived at. This transparency can be translated into Finlay's two first criteria – *clarity* and *credibility*. I have certainly attempted to justify my interpretations and, in the reports, I have aimed to 'take the reader by the hand' by showing the data points and discuss in detail how my interpretation is grounded in the data and how it was guided by theoretical knowledge. It has been my aim, that is, that the reader can read over my shoulder and audit my interpretive steps. Further I have attempted to present a relatively detailed argument for the core commitments of the research design under which the data were collected (see Section 1.5) – such arguments are often treated as a core aspect of credibility (Aguinaldo, 2004).

One potential shortcoming of this study is that the rhetorical-*cum*-dialectical analysis of normative pragmatics is less systematic. Different kinds of theoretical knowledge need to be applied at different data points – this is a typical characteristic of such analysis (Leach, 2000). I have, however, attempted to alleviate this concern by constructing the four-step analysis procedure (see Section 1.6). This procedure does endow a certain measure of regularity to how the data set was approached, prepared, and analysed. Now, since it was impossible to conduct detailed normative pragmatics analysis of all sequences in the data set a selection had to be made. As described (Section 1.6), this selection was hermeneutical in nature.

The last two criteria that Finlay (2006; 2007) proposed are more difficult for me to assess – they depend on you, the reader. In terms of *contribution*, I have presented an argument for why this empirical study could have an impact for science education research. Whether it will have an impact on practice is a more contentious issue, however. While this dissertation is written to researchers it does have a number of smaller suggestions for practice.

With regard to the study's *communicative resonance*, a number of steps have been taken. First, the initial interpretations were audited by a researcher in argumentation theory who has experience with conducting normative pragmatics analysis. This resulted in a dialogue about the interpretation, and these were slightly adjusted at some points, and at other additional layers of the analysis were added.

Second, the present reports (Papers II through IV) are the product of multiple iterations of presenting my interpretations and receiving feedback from colleagues in science education (both in person, at conferences and symposia, and through peer review).

Since this study *purely* focused on interactive argumentation it is even difficult to gauge it in terms of usual criteria from the social sciences. Most studies in social sciences, in general, and in science education, in particular, study *causal* relations. *But this study did not study causal relations*. For when one investigates a given piece of argumentative discourse so as to elucidate on the role that specific types of articulations play in their immediate dialectical context, one does not study causal relations, but, rather, relations between articulated *reasons* and other argumentative items.

Indeed, the closest established analytical methodology genus for this study is *rhetorical analysis* – which, generally conceived, pertains to "the relationship between opposing argumentative positions" (Potter, 2002, p. 134), and which seeks to "arrive methodologically at insights into the performance of a communication event (or assemblage of events) through an investigation of select features of the event" (Zachry, 2009, p. 68). Thus, the empirical part of this study is a piece of analysis that falls under argumentation theory or *applied philosophy*, more generally. In other words, the products of this study are discursive acts about discursive acts: They are *arguments about actual argumentation*.

The aim of this study was *not* to establish generalizable findings that exhaust the data. The explicit aim of this study was to afford an interpretation of the data in great detail. The small-scale and exploratory nature of this qualitative study follows a growing tradition of conducting research on socio-scientific activities that does not aim at being generalizable, but, rather, aim at providing concrete empirical examples in order to raise issues for discussion in the science education community (Albe, 2008; Barrett & Nieswandt, 2010; Lindahl, 2009; Marttunen, 1997; Orlander Arvola & Lundegård, 2011; Pouliot, 2008; Sadler, 2006; Sadler & Zeidler, 2005).

Indeed, rather than purporting to make generalizations, this study aimed at building the basis for a *critique* of generalizations. As such, the study could be seen as belonging to a more general *interpretivist* or *critical* philosophical approach to social research (Fay, 1996; Giddens, 1976), which appreciates that the generalizations of social sciences "decay" and are "valid only as history" (Cronbach, 1975, pp. 122-3). Howe (2004) has succinctly described this approach as manifesting a "double hermeneutic" in which

> [s]ocial researchers engage in various interpretive (hermeneutical) acts in the process of coming to an understanding […] When researchers subsequently disseminate their findings to a public audience, members of this audience engage in (or at least may engage in) their own interpretive (hermeneutical) acts. This constitutes the "double" part of the double hermeneutic, and it has the potential to stimulate behavior on the part of the public that results in the decay of generalizations about social life. *For "critical" researchers, making generalizations decay* […] *is an explicit goal of social research* (p. 51-2; italics added).

From this perspective, knowledge is *not necessarily* cumulative. Consequently, the key virtue of interpretivist research is to produce interpretations that shed light on the slight imperfections in what we (the scholarly field) think we know already; and it is through this that systemic changes to practice can be made. Correspondingly: *The primary aim of this study was to thematise socio-scientific argumentation, from a new analytical perspective in order to invite or even entice a new way of talking about such discourse in the field of science education*.

6.3.1 Limitations and Ideas for the Future

There are, of course, always limitations to studying the finer details of discourse. Some of those limitations deserve explicit emphasis. First, *no effort was put into exploring the prior knowledge of the students*. Since so much of the previous literature suggests that prior knowledge – both disciplinary knowledge and knowledge about science – are determining factors for the quality of socio-scientific discussions, one could argue that it is short coming of this study that it does not takes into account the students' epistemic background. This background was not included because it would have greatly expanded the study which, already at the outset, appeared to be analysis-heavy. Further, as argued in Section 1.2, the quality of the discussions was not the direct object of study for this project. In future, more comprehensive, iterations of similar studies, however, this information may be valuable.

Second, related to the first limitation is the fact that *the courses on genetics that culminated in the discussion activities were not observed*. As Jankvist (2009a, 2009b) has recently argued, it can be possible to identify episodes in students' discourse that link to "anchoring points" in the observed prior teaching. Information of this type would have been valuable for the analysis of some passages. Clearly, the students' choice of subordinate issues and their way of addressing those are, in part, tinted by how they addressed genetics in the prior course. Unfortunately it was not possible to follow the courses systematically, and even if the opportunity had presented itself it would have expanded the project significantly. There is no question, however, that this is very concrete limitation of this particular study. But there is nothing that precludes analysts to use that information in normative pragmatics. So future normative pragmatics studies could very well benefit from taking this into account.

Third, *although body language and contextual cues where used indirectly in the transcription of the discussions, such aspects were not directly used in the analysis*. As discussed in Section 1.5, it was a conscious choice to focus only on overtly expressed discourse. This follows the main tradition of argumentation theory and it provides a clean focus to the analysis. But clearly there are a number of tacit layers in the communication between the students. Students' reactions to each other in discussion sessions may be partly determined by their relative roles in their network. For example, it is conceivable that a marginalized student's contributions will not be accepted at face value or even overlooked. There is no way for this study to incorporate these tacit layers of communication. But, to be sure, a comprehensive study could also make attempts to incorporate such layers.

Fourth, *this study only superficially attended to the conceptual quality of the expressed science*. From the perspective of the continental European traditions of *didactique, or Didaktik*, this is a significant shortcoming. Roughly put, the central issue in these traditions is the question of how a *specific disciplinary piece of knowledge is transposed to the classroom context* (Chevallard, 2006). This study did not have this aspiration. It did not ask how students appropriated or constructed specific knowledge or how certain design features could foster such appropriations or constructions. Its focus was more general in the sense that it asked how students apply and manage already appropriated or constructed science knowledge. That being said, it would still be interesting to investigate the quality of the expressed science, but that would be the topic of future work.

Fifth, *this study only to a marginal extent quantified the qualitative data*. There is certainly an argument for using *mixed methods* (Benz & Newman, 2008; Creswell, 2009; Greene, 2007). The interpretive findings of this study could possibly have benefitted from a scaffold consisting of quantitative information. But from my perspective this could be the next step. It may be possible to construct a list of categorical or archetypical usages of science that an analyst could look for and enumerate across a greater data set. The key is, I think, that the greatest strengths of this type of study are harbored in the detailed qualitative interpretations. As argued in Paper I, it is this type of analysis which dialogical argumentation calls for in the first instance. It really does not make sense to enumerate and count categories *before* we have agreed on what those categories denote.

Sixth, *it may have been informative to have the students validate the interpretations*. Now it is not clear how we should understand the operative term 'validate' in this context. It would be strange to assume that Betsy, for example, would concede that 'Yes, I was in fact co-opting the possibility to explain a science concept for my own argumentative purposes'. Even if she were consciously aware of how the finer details of her strategy worked to make her argument compelling, it is not necessary that she would grant that point. Another problem is that the analysis is time consuming. Even if a discussion could be analysed in, say, two weeks it is questionable how much the students would recall. Still, it could have been interesting to 'take' these interpretations 'back' to the students and discuss the interpretive findings with them. Such attempts could be further scaffolded by showing the students selected video sequences of their discussion and have them annotate those sequences.

Seventh, as mentioned in Paper III, the participants in two groups largely agreed. And while their discussions, like the other six discussions, are literal treasure troves of data, it could be argued that *the written material* could have fostered discussions to a greater extent. Maybe a number of auxiliary tasks would be conducive to disagreement (Nielsen, 2009, 2010). But then again, this study did not set out to enumerate confrontational episodes. One of the clear limitations of this study, however, is *the lack of information about the extent to which the written material directed the discussions*. This harks back to the first two limitations mentioned above. One of the aspects that only received passing attention in the discussion was the issue of how policy-makers concretely govern the progress of research. One would have expected this issue to be raised as subordinate to the issue of how gene therapy should be regulated. But it didn't, and it is unclear why. As an interested researcher (or, rather, an aspiring one), I would have liked to know more about what triggered these students to raise the issues that they did; but as an advocate of this particular study, I would hold that it must be admissible to focus, initially, on *how* the students articulated themselves when they raised the issues that they raised, and why some articulates worked and other not.

Eighth, *it could have been informative to compare the responses in the questionnaire (that was used to combine the groups) to the positions adopted in the discussions*. This point simple occurred too late to me (although an obvious one, I had to be made aware of it through a brilliant comment from one of my fellow ESERA summer school members). Sadly, after the fact this comparison could not be made convincingly. The questionnaire (cf. Appendix II) was one of those last-minute corrections to the final research design (cf. Section 1.5), and it purely served a scaffolding purpose. Essentially, the questionnaire would not pass as a research based representation of the students' position – it only gave a rather coarse indication. This would be a concrete point where this study could be improved. Together with observations from the genetics course, such background information could establish a more privileged vantage point for the interpretations. But, from my perspective, the pragmatic 'mechanics' of the identified strategies would not change against on the basis of this background information. Rather, knowledge about the background would 'only' aid in the identification of strategies.[1]

Ninth, and finally, while this study explicitly did not aim at being exhaustive, *it may be valuable, in the future, to make comprehensive investigations of students' discussions*. As discussed in Section 1.6 as well as in papers II through IV, the normative analysis (step three in the four-step analysis procedure) was *hermeneutical* in the sense that it took outset in one example and then proceeded to illuminate similarities and differences to other sequences, until a certain point were some general interpretations could be arrived at. While this allows the analyst to be deeply focussed on one kind of linguistic item (expressions of science content) it has a price in terms of breadth. During the analysis I encountered a plethora of topics, contents and issues that I had to dismiss in order to focus on expressed science content. Here are a few that deserve future investigation:

- Students would often use expressions such as "go in and change [the genetic material" (Danish: *gå ind og ændre*) (Angelica, 72 A3) when they were in the midst of

[1] This is essentially a critical realist stipulation that the object of study – while being historically plastic – is reified sufficiently to be independent of the analyst's knowledge. What is dependent on the analyst's knowledge, however, is the *possibility* to investigate the object of study (Guba & Lincoln, 1994).

arguing against germ-line gene therapy. Coupled with the analysis of the term 'fiddle' (cf. Papers III and IV), it would be interesting to catalogue the negative ways of articulating gene therapy.

- Connected with this point about the negative ways of articulating gene therapy is the emergent hypothesis that the adjective "perfect" almost always had negative connotations – so the statement that "[allowing germ-line gene therapy leads to the creation of the] perfect human" (April, 85 C1) was never an ascription of a positive quality to gene therapy.

- It seems that essentially all the students had the notion that the allowing the *use* of germ-line gene therapy is logically distinct from allowing *research* on germ-line gene therapy. For example, when talking about allowing research but not applications of germ-line gene therapy, Emily said that one could "just look through the gate and open it, you don't have to go through it" (429 C3). But this, of course, is one of the key problems in bioethics: The distinction between use and research is blurred (Holland, 2003). Indeed, doing research on human germ-line gene therapy involves some measure of *doing* germ-line gene therapy. Pursuing such issues *as conceptual challenges* for the learning of genetics is a project which is underway.

- It would be interesting to investigate in more detail the practical significance of messages that communicate the speaker's own experiences related to the science content – such as Angelica's experience of being in a cervical cancer vaccine trial (cf. Paper III). While this occurred rarely, it does seem to afford the speaker with some pragmatic authority.

6.3.2 Concerns about Transcriptions

It is certainly a truism that no transcription format is neutral, and that different ways of transcribing discourse have different weaknesses and strengths (Davidson, 2009; Ochs, 1979). Some lines of research, such as Conversational Analysis, have to rely heavily on contextual cues, such as 'intonations', 'cut-offs', 'extensions', a 'noticeable pauses' and so forth (Jefferson, 1985). There is definitely a case to be made that these very elaborate formats of transcribing are valuable for discourse analysis in general. But within the confines of this study, it was not practically possible to transcribe the discussions in that amount of detail. The focal point of the transcriptions were thus to represent "words and relatively gross features such as corrections and hesitations" (Potter, 2002, p. 136). As such, this study follows the traditional standard for transcribing and representing argumentative discourse in the field of argumentation theory (Eemeren, 1993; Emmertsen, 2006; Govier, 2010; Jackson & Jacobs, 1980; Jacobs & Aakhus, 2002; Jacobs & Jackson, 1983, 1992; Mercer, 2009) and the emerging standard for representing dialogic argumentation in science education (Erduran & Jiménez-Aleixandre, 2007; Erduran, Simon, & Osborne, 2004; Lemke, 1990; Naylor, Keogh, & Downing, 2007; Osborne, Erduran, & Simon, 2004).

The weaknesses of this, somewhat coarse, representation is that many aspects are lost in translation. Ideally, of course, the transcriptions ought to have been more fine-grained. But within the limits of this study this was not a possible goal to pursue. The reliability of the transcriptions is supported by the fact that the discussions have been transcribed by two persons in parallel. These two sets of transcriptions were compared and adjusted by me.

6.4 Final Conclusion

The study presented in this dissertation has provided a window into the complexity of students' deliberations on a socio-scientific issue. The students in this study were not only able to launch and execute complex and elaborate argumentative strategies that involved science content, they were also able to operationalize such science content in ways that suited their momentary or long-term argumentative needs.

Through the lens of normative pragmatics it was possible to identify different argumentative strategies and to explain how speakers can accomplish something by using them. The interpretive finding that should give the science education community pause is that science seemed to do more than just *inform* the discussions. When students invoked science content, they occasionally invoked more that the propositional content – they also invoked the determinacy and apparent certainty of the science claim, and they could use that to scaffold and pragmatically support their value-laden argumentation. Thus they were not just selective in terms of what science content to use, at times they also actively utilised the determinacy of science factual statements – for example by bootstrapping value-statements onto science factual statements or by making reference to science content in a way that made it appear that a particular way of framing the issue was mandated by science.

The students at times manifested a remarkable argumentative creativity; and while that should fascinate everyone who is concerned with how students deliberate, it should not be too surprising. After all, such argumentative strategies are a very ordinary part of discursive reality. . But while we should not be surprised, we ought to be perplexed. The interpretive findings from this study may provide further flesh to the concern that science education research is still in need of a theoretical exposition of what it means to use science on issues from outside science.

While this study has invited colleagues from science education to address this concern in a way that moves beyond equating science content with *evidence*, it is still an open question exactly what the role of science in socio-scientific deliberations should be. To be sure, the interpretive findings from this explorative study do not harbour a systematic answer to that question. It is my hope that this dissertation can point to a new way for science educators to converse in productive ways about what it means to ask students to make scientifically informed socio-scientific decisions; and it is my hope that this dissertation will have given food for thinking about what it could mean for teachers to assess students' socio-scientific argumentation. Hopefully, that is, this dissertation has accomplished more than simply to raise the issue of the role of science in socio-scientific discussions. Hopefully it has *framed* the issue in a way that may be useful for future scholarly work.

6.5 References

Aguinaldo, J.P. (2004). Rethinking Validity in Qualitative Research from a Social Constructionist Perspective: From "Is this valid research?" to "What is this research valid for?". *The Qualitative Report, 9*(1), 127-36.

Albe, V. (2008). Students' positions and considerations of scientific evidence about a controversial socioscientific issue. *Science & Education, 17*(8-9), 805-27.

Barrett, S.E., & Nieswandt, M. (2010). Teaching about ethics through socioscientific issues in physics and chemistry: Teacher candidates' beliefs. *Journal of Research in Science Teaching, 47*(4), 380-401.

Benz, C.R., & Newman, I. (2008). *Mixed methods research : exploring the interactive continuum*. Carbondale: Southern Illinois University Press.

Cavagnetto, A.R. (2010). Argument to Foster Scientific Literacy. *Review of Educational Research, 80*(3), 336-71.

Chevallard, Y. (2006). Steps towards a new epistemology in mathematics education. *Proceedings of the Fourth Congress of the European Society for Research in Mathematics Education*, 10.

Corbin, J.M., & Strauss, A.L. (2008). *Basics of qualitative research: techniques and procedures for developing grounded theory*. Thousand Oaks: Sage Publications, Inc.

Creswell, J.W. (1998). *Qualitative inquiry and research design: choosing among five traditions*. Thousand Oaks: Sage Publications.

Creswell, J.W. (2009). *Research design : qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J.W., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39*(3), 124-30.

Cronbach, L. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist, 30*, 116-27.

Davidson, C. (2009). Transcription: Imperatives for Qualitative Research. *International Journal of Qualitative Methods, 8*(2), 36-52.

Denzin, N.K., & Lincoln, Y.S. (1998). *Strategies of qualitative inquiry*. Thousand Oaks, Calif.: Sage Publications.

Eemeren, F.H.v. (1993). *Reconstructing argumentative discourse*. Tuscaloosa: University of Alabama Press.

Emmertsen, S. (2006). Retorisk samtale og argumentationsanalyse. *Retorikkens Aktualitet*, 139-59.

Erduran, S., & Jiménez-Aleixandre, M.P. (2007). *Argumentation in Science Education*. Dordrecht: Springer Netherlands.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse. *Science Education, 88*(6), 915-33.

Fay, B. (1996). *Contemporary philosophy of social science*. Malden, MA: Blackwell.

Finlay, L. (2006). 'Rigour', 'Ethical Integrity' or 'Artistry'? Reflexively Reviewing Criteria for Evaluating Qualitative Research. *The British Journal of Occupational Therapy, 69*(7), 319-26.

Finlay, L. (2007). Qualitative research towards public health. In S. Earle (Ed.), *Theory and research in promoting public health* (pp. 273-96). London: SAGE.

Giddens, A. (1976). *New rules of sociological method*. New York: Basic Books.

Govier, T. (2010). *A Practical Study of Argument* (7th ed.). Belmont: Wadsworth Cengage Learning.

Greene, J.C. (2007). *Mixed methods in social inquiry* (1st ed.). San Francisco, CA: Jossey-Bass.

Guba, E.G., & Lincoln, Y.S. (1994). Competing Paradigms in Qualitative Research. *N. K. Denzin & Y. S. Lincoln (Eds.), Handbook of qualitative research. London: Sage*, 105-17.

Hill, S. (2008). 'Is'–'Ought' Derivations and Ethical Taxonomies. *Philosophia, 36*(4), 545-66.

Holland, S. (2003). *Bioethics. A philosophical Introduction*. Cambridge: Polity.

Howe, K.R. (2004). A Critique of Experimentalism. *Qualitative Inquiry, 10*(1), 42-61.

Jackson, S., & Jacobs, S. (1980). Structure of conversational argument: Pragmatic bases for the enthymeme. *Quarterly Journal of Speech, 66*(3), 251-65.

Jacobs, S., & Aakhus, M. (2002). What mediators do with words: Implementing three models of rational discussion in dispute mediation. *Conflict resolution quarterly, 20*(2), 177-203.

Jacobs, S., & Jackson, S. (1983). Strategy and structure in conversational influence attempts. *Communication Monographs, 50*(4), 285-304.

Jacobs, S., & Jackson, S. (1992). Relevance and digressions in argumentative discussion: A pragmatic approach. *Argumentation, 6*(2), 161-76.

Jankvist, U.T. (2009a). A categorization of the "whys" and "hows" of using history in mathematics education. *Educational Studies in Mathematics, 71*(3), 235-61.

Jankvist, U.T. (2009b). *Using History as a 'Goal' in Mathematics Education.* RUC.

Jankvist, U.T., Nielsen, J.A., & Michelsen, C. (2011). *'Modeling and Interdisciplinarity' – a course for pre-service upper secondary teachers.* Paper presented at the 11th meeting of the International History, Philosophy and Science Teaching Group.

Jefferson, G. (1985). An exercise in the transcription and analysis of laughter. In T. van Dijk (Ed.), *Handbook of discourse analysis* (Vol. 3, pp. 25-34). London: Academic Press.

Johnson, R.H. (2002). Manifest rationality reconsidered: Reply to my fellow symposiasts. *Argumentation, 16*(3), 311-31.

Kelly, G. (2011). *Analysing Classroom Activities: Theoretical and Methodological Considerations*. Paper presented at the 9th conference of the European Science Education Research Association. from http://www.personal.psu.edu/gjk13/blogs/esera2011/PlenaryKellyESERA2011.pdf

Kock, C. (2007). Norms of legitimate dissensus. *Informal Logic, 27*(2), 179-96.

Kock, C. (2008). Dialectical Obligations in Political Debate. *Informal Logic, 27*(3), 223.

Kolstø, S.D., Bungum, B., Arnesen, E., Isnes, A., Kristensen, T., Mathiassen, K., et al. (2006). Science students' critical examination of scientific information related to socioscientific issues. *Science Education, 90*(4), 632-55.

Leach, J. (2000). Rhetorical Analysis. In Martin W. Bauer & George Gaskell (Eds.), *Qualitative researching with text, image and sound : a practical handbook* (pp. 207-96). London: SAGE.

Lemke, J.L. (1990). *Talking science : language, learning, and values*. Norwood, N.J.: Ablex Pub. Corp.

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Thousand Oaks: Sage Publications.

Lindahl, M.G. (2009). Ethics or Morals: Understanding Students' Values Related to Genetic Tests on Humans. *Science & Education, 18*(10), 1285-311.

Marttunen, M. (1997). Electronic Mail as a Pedagogical Delivery System: An Analysis of the Learning of Argumentation. *Research in Higher Education, 38*(3), 345-63.

Maxwell, J.A. (1992). Understanding and Validity in Qualitative Research. *Harvard Educational Review, 62*(3), 279-301.

Mercer, N. (2009). Developing Argumentation: Lessons Learned in the Primary School. In Nathalie Muller Mirza & Anne-Nelly Perret-Clermont (Eds.), *Argumentation and Education* (pp. 177-94): Springer.

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education, 37*(1), 17-39.

Nielsen, J.A. (2009). Structuring Students´ Critical Discussions Through Processes of Decision-Making on Socio-Scientific Controversies. *Revista de Estudos Universitários, 35*(2), 139-65.

Nielsen, J.A. (2010). Structuring Discursive Trajectories: Provisional Thoughts on Designing for Critical Discussions and Socio-scientific Decision-making. In C Winsløw & B Evans (Eds.), *Didactics as a Design Science - peer reviewed papers from a Ph.d.-course at the University of Copenhagen* (pp. 23-34). Copenhagen: Department of Science Education.

Ochs, E. (1979). Transcription as Theory. In E. Ochs & B.B. Schiefflin (Eds.), *Developmental pragmatics* (pp. 43-72). New York: Academic.

Orlander Arvola, A., & Lundegård, I. (2011). 'It's Her Body'. When Students' Argumentation Shows Displacement of Content in a Science Classroom. *Research in Science Education,* (Advance online publication), 1-25. Retrieved from http://dx.doi.org/10.1007/s11165-011-9237-2. doi:10.1007/s11165-011-9237-2

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020.

Patton, M.Q. (2002). *Qualitative research and evaluation methods* (Third ed.). Thounsand Oaks: Sage Publications.

Potter, J. (2002). Discourse Analysis and Constructionist Approaches: Theoretical Background. In J.T.E. Richardson (Ed.), *Handbook of Qualitative Research Methods for Psychology and The Social Sciences*. Oxford: BPS Blackwell.

Pouliot, C. (2008). Students' inventory of social actors concerned by the controversy surrounding cellular telephones: A case study. *Science Education, 92*(3), 543-59.

Putnam, H. (2002). *The Collapse of the Fact/Value Dichotomy and Other Essays*. Cambridge, MA: Harvard University Press.

Putnam, H. (2004). *Ethics without ontology*. Cambridge, MA: Harvard University Press.

Ryder, J. (2001). Identifying Science Understanding for Functional Scientific Literacy. *Studies in Science Education, 36*(1), 1-44.

Sadler, T.D. (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education, 17*(4), 323-46.

Sadler, T.D., & Zeidler, D.L. (2005). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Resarch in Science Teaching, 42*(1), 112-38.

Samuels, W.J. (1973). You cannot derive "ought" from "is". *Ethics, 83*(2), 159-62.

Searle, J.R. (1964). How to Derive "Ought" From "Is". *The Philosophical Review, 73*(1), 43-58.

Silverman, D. (1993). *Interpreting Qualitative Data*. London: Sage.

Simco, N., & Warin, J. (1997). Validity in image-based research: an elaborated. [Article]. *British Educational Research Journal, 23*(5), 661.

Simonneaux, L. (2011). *Questions Socialement Vives and SocioScientific issues: new trends of research to meet the training needs of post-modern society*. Paper presented at the 9th conference of the European Science Education Research Association. from http://www.esera2011.fr/images/stories/ESERA__2011_Detailed_Prog_Plenary_Conferences.pdf

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*. Newbury Park, CA: Sage.

Thomson, J., & Thomson, J. (1964). How not to Derive "Ought" from "Is". *The Philosophical Review, 73*(4), 512-6.

Wodak, R., & Meyer, M. (2009). *Methods of critical discourse analysis*. London: SAGE.

Zachry, M. (2009). Rhetorical Analysis. In F Bargiela-Chiappini (Ed.), *The Handbook of Business Discourse* (pp. 68-79). Edinburgh: Edinburgh University Press.

”Et valg er ikke sandt eller falskt”
Aristoteles, *Den Eudemiske Etik*

Abstract in Danish

Denne afhandling undersøger brugen af naturvidenskabelig viden i diskussioner om samfundsmæssige problemstillinger. Til dette formål diskuterer afhandlingen, hvordan naturfagsdidaktikere bør forstå og analysere elevers socio-videnskabelige argumentation. Der argumenteres for, at socio-videnskabelig argumentation er en diskursform, hvor personer administrerer deres (potentielle) uenigheder om, hvad man skal *gøre* (ikke bare om hvad der er sandt). Afhandlingen anvender normativ pragmatik til at analysere eleveres brug af naturvidenskabeligt indhold i otte gruppediskussioner om hvorvidt human genterapi skal tillades. Fokusset i afhandlingen lå på den argumentative rolle af naturvidenskabeligt indhold, og på hvilken effekt brugen af naturvidenskabeligt indhold havde på resten af diskussionen. Analyserne tyder på at naturvidenskabeligt indhold kan spille en informativ rolle hvis det bruges i et forsøg på at etablere et faktuel udgangspunkt for den efterfølgende beslutningstagen. Men eleverne brugte ofte naturvidenskabeligt indhold på en selektiv of kreativ måde til at indramme (frame) problemstillingen på dén måde, der var mest gunstig for dem. Afhandlingen forsøger at forklare hvordan sådanne strategier kan virke pragmatisk i diskussioner.

Summary in Danish

Denne afhandling består af fire artikler, som hver i sær tematiserer hvad det vil sige, at elever skal træffe en beslutning om en socio-videnskabelige problemstilling – der omhandler human genterapi – og hvad det vil sige at bruge naturvidenskabelig viden i sådanne situationer.

Den første artikel – *Dialectical Features of Students' Argumentation: A critical review of argumentation studies in science education* – er et kritisk review af hvordan internationale naturvidenskabsdidaktikere hidtil har analyseret elevers dialogiske argumentation. Den model man typisk har brugt – Toulmin-modellen – kan ikke begrebsliggøre dialektiske aspekter af argumentation (dvs. de aspekter der er på færde når personer argumenterer 'frem og tilbage' med udgangspunkt i hinandens argumenter). Samtidigt argumenteres der for, at Toulmin-modellen ikke kan anvendes medmindre man har informationer om de dialektiske aspekter af den diskurs man agter at undersøge. Dette paradoks indikerer at nye analysetilgange er tiltrængt.

I de sidste tre artikler redegøres for det empiriske studie. Her blev normativ pragmatik anvendt til at analysere otte grupper af gymnasieelever fra biologi B. Hver gruppe bestod af fire til fem elever (i alderen 16-19 år); og de diskuterede i omkring 35-60 minutter om hvorvidt human genterapi skal tillades.

I den anden artikel – *Co-opting Science: A preliminary study of how students invoke science in value-laden discussions* – redegøres for et foreløbigt studie af tre af diskussionerne. Der er særligt vægt på hvordan eleverne sammenfletter naturvidenskabelige 'fakta' og værdidomme. Ud fra analysen af diskussionerne tegner der sig et billede af, at eleverne i mange tilfælde bruger naturvidenskab til at hytte deres egne argumentative fjer. Blandt andet kunne naturvidenskab blive brugt til at få det til at virke som om at en

bestemt måde at frame problemstillingen på var bedre end andre måder at frame denne problemstilling på.

I den tredje artikel – *Science in Discussions: An analysis of the use of science content in socio-scientific discussions* – blev alle de otte diskussioner analyseret. På baggrund af analysen stod det klart at selvom naturvidenskab blev brugt informativt, valgte eleverne ofte at bruge naturvidenskab i et forsøg på at hytte deres egne argumentative fjer. I den sidste type strategi blev naturvidenskab brugt på måde der tildækkede at det kunne være relevant at diskutere ud fra hvilke kriterer en beslutning skulle træffes. Endvidere blev det klart, at elevernes socio-videnskabelig argumentation er yderst kompleks. For eksempel kunne naturvidenskab indgå på en informativ måde i en udveksling, men denne udveksling kunne en af de deltagende elever senere i forløbet inddrage på en strategisk måde til sit eget formål.

I den fjerde artikel – *Arguing from Nature: The role of 'nature' in students' argumentations on a socio-scientific issue* – blev alle de otte diskussioner analyseret med henblik på at undersøge hvordan eleverne gjorde referencer til begrebet 'natur' eller begrebet om 'hvad der er naturligt' Endvidere blev det undersøgt hvorvidt eleverne brugte naturvidenskab til at udbyde deres brug af 'natur'. På baggrund af analysen stod det klart at eleverne inddrog 'natur' på helt centrale steder i diskussionerne. Ofte havde referencen til 'natur' status som en ukritisk appel. Og eleverne inddrog ofte 'natur' når de havde udtømt deres argumentative muligheder. Hvis andre konfronterede deres inddragelse af 'natur' ændrede de meningen med begrebet 'natur' i stedet for at uddybe deres argumentation.