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A Discourse Perspective on the Learning of Biotechnology

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Abstract

Analyses of how students and a professor in an introductory university biotechnology course justify and evaluate knowledge claims considering GM food are reported in this licentiate thesis. In the public discussion of Genetically Modified (GM) food the representations of science as a social good, conducted in the public interest to solve major problems are being subjected to intense scrutiny and questioning. Scientists working in these areas have been seen to struggle for the position of science in society. Few in situ studies of how the debate about science appears in learning situations at the university level have been undertaken. In the present study an introductory course in biotechnology was observed during one semester, lectures and small group supervision concerning GM food were videotaped and student´s reports on the issue were collected. The ethnographic approach to discourse analysis was conducted by means of a set of carefully selected and representative observations of how a group of students learn to argue and appropriate views held in the Discourse they are enculturated into. While socio-scientific issues (SSIs) are often associated with achieving scientific literacy in terms of “informed decisions” involving “rational thought and discourse” this study shows that SSI in practice, in the context studied here, is primarily concerned with using scientific language to privilege professional understandings of GMOs and discredit public worries and concerns. Scientific claims were privileged over ethical, economical and political claims which were either made irrelevant or rebutted. During the course certain positive properties and qualities such as accuracy and efficiency are attributed by the participants to scientific practices, and the case for biotechnology was established in response to criticisms originating from other, competing authorities. The students were seen to appropriate a Discourse model held within the biotechnological community, that the introduction of the more robust, healthier and environmentally friendlier GM crops is impaired by public skepticism due to insufficient knowledge, and by regulations disadvantageous to GMO crops. The present study offers insights into biotechnology students’ decision making regarding socio-scientific issues, while also demonstrating the utility of discourse analysis for understanding learning in this university context. Implications for reflection on the institutional discourse of science and teaching of controversial issues in science are drawn and the study contributes to the investigation of claims of scientific literacy coupled to SSIs and argumentation.

Keywords: Discourse analysis, higher education, biotechnology, socio-scientific issues.

“Lack of insight always ends in despising or else unreasoned admiration“

John Dewey

List of publications

Appended papers

I Solli, Anne, Bach Frank and Åkerman Björn. (2012). Learning to argue as a biotechnologist: disprivileging opposition to genetically modified food. Under review: Cultural Studies in Science Education.

II Solli, Anne. (2012). Appropriating “scientific habits of mind”: Students Alignment with the Bioscience Community in the GM food debate**.** Submitted to Journal of Research in Science Teaching.

Publications not included in the thesis

Solli, Anne. (2011). Enculturation of students into technoscience: the disprivileging of opposition towards GMO. Paper presentation. JURE - EARLI, European Association for Research and Learning and Instruction conference 2011. Exeter, England.

Solli, Anne. (2011). Identifiering av diskursmodeller: ett alternativt sätt att förstå lärande inom kontroversiella frågor. Paper presentation. NOFA konferensen. Karlstad, Sverige.

Solli, Anne. (2011). Enculturation of students into technoscience: the disprivileging of opposition towards GMO. Paper presentation. ESERA conference 2011. European Science Education Research Association. Lyon, France.

Frändberg, Birgitta; Rocksén Miranda; Solli, Anne; Thörne, Karin; Wahlberg, Sara. (2009). *Communicating about molecules*, Poster presentation, ESERA conference 2009, European Science Education Research Association. Istanbul, Turkey.

Contents

Prologue

This thesis belongs to a tradition arguing that what we say, think, and feel, that what is considered "right" and "true," depends on the social group to which we belong. Therefore, a description of the social groups I have been and am part of provides useful perspective when reading my text. I have studied how students are introduced to biotechnology in a technical university. Why am I so interested in the details of teaching and learning about genetically modified (GM) plants? First, having worked at the Universeum science center since 2001, and being part of an effort to encourage children's and young people's interest in science and technology, I wanted to study the sort of education in which we encourage young people to engage. Second, studying this matter allows me to reflect on the biotechnological Discourse[1] to which I have belonged. When I started video-documenting what students experienced when they started their biotechnology education, it was 20 years since I had begun a similar education in Norway. At that time, biotechnology engineers started their studies with courses in mathematics, physics, chemistry, and laboratory work before being introduced to biotechnology as such. Although we were not offered any courses in which biotechnology was put into a societal context, we were guided by enthusiastic professors who made learning about the new and promising gene technology an inspiring experience. However, I had no knowledge of philosophy, economics, or ethics as coupled to issues of biotechnology. After graduation, I entered an environment that conducted research into how organisms adapt to stress. I was associated with molecular biology laboratories in Norway and the USA that researched plant–microbe interactions. It was at Michigan State University that I first had a taste of the FLAVR SAVR tomato, a GM tomato that could be picked when ripe for better taste (ordinary tomatoes are picked green and ripen during transport). My colleagues were enthusiastic and curious about the commercial application of the gene technology they used in the lab on a daily basis, and I was most interested in their reactions. In Norway, however, skepticism about GM crops was greater.

Moving from Oslo to Trondheim, Tromsø, Michigan, and finally Gothenburg, I became interested in comparing the reactions and opinions of groups of people, whether in families, workplaces, professions, regions, or nations. What qualifies as a good lunch, what is funny, what are considered reasonable working hours, or whether whaling is defensible - these

[1] Gee (2005) capitalizes "Discourse" to distinguish this use of the term from a mere passage of language, which he identifies simply as "discourse." Any passage of language (discourse) is always embedded in a particular way of knowing (Discourse).

questions elicit different answers depending on the societal context. For example, as a Norwegian, I, and many like me, used to think of ourselves as rational supporters of whaling based on scientific arguments—as opposed to the whaling opponents from the rest of the world. When I discovered James Paul Gee's texts on ideology, culture, and discourse analysis, I acquired a language with which to express ideas about belonging and what is considered true and correct in certain groups. Armed with these conceptual tools, it was now possible to understand and describe what was available for students to learn in a biotechnology course at a Swedish university. I believe that reflecting on and gaining meta-knowledge of the Discourses to which we belong and of Discourses in general provides a foundation for change.

1 Introduction

This thesis investigates how university students arrive at decisions by learning to evaluate and justify arguments regarding the controversial development and use of GM crops and food, in a way that is appropriate in a biotechnological Discourse. I have come to understand decision making in terms of Discourses and of conflicts between people with divergent interests, not in terms of "rationality" and "critical thinking." My thesis develops the implications of science and science education being part of larger communities, in the sense that the sides taken in social–cultural conflicts and people's enculturation into domains, such as biotechnology, include appropriation of the value systems embodied in Discourse-specific ways of knowing and doing.

This licentiate thesis consists of a report and two appended papers. This first chapter situates my research by addressing various studies of controversial issues with ties to science and technology. I first describe the controversial issue of genetically modified organisms (GMOs), before critically reporting on the arguments for including socio-scientific issues (SSIs) in science education and reviewing what is known about learning in SSI contexts in classrooms. Furthermore, I will argue for an alternative, sociocultural perspective on science education (Lemke, 1990, 2001; Roth & Barton, 2004; Roth & Désautels, 2004; Roth & Lee, 2002) and on the idea that language is situated action (Gee, 2008)—questioning, in the process, dominant ideas of scientific literacy advocated by the SSI movement (Sadler & Zeidler, 2009). The chapter ends by presenting the purpose and research questions of my work, which applies a sociocultural approach to investigating how an SSI is enacted in a practice. Following this chapter, I elaborate on the theoretical framework, methods, and analysis on which the thesis is based. The two papers are then briefly summarized and followed by a discussion.

1.1 Controversy and genetically modified organisms (GMOs)

Public debate has challenged the legitimacy and credibility of scientific endeavor in controversial areas of science (Motion and Doolin, 2007), and scientists have been seen to struggle to uphold the status of science in society (Cook, Pieri, and Robbins, 2004). One of today's most controversial biotechnology policy issues involves the development and consumption of GM foods (Legge Jr. and Durant, 2010). Of the many players in the GM debate, scientists can make an influential contribution. On a commercial scale, GMOs have only become possible through their research, and their specialist understanding can help to monitor and assess physical effects of GMOs that may otherwise be difficult to perceive. In October 2011, 41 Swedish scientists from seven universities addressed an open letter to politicians and environmentalists that encouraged a revision of European legislation based on scientific assessments of GM technology, an approach that they believe will foster the development of GM crops with their potential benefits (Jansson et al., 2011). More than 400 scientists from Europe have endorsed the Swedish letter (Moloney et al., 2012). Bioscientists presume that the main issue is risk, a scientific matter, and public disaffection is assumed to originate in a rejection or misunderstanding of the science (Wynne, 2002). Whereas their proponents argue that GM crops could solve future food supply problems by providing a growing population with cheaper, healthier, and more environmentally friendly food, opponents make a variety of arguments, referring, for example, to potential health and environmental risks, intellectual property rights, and global justice issues (Myhr & Traavik, 2001; Nestlé, 2003; Shiva, Emani, & Jafri, 1999).

The consensus that seems to have emerged in the bioscientific community differs from the view of the general public, at least in Europe. An analysis of Eurobarometer 73.1[2] found that 67% of Europeans believed that GM foods should not be developed, and that only 5% strongly supported such development (Eastwood et al., 2011). Some consumers and environmentalists fiercely oppose GM food research, including some who have resorted to violence. In 1999, a laboratory at Michigan State University was set on fire by eco-terrorists to protest research into GM plants (Palfreman, 2001). David Dickson, the former news editor of *Nature*, attempted to engage the scientific community in a discussion of the relationship

[2] Life Sciences and Biotechnology, a public opinion survey conducted on behalf of and coordinated by the European Commission.

between science and the public, and claimed that the public distrusts science because it excludes consumers from decision making and has, in the case of GMOs, denied farmers the choice of whether to preserve seed from one season to the next (2000). Dickson saw the controversy as less concerned with whether Monsanto's[3] science is sound and more concerned with the fact that Monsanto, which is financially influential, had not taken into account the needs and concerns of all those affected by its science. In the 1960 and 1970s, Monsanto's business was increasingly threatened by the emergence of the environmental movement and tougher environmental regulation. Monsanto was a major producer of dioxins and polychlorinated biphenyls (PCBs)—both persistent environmental pollutants posing risks to the environment and human health. After the breakthrough in 1978, when genetically modified *E. coli* bacteria were produced to make human insulin, it was unclear whether a commercially viable agricultural biotechnology industry could be created from this new science. Monsanto was just one of many agribusiness companies monitoring developments in the field. The uncertainty surrounding the development of biotechnology resulted in a discursive framing of the technology as clean, green, environmentally friendly, an alternative to chemical-dependent agriculture, and potentially beneficial to poor people—a discourse that developed in Monsanto in biotechnology's early days (Glover, 2008).

Scientists, bureaucrats and non-governmental organizations (NGOs) are well aware of current worries about the consequences of biotechnology research. However, there is still considerable controversy about where the points of contention lie and who should address them (Gisler & Kurath, 2011). The controversy over the production and consumption of GMOs is no different from many other public controversies, in that there are fundamental disagreements about what problems deserve attention, what has caused these problems, how serious these problems really are, for whom these constitute problems, and the strengths and weaknesses of the proposed solutions. The extent to which multiple and competing perspectives are being voiced about what should be done to address a problem facing the community is not a flaw of democracy, but a marker of how democratic a community is in practice (Hess, 2009).

1.2 Socio-scientific issues (SSIs)

In science education, controversial issues related to science and technology are termed socio-scientific issues (SSIs) (Kolstö, 2001). SSIs are regarded as difficult to negotiate because they

[3] The Monsanto Company is a multinational agricultural biotechnology corporation. Monsanto is the second largest producer of genetically engineered seed.

are open-ended, ill-structured, and typically subject to multiple perspectives and solutions (Sadler, 2004). An interdisciplinary approach has been recommended when dealing with SSIs, since proficiency in one discipline is in most cases insufficient to address them appropriately (R. Levinson & Turner, 2001). Many science educators in the international community include SSIs in science classrooms to develop “scientific habits of mind,” which concern scientific knowledge “obtained from data interpretation, analysis of conflicting evidence and arguing viewpoints that may conflict with previous misconceptions” (Zeidler, Sadler, Applebaum, & Callahan, 2009). The SSI movement consists of science educators reported to have progressive goals, who emphasize SSIs as learning contexts and strive to treat SSIs in science classrooms (Sadler & Zeidler, 2009). Introducing SSIs in science classrooms is thought to create ideal contexts for bridging school science and students’ lived experience (Sadler, 2011) and for enabling students to engage in sophisticated discourse concerning matters of personal and public interest (Zeidler et al., 2009). The aim is to develop responsible citizens capable of applying scientific knowledge and habits of mind such as “acquiring skepticism, maintaining open-mindedness, evoking critical thinking, recognizing multiple forms of inquiry, accepting ambiguity, searching for data-driven knowledge” (Zeidler, Osborne, Erduran, Simon, & Monk, 2006). Although some ethnographic studies have addressed SSIs in the classroom (Albe, 2008; Pouliot, 2009), most empirical research into SSIs in classroom settings typically relies on reports from curricular units designed by researchers belonging to the “SSI framework” (Zeidler, Sadler, Simmons, and Howes, 2005). Such research is based on what is learned during interventions. The positive effects of treating SSIs in classrooms as reported in a recent review of the SSI literature (Chang Rundgren & Rundgren, 2010) include: achieving scientific literacy, transferring content knowledge and skills to real contexts, enhancing decision making and critical thinking, inducing interest in learning science, providing cross-disciplinary concepts, and promoting science communication. When students participate in such design studies, they both acquire science content knowledge and learn to argue (von Aufschnaiter, Erduran, Osborne, & Simon, 2008; Zohar & Nemet, 2002). A recent study identified the effects on student reasoning by comparing students who had undergone an “SSI treatment” with biology majors; it found that SSI-treated students displayed higher levels of reasoning and tendencies to incorporate more perspectives in their decision making (Eastwood et al., 2011). Training students in argumentation aims to develop student understanding and ability to consider scientific evidence (Duschl & Osborne, 2002) and is thought to have the potential to change minds: “The confrontation between a creationist and a Darwinist without any attempt to rebut the data or the warrants of the other would have no potential *to change the ideas and thinking* of either" (Zeidler, Osborne, Erduran, Simon, & Monk, 2006). The assumption is that learning activities embedded within an SSI framework enable students to "think for themselves" (Walker and Zeidler, 2007).

Although it has been argued that few researchers have empirical evidence that "high-quality" argumentation patterns can positively influence daily thinking and decision making outside educational settings (Feinstein, 2011), the SSI movement plays a central role in promoting scientific literacy (Albe, 2008). Preparing students to take informed positions on complex problems through critical evaluation is thought to be an important aspect of scientific literacy (Roberts, 2007). In school, student abilities to engage in informal reasoning regarding SSIs are thought to be influenced by scientific content knowledge (Sadler & Zeidler, 2005; Zohar & Nemet, 2002) and misunderstanding of the basic science is believed to result in a failure to identify key relevant issues, "leading to flawed lines of reasoning and possibly inappropriate decision-making" (Lewis & Leach, 2006). Two recent studies of university students' ability to reason regarding SSIs made claims regarding students' lack of "rational" and "critical thinking." Simonneaux and Simonneaux (2009) concluded that emotional proximity to issues "hindered rational thinking." Similarly, a study of college student's socio-scientific decision making regarding invasive species (Liu, Lin, & Tsai, 2011) concluded that more science than non-science majors exhibited a "less critical thinking disposition."

In the studies mentioned above, argumentation is seen as something discrete or acquired by individuals, not analyzed in a context of what is believed in the society, group, or nation. The idea is that each individual appropriates and exhibits certain "basic skills" and that students need to be assessed to determine whether they have gained this knowledge and these skills by isolating them from resources normally available in everyday situations. In seeking to understand how students learn to argue about an SSI in a particular social context, I move away from understanding reasoning along the lines of "critical thinking," "rationality," and "sophisticated reasoning." Sociocultural learning theories problematize the idea that knowledge is discrete and acquired by individuals, as people are continually shaping and being shaped by their social contexts (Roth & Lee, 2007).

1.3 An alternative perspective

The impressive claims regarding the powers of argumentation and scientific literacy have been disputed (Gee, 2008). One such claim is that including argumentation about SSIs in science classrooms improves students' analytical and critical thinking, fostering political democracy, greater social equity, and "better" citizens. What scientific literacy is depends very much on the conception of knowing and learning that one associates with it (Roth & Barton, 2004). Roth and Désautels (2004) argue that the rationale for promoting scientific literacy by means of policies and curricula leads to the adoption of a "scientistic" attitude. They believe that this results in particular ways of thinking being overvalued, and the scrutinizing of knowledge production obscures ideological dimensions and the political ties of technoscience to the financial and industrial sectors of society. Based on a sociocultural perspective on science education, Lemke (2001) criticized the idea that scientific evidence can make people change their mind as he saw science and science education as part of larger communities and their cultures, including the sense in which they take sides in conflicts. Institutions such as schools and universities rarely openly recognize that different social groups may have conflicting interests (Lemke, 1990). Gee (2008) argues that literacy is not just a matter of what is inside people's heads, as literacy has cultural and social contexts. What is in our heads is just one aspect of larger, more public, and historical context that in reality constitute "our" knowledge. Social institutions and elite groups in society often privilege their own versions of meaning as if they were natural, inevitable, and incontestable. In Discourses, the boundaries that disciplinary experts create, and that they police, can dissolve as we humans go about making and being made by meaning. Most of what a Discourse does with us and most of what we do with a Discourse is unconscious and unreflective. Each Discourse protects itself by demanding from its adherents performances that act as though its ways of being, thinking, acting, talking, writing, reading, and valuing are "right" and "natural," i.e., the way "good," "intelligent," and "normal" people behave (Gee, 2005).

How debates about science manifest themselves in teaching and learning situations have not been thoroughly studied. There has recently been a call for more in situ research into the epistemic practices of science education (Kelly, McDonald, and Wickman, 2012). In the present study, my emphasis is not on designed, "ideal" ways of teaching SSIs, nor is the point of departure the notion that SSIs create ideal contexts for learning. Instead, the methodological orientation is to investigate through the study of social interaction how students become part of the cultural practices that constitute membership in a biotechnological community when SSIs are discussed. My perspective is similar to that of ethnographers of science (Latour, 1987): By studying the everyday activities in a biotechnology course, I have come to identify the shared cultural practices that constitute doing biotechnology. Members of a scientific field construct a community and a culture that both identifies them as members and distinguishes them from others (Kelly, Chen, & Crawford, 1998). Discourse analysis, when guided by an ethnographic perspective, forms a basis for identifying what members of a social group need to know, produce, predict, interpret, and evaluate in a given setting or social group to participate appropriately and, through that participation, learn (Gee and Green, 1998). An ethnographic perspective therefore provides a conceptual approach for analyzing discourse data from an insider's perspective and for examining how discourse shapes both what is available to be learned and what is learned.

1.4 Purpose

Science education has social and political effects and consequences, and it is vital to bear this in mind when considering the learning of biotechnology, SSIs, argumentation, and scientific literacy. This study examines how students and professors justify and evaluate knowledge claims about GM food as communicated and appropriated in a biotechnology course.

The main research questions were:

a) How do the participants characterize the opposition to GM food?

b) How are the arguments opposing the use and production of GM food evaluated?

c) How are bioscientific practices characterized and used as a resource when the controversy over GM food is addressed?

By studying a group with interests in the GM controversy using a discourse analytical approach, I was able to identify how science is constructed interactionally through discourse processes and what is considered science by the group under consideration (Kelly, 2008; Kelly et al., 1998). This also contributes to the investigation of what some parts of the science education research community refer to as "scientific habits of mind" (Zeidler et al., 2009).

2 Theoretical framework

2.1 A sociocultural perspective on science education

This thesis relates to, and to a certain extent questions, a number of studies of the learning of SSIs that are based on a more cognitive perspective on science education. In the following, I will elaborate on the sociocultural perspective underlying this study.

Historians, sociologists, and cultural anthropologists have increasingly come to see that science must be understood as a human activity whose focus of interest and theoretical dispositions are a part of the dominant cultural and political issues of our age (Lemke, 2001). The sense-making process at the heart of scientific investigation was seen to involve instrumentation and technologies, in effect "distributing" cognition between people and artifacts mediated by artifacts, discourses, and symbolic representations. The view that science represents a uniquely valid approach to knowledge, disconnected from social institutions and wider cultural beliefs and values, was strongly challenged by research in the sociology of science (e.g., Latour, 1987). Scientific knowledge was seen not only as socially coded and historically situated, but as sustained and made durable by material networks. Latour introduced the notion of two discourses involving settled ("ready-made science") or unsettled ("science-in-the-making") aspects of technoscience. Controversial issues such as GM food can be considered to belong to the domain of "science-in-the-making." In his study of scientists at work (1987), Latour argues that, in striving to make their claims more credible than others', scientists use texts, documents, and articles to force others to transform what was at first an opinion into a fact. Latour's translation model of science highlighted how "science-in-the-making" requires that many more work outside than inside the laboratory to make the work inside the laboratory possible. Part of what constitutes scientific research is working on the outside to help define, negotiate, sell, and spread the results. From this perspective, it is necessary to enroll interested groups; students can thus be conceived as future members of the technoscientific community actually doing plant biotechnology research or, more likely, helping "sell" technoscience to a wider audience.

This view of science education as a second socialization or specialist enculturation into a sub-community was in opposition to views of autonomous cognitive development. Piaget's view of the autonomous child–scientist was revised along Vygotskyan lines to take into account the social and cultural origins of learners' logical, linguistic, and semiotic resources and models, learned from more experienced social partners. The idealized view of social interaction as occurring between autonomous minds was replaced with the notion of learning-in-community. Science education took a "linguistic turn" and began to examine how people learned to talk and write the language of science and to engage in science's wide range of subculture-specific activities (e.g., observing, experimenting, and publishing) and signifying practices. People studying the *functions* of language in social interaction (e.g., Halliday, 1978; Martin, 1992; Schegloff, 1991; Lemke, 1990; Bazerman, 1988) began to see language as a culturally transmitted resource for making meaning socially (e.g., Gee, 1990; Lemke, 1995) that was also useful in talking oneself through science problems. From a sociocultural perspective, what matters to learning and doing science are primarily the socially learned cultural traditions of what kinds of discourses and representations are useful and of how to use them.

Kelly et al. (1993) believed that one implication for science education following from social studies of science findings is that sociocultural values fundamentally influence the process, content, and application of scientific knowledge. The social studies of science field advocates the continued erosion of the epistemological separation of the social and natural sciences. Sociologists of science explaining the social and scientific worlds have undermined, appropriately, the authority of science as the best arbitrator in technological decision making. Portrayals of science as epistemologically "harder," and therefore less problematic, than social and humanistic approaches become more difficult to maintain. Kelly et al. (1993) believed that some otherwise exemplary science-technology-society curricula establish just such an epistemic hierarchy and imply that scientific knowledge has special status in the resolution of societal problems. They suggested that science educators needed to retire the idea that, by learning science, citizens would automatically be equipped to make good public decisions.

Biotechnology education can be thought of as contributing to a process in which novices are initiated into a community of practice (Lave and Wenger, 1989). Becoming a scientist involves coming to see the world in particular ways: "coming to understand how to articulate an appropriate argument given certain contexts; and coming to know how to present oneself and one's data in socially and scientifically appropriate ways" (Kelly et al., 1998). Learning disciplinary knowledge entails more than simply acquiring basic skills and bits of received knowledge. It also involves developing identity and affiliation, as well as critical epistemic stances and dispositions, as learners participate in the discourse and actions of a collective social field. From this perspective, knowledge is not held in texts and books, but is constructed through ways of speaking, writing, and acting. Knowledge is continually tested and reconstructed. Knowledge is not held in the "official" curriculum, although the curriculum supports and constrains the possibility of students' accessing particular types of knowledge. Knowledge claims and the evaluation of knowledge claims are the criteria for evaluating change over time (Kelly, Luke, & Green, 2008). Such change occurs through actions taken by individuals and by groups through their common activities. So what counts as knowledge and whose knowledge counts are interactionally determined and potentially subject to change, revision, and critique, depending on the rules of the institutional, political, and economic fields in which such knowledge is constructed. According to the ethnographic perspective on discourse analysis (Gee & Green, 1998); what defines learning is changed patterns of participation in specific social practices within various "communities of practice." The student is socialized into a culture and in turn changes that culture. Socialization is not only a question of appropriating the culture at the individual level, but also a collective process of inventive and interpretive reproduction.

2.2 Discourse analysis

Foucault has exerted a decisive influence on the identification and analysis of discourses (Fairclough, 2003). Foucault, in commenting on his own use of the word "discourse," said that he had used the word in various senses. I use the concept of "Discourse" to build on a specific perspective on language and literacy that Gee developed in his work on social linguistics, literacies, and discourse analysis (Gee, 2005, 2008). To appreciate language in its social context, my focus will not be on language alone, but on what Gee calls "Discourses," with a capital "D." Discourses are ways of behaving, valuing, thinking, speaking, and often reading and writing that are accepted as instantiations of particular identities by specific groups, whether families, scientists, or women or men of certain sorts. Discourses are ways of being "people like us." Each of us is a participant in many Discourses, each representing one of our multiple identities. Each Discourse incorporates a usually taken-for-granted set of "theories" about what is considered a normal person and the right way to think, feel, and behave, as ways of representing aspects of the world. Different Discourses constitute different perspectives on the world. Most of what a Discourse does with us and most of what we do with a Discourse is unconscious, unreflective, and uncritical.

The focus of discourse analysis is any form of written or spoken language, such as a conversation or newspaper article. The main topic of interest is the underlying social structures, which may be assumed or played out within the conversation or text. Discourse analysis concerns the sorts of tools and strategies people use when communicating, such as slowing one's speech for emphasis, use of metaphors, choices of particular words to display, for example, affect. Discourse analysis can be described in general terms as attempting to identify categories, themes, ideas, views, roles, etc., within the text itself. Its aim is to identify shared discursive resources and shared patterns of talking. The investigator tries to determine, for example, how the discourse helps us understand the issue under study, how people construct their own version of an event, and how people use Discourses to maintain or construct their own identities. The terminology and approach used here is that of Gee's discourse analysis (Gee, 2005). Since this thesis aims to contribute to the learning sciences, I made use of Gee and Green's (1998) methodological study of discourse analysis, learning and social practice to understand what is made available to learn and what is learnt.

2.3 Situated meanings and Discourse models

An assumption of the discourse analytical approach taken here is that the meanings of words, when we look at them in their actual contexts of use, are not general. Words are not associated with general concepts that accompany them wherever they go; instead, words have different specific meanings in different contexts of use, meanings that are linked to and vary across different social and cultural groups. The meaning of a word varies across different contexts, both within a given Discourse (e.g., that of biotechnologists) and across different Discourses (e.g., between biotechnologists and people not professionally engaged in science); consequently, scientists and non-scientists may understand the "same" words differently. Gee (2005) considers two areas in which it is clear that the meaning of any word or phrase is multiple and flexible: the first involves how children acquire the meanings of words, while the second concerns how scientists and nonscientists use the "same" word to mean different things. When a child first learns the meaning of the word "shoe," for example, it refers to very specific objects. The child may then "overextend" the meaning of the word beyond adult usage. The child must come to realize that the features associated with different contexts that trigger the use of the word are not simply random. The features "hang together" to form a pattern that specific groups of people find significant. In the case of shoes, features such as hard, shiny, formal, rigid soles, and thin laces tend to hang together. They form a pattern, representing a certain set of shoes—formal shoes. Other features hang together to form a pattern representing a different set of shoes, such as athletic shoes. Humans recognize certain patterns in their experience of the world. In a context in which a teenager says "I can't play basketball today, I haven't got any shoes," the situated meaning of "shoes" is something like the above pattern for shoes. The comment does not mean that the person has no shoes whatsoever. The other example is from what science educators used to regard as "misconceptions" about light[4]. When children were asked how far the light from the candle goes, the incorrect answer would be "not very far." The correct *scientific* answer is that a ray of light travels indefinitely far unless or until it strikes an object. What is happening when children answer "incorrectly" can be viewed in terms of what Gee (2005) calls the "lifeworld," i.e., all those contexts in which we humans think, act, and communicate as everyday people and not as specialists. Even specialists spend much of their time in their lifeworld outside professional specialist Discourses. In the research referred to here, one form of language, practice, and thinking, namely, that of professional physicists, is being substituted for another form, namely, that found in the lifeworld. The lifeworld form is claimed to be a mistaken version of the scientific form, when in fact the lifeworld form is not actually trying to be correct in the same way in which the scientific form is correct. In everyday contexts, "light" means illumination and illumination is the range through which an observer can see the visible effects of the light. The situated meanings of words are relative to specific Discourses. The Discourse of physics has a different set of situated meanings for the word "light" than do lifeworld Discourses.

In addition to situated meanings, each word is associated with a Discourse model. A Discourse model is usually an unconscious explanatory theory or "storyline" connected to a word or a concept—distributed among people in a social group—that helps to explain why the word has the different situated meanings. An example is the success model in the USA, i.e., "anyone can make it in America if they work hard enough," which helps many people make sense of words such as "success" and "failure." This model can lead to the blaming of poor people when they fail to succeed and to claims that they are lazy. Cultural models have been used as Discourse models, but not everyone who shares a given Discourse model is a member of the same culture and not everyone in the larger culture shares the same Discourse model. We learn Discourse models from experiences shaped by the social and cultural groups to which we belong, such as working-class parent, middle-class parent, traditional teacher, science teacher, and corporate executive. Discourse models are simplified, often unconscious,

[4] I am aware that these are nowadays usually called "alternative conceptions" and that one should not regard one version as a mistaken form of the other. I think the example is still applicable, however, since many still use the term "misconception" in, for example, science education research conferences and resource pages for science teachers on the Internet.

and taken-for-granted theories about how the world works that we use to get on efficiently with our daily lives. They are the often unconscious theories we uphold that help us make sense of texts and the world. We often acknowledge that they are simplifications of the world. Discourse models are not just mental: they exist in the media, the knowledge we gain from others, and what we infer from the social practices around us. All theories are simplifications useful for some purposes and not others, but simplifications in Discourse models can do harm by implanting dismissive and derogatory assumptions about other people. Assumptions marginalize people, as part of their function is to establish what are considered central, typical cases, and what are considered marginal, non-typical ones. Discourse models embed assumptions about what is appropriate, typical, and normal. In our minds, we build simulations that are not neutral. These simulations are meant to express a perspective on things that foreground certain elements we consider important or salient and backgrounds other elements we consider less important. Discourse models are important tools of inquiry because they mediate between the personal level of human interaction and the meta-level of institutions. These models mediate between the interactional work we do and Discourses as they operate to create the complex patterns of institutions and cultures.

3 Method & Analysis

3.1 Ethnographically oriented approach

Ethnographically oriented studies have focused on the actual practice of scientists in everyday situations (Knorr-Cetina & Amann, 1990; Latour, 1987). These studies are purposefully set out to be symmetric in terms of explanations of true and false beliefs. They are agnostic regarding scientific truth in order to study in an unbiased manner the social processes that lead scientists to determine the plausibility of knowledge claims. However the naturalistic attitude does not deny scientific truth, rather the investigators remain agnostic for methodological reasons (Kelly et al., 1998). Science studies can serve as analogous cases for similar investigations in educational settings. Simply put, a central lesson of science studies is not conclusive evidence about the true nature of science, but rather the methodological orientation to investigate science education from an empirical, descriptive point of view as it is created through social activity (Kelly et al 1998). In the same way I have purposefully tried to not relate to the scientific truths of the claims in my analysis and in discussions of the results with fellow researchers. Investigating *how* truth and reasons are accomplished is contributing to demystify scientific practice.

The goals of this research has not been to identify the one true account of bioscience education as science studies do not seek to identify the true essence of the nature of science or the scientific method. Instead I investigated how socio-scientific issues are being constructed and modified as a group of people engaged in various activities in a biotechnology course. From this point of view, empirical research of the ethnographic variety contributes to ongoing conversations about how to interpret and understand what counts as disciplinary knowledge and practices in various contexts from various points of view. I have investigated not only what students come to know, but also how people come to know in the setting of an introductory biotechnology course.

3.2 Context of the study

The data was collected in the first semester of a five year program in biotechnology in a Swedish technological university (September-December 2009). This university has a general goal of promoting sustainable development throughout its courses and research. The course in introductory technical biology was particularly relevant to this study due to the issues it examines, which concern personal, professional and political decision making. Although several subjects taught in the course belong to what is often termed socio-scientific issues, the teachers involved are not part of the SSI movement. They are unlikely even to have heard the term since they are not part of the science education research community. The students participating have just graduated from *gymnasiet* (12 years of schooling) with a concentration in science and mathematics. The biotechnology program has a high application rates, and the students' grades are good. Compared to the average citizen they have good knowledge of physics, chemistry and biology. The course aims to give students insight into various areas of biotechnology and requires that the students learn how to gather information from various biotechnological sources and write a report. The first part of the course consisted of lectures on diverse aspects of biotechnology, such as ethics and sustainability, in addition to research areas such as tissue engineering, pharmaceutical applications and producing GMOs. When the term "GMO" is used in the course, it refers to genetically modified crops and foods, not genetically modified bacteria for the production of pharmaceuticals, for example. In the second part, the students chose a biotechnology topic and worked in small groups to produce a written report and oral presentation to supervisors and peers. Two groups (ten students in total) chose to examine GMOs and were supervised by the professor who gave the lecture on the subject. Themes for the report were suggested by the supervisor, but students were free to follow their own interests. One group chose working on GMO in the third world; the other group started off working on healthy GMO products but ended up writing more about the controversy in society. The students met the supervisor four times over six weeks. In the first meeting the students were guided in their task, and could ask about the literature and about the report format. In the two following meetings, students had searched the literature, the findings were discussed and the fourth meeting focused on the formulations of the written report.

The technology discussed is based on the knowledge about the soil bacteria *Bacillus thuringensis*, which has genes that expresses a protein (cry-toxin) toxic to certain insect pests. These genes are cut out from the bacterium's genome and inserted into plants; soy, potatoes, and cotton. In this way the plant is able to produce the cry-toxin. This means that the plant produces its own insecticide. Every cell of the modified plant makes its own pesticide, a chemical protein harmless to most insects and to humans, whose bodies rapidly break it down, but lethal to the insects of interest. Because such Bt crops replace pesticides, many scientists believe genetic engineering could help save the environment.

3.3 Data collection

All the lectures in the course were observed (600 min) to understand the context of the course. The parts of the course dealing with GMO were focused on; video data collected from the lecture (90 min), and supervision of two groups of students (225 min). The written reports on GMO were collected. Video enabled capturing versions of the action, activity and interaction that arise within education and subject them to repeated analytic scrutiny (Hindmarsh & Heath, 2007). It enables access to the details of conduct – people´s talk, their bodily conduct, their use of tools, technologies and so forth that are largely unavailable by field work, observation and audiodata. Unlike other forms of qualitative data it also allows researchers to show and share the material on which observations are based, so that they can judge for themselves the persuasiveness and validity of insights and analysis.

3.4 Analysis

In the preparing of the transcripts using Transana[5], a relatively "broad" transcription style (Gee, 2005) was opted for. The initial transcripts were only focused on words, but as certain transcripts were analyzed in more detail speech features such as pauses or tone deemed meaningful to the analysis were added.

The text documents; transcripts and reports were imported to NVIVO[6] to facilitate the analysis. Examples of themes and activities engaged in by the participants were identified: "argumentation in favor of GMO", "describing the opponents to GMO" "scientific argumentation", "discussing the writing of the report". For the analysis recurring themes throughout the texts from the lectures, supervision and students reports and/or presentation were chosen. The findings points of departure are the claims the students make at the end of the course, either in the reports or in the final presentation. These claims are understood as active responsive understandings of what happened before the report in the lectures and supervision meetings. For article 1 the theme was "opposition to GMO". Excerpts addressing opponents to GMO and their arguments were chosen for the subsequent analysis. For article 2 the theme was "Science used to respond to criticism of GMO". Excerpts chosen for the subsequent analysis originated from the students´ presentation and four excerpts from the supervision.

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[5] Qualitative analysis software for video and audio data, Developed at the University of Wisconsin-Madison Center for Education Research

[6] NVivo 8 is software by QSR, enabling working with text documents and video

The discourse analytical approach was based on Gee´s (2005) understanding of language as a tool, used alongside other tools, to help listeners or readers to build areas of “reality”. Analysis was engaged in by focusing on the following building tasks:

1. The activity or activities this piece of language is being used to enact.

2. The identity or identities this piece of language is being used to enact.

3. The sort of relationships this piece of language is seeking to enact with others.

4. Politics: what is being communicated to be “normal”, ”right”, ”good”, ”correct”.

5. The specific sign systems (technical vs everyday language), or how different ways of knowing and believing this piece of language privilege or disprivilege.

In analyzing transcripts I followed Gee´s approach of breaking the texts up into lines and stanzas in order to make the logic inherent in a text more apparent. The solid blocks of transcribed texts were taken apart so that each number in the transcript corresponds to a sentence. Each number in the transcripts is divided in lines, each line in a transcript consists of a unity of speech that ”usually contains only one main piece of salient information” (Gee, 2005, p125). These lines have then been grouped into sets of lines, which Gee refers to as ‘stanzas’. Each stanza being a set of lines devoted to a single topic, event, image, perspective or theme. In the transcripts every line represents an idea unit. Everything with the same number (e.g. 1a-b) is a loosely connected syntactic unit akin to a sentence, though, of course, what constitutes a sentence in speech is more varied and less tightly integrated unit than in much writing. A period stands for an intonation contour that sounds “final”. The stanzas represent claims about how topics are organized in the data, claims that are supported by the discourse analysis. The “tool of inquiry” (ibid) in order to analyze the workings of the building tasks I have used Discourse models. I have constructed representations of Discourse models through analyzing the participant’s actions over time and from event to event. For two stanzas, I have chosen to add drawings, excerpts are reconstructed into “cartoons”, in order to better represent the event with respect to gestures and spatial arrangements of bodies (Ivarsson, 2010).

The terms reliability and validity are often more connected to quantitative studies by techniques such as test-retest correlations or interrater-reliability. Validity is often treated as established by a congruence between different instruments, or perhaps a triangulation from different research methods. Because of the different theoretical assumptions in discourse work, along with its largely non-quantitative nature, these approaches to reliability and validity are not useful here. Reliability and validity are not so clearly separated in discourse work. Nevertheless, I would like to address questions regarding the reliability and validity of this work. Discourse analysis remains a matter of interpretation. The question of reliability in discourse analysis concerns whether different researchers would interpret the text in similar ways. There is no guarantee that such reliability is possible, given that researchers are likely to differ in their motivational factors, expectations, familiarity with the situation etc. Although this analysis has been discussed with a number of other researchers within the science education research community, and with the course leader and the interpretation of the data were agreed upon, it has to be accepted that the interpretations of the data in this report are subjective and another researcher may interpret the data differently. Gee (2005) base the validity for discourse analysis on four elements; convergence, agreement, coverage and linguistic details. The more the analysis offers compatible and convincing answers to the questions about building tasks; significance, activities, identities, politics, connections and sign systems (relationships and connection). Agreement with other researchers is what some researchers call reliability and is addressed above, that is if other analysts interpret the text in the same way. An important and distinctive feature in the validation of discourse work is the presentation of rich and extended materials in a way that allows readers of discourse studies to evaluate their adequacy. It allows the readers to assess the particular interpretation that is made side by side with the original materials. This is not the case in much ethnographic work where the interpretations have to be taken largely on trust; nor is it the case with much traditional experimental and content analytic work where 'raw' data is rarely included. The coverage of the analysis; the analysis is more valid the more it can be applied to related sorts of data. I have used excerpts throughout the course from different occasions, and have also seen that features of my texts are similar to what other discourse analysts have found amongst other biotechnologists. Finally the analysis is more valid the more it is tied to details of linguistic structure. Since this is work is written in English to be able to communicate to a greater group of science education researchers, the analysis of linguistic details have been complicated. Anyway, I included some Swedish text to show how the uses of linguistic details work to accomplish the building tasks. All these features are not all present in all discourse studies; nor do they singly or in combination guarantee the validity of an analysis. As sociologists of science have repeatedly shown, there are no such guarantees in science (Potter, 1996).

3.5 Ethical considerations

Prior to data collection the course leader allowed the first author to observe the lectures in the course. The professor was informed in writing and in meeting prior to the videotaping that the focus of the research was how students learn to discuss GMO at the University. The students engaged in the GMO projects were informed about the research project, that participation in the study was voluntary. They accepted to be videotaped and signed a letter of consent. The videotapes are kept in a secure place and will not be shown to members outside the scientific community and will not be shared for use by other researchers.

4 Summary of articles

The two articles included in this thesis have the same focus: looking at the learning of biotechnology and a socio-scientific issue with an ethnographic approach to discourse analysis. They report how students learn to argue as biotechnologists and take sides with this community in the controversy on GM food. The two articles have different foci in that the first is more concerned with identities of the opposition and the rebutting of their arguments and the second is more concerned with the use of scientific language to privilege professional understandings of GMOs. SSIs are often associated with a broader approach to achieving scientific literacy where an ability to reason over and analyze the social and cultural dimensions of science is considered integral to literacy. This study shows that SSI in practice, in the context studied here, is firstly concerned with using scientific language to privilege professional understandings of GMOs and discredit public worries and concerns. Rather than becoming more scientifically literate through the development of "critical thinking", students are learning to adopt "scientific habits of mind" found among those bioscientists implicated in the development of biotechnology.

4.1 Learning to argue as a biotechnologist: Disprivileging the opposition to Genetically Modified foods

Article 1 reported a study that examined how the opposition to GM food was characterized and how opposing arguments to using and producing GM food was selectively evaluated when the controversy over GM food was addressed. The article reported on how new students came to understand how to articulate an appropriate argument in a techno-scientific community exhibiting the features of biotechnological Discourse, a use of language that legitimates the epistemic and moral authority of science and marginalizes opponents. The participants were oriented to assume a difference between the "Us" biotechnologists and the "Them" that oppose the production and the use of the technology. The students taking the course appropriated a Discourse model, assigning opposition to GM crops and food to lack of scientific knowledge. Other possible relevant knowledge for decision making was made irrelevant. The Discourse offered students definition of themselves as more rational decision makers concerning GM food than people not as familiar with DNA.

4.2 Appropriating "Scientific Habits of Mind": Student Alignment with the Bioscience Community in the GM Food Debate

Article 2 examined how bioscientific practices was characterized and used as a resource when the controversy over GM food was addressed in a university biotechnology course. Language used by the participants fashion the identities of the opponents as irrational. The identities of bioscientists were constructed to be knowledgeable and capable of doing precise and extreme experiments. The sign system, or knowledge system privileged over other ways of knowing is bioscientific knowledge and method. What is communicated as "good" is coupled to properties of the plant created through biotechnology and the problems it solves, whereas the solution of the problems in the 3rd world countries is restricted by opposition by the public and environmentalists. This gave rise to an expression of a Discourse model: the introduction of "robust", "nutritious" and "good for the environment" GMO is impaired by "reluctant consumers" and "regulations". During the course certain positive properties and qualities such as accuracy and efficiency are attributed by the participants to scientific practices and claims, and the case for biotechnology is established in response to objections and criticism originating from other competing authorities such as environmental groups and health organizations.

5 Discussion

This study reports how a SSI was enacted in an introductory university biotechnology course. Discourse analysis, guided by an ethnographic perspective, forms a basis for identifying what a group of biotechnology students needed to interpret, produce and know so they can participate appropriately and, through that participation learn. Although focused on a small sample, this study offers insights into biotechnology students' decision making regarding SSIs, while also demonstrating the utility of discourse analysis for understanding learning in this context. The study demonstrates how students learn "the right" ways of considering a controversial issue such as producing and consuming GMO. The students were oriented to assume a difference between the "Us" and the "Them". "Us" are biotechnologists, the possible producers of GMO and "Them" are the ones opposing the production and the use of the technology. "We" have knowledge of science and technology and the facts and evidence considered originate from natural sciences. The arguments made relevant underpin a Discourse model that opposition to GMO is irrational and the students are offered an identity as rational decision makers. This study showed how students, as they appropriated "scientific habits of mind", learn to argue, and being critical towards environmentalists, but not to bioscience and the institutional contexts in which GMOs have been developed. During the course, certain positive properties and qualities such as accuracy and efficiency are attributed by the participants to scientific practices and claims, and the case for biotechnology was established in response to objections and criticism originating from other, competing authorities such as environmental groups and health organizations.

The ethnographic approach to discourse analysis taken in this study makes it different from the dominating approach to understanding what is learnt when SSIs are discussed in science classrooms. While socio-scientific issues (SSIs) are often associated with achieving scientific literacy in terms of "informed decisions" involving "rational thought and discourse" this study shows that SSI in practice, at least in the context studied here, is firstly concerned with using scientific language to privilege professional understandings of GMOs and discredit public worries and concerns. The SSI movement consists of science educators who focus on SSI as learning contexts and strive for the inclusion of SSI in science classrooms (Sadler & Zeidler, 2009). The research is often based on what is learned during interventions, reports about positive effects of what SSI can do in classrooms as reported in a recent review of the SSI literature (Chang Rundgren & Rundgren, 2010): achieving scientific literacy, enhancing decision making and critical thinking. In addition to have constructed representations of

Discourse models shared among members in the biotechnological community, the study enables questioning of what I have come to see as a Discourse model held by the SSI movement in the science education research literature that inclusion of SSI in science classrooms is worth striving for, that "sophisticated" argumentation and "scientific habits of minds" means "critical thinking" and lead to "better" citizens. As if the "ideal" person, scientifically literate presumably, takes all perspectives into consideration and makes "informed", "responsible", "rational" decisions not "hindered by emotional proximity". This study explored decision-making in terms of Discourses, instead of explaining the decision-making process along the lines of "rationality", "critical thinking" or "sophisticated argumentation". In this study the attempt is not to have a priori conceptions of SSI as "the way to do science teaching". I do not have any desired learning outcomes to prove. Rather the methodological and theoretical approach to understanding learning in this context enabled me to draw attention to:

- What it can mean that science and science education are always part of larger communities and their cultures, including the sense in which they take sides in social and cultural conflicts that extend beyond the classroom.
- How enculturation into a domain, such as bioscience, includes appropriation of the value systems embodied in the cultural-specific ways of knowing and doing.
- Decision-making as questions of clashes between people with different interests, instead of questions about "critical thinking" and "sophisticated argumentation".

In our culture, many insist that the individual mind is the natural unit of all valuing and meaning making practices. And so does many science educators: rationalism should be the sole basis of decision making not just in science but in life, Lemke (2001) describes it as the "heroic, romantic, and masculine myth" that "glorify one man with the truth struggling against ignorance and error to triumph over all". An assumption in some of the science education literature is that people can simply change their views on one topic or one scientific domain without needing to change anything else in their lives. Doing detailed research to understand how Discourses, values and practices arise and spread contributes to debunking the myth. To change your mind from believing in creationism to evolution requires much more than acquiring more "sophisticated argumentation" or some "rational" explanation of the facts. It would mean to change a core element of your identity. Mind-changing is a social process with social consequences. It is not simply a question of what is right in the strict rational sense; it is about who we are, who we like, what our role models believe and how we are made to feel about ourselves and others. To argue that GMO should not be developed and used and working together with environmentalists to hinder the development, would for a biotechnologist mean to work towards less prospective jobs for instance. It would also mean to align with a group of people who are perceived to be "wrong" in many ways by those with strong voices in the community. It is evident that there is a lot more at stake than "rational" choices among competing claims and theories.

It is worth considering how we phrase ideas of literacy and citizenship coupled to SSIs in science education. In the context of the two studies I have reported here, scientific content knowledge which is believed to be crucial when resolving SSIs (Lewis & Leach, 2006; Sadler & Zeidler, 2005; Zohar & Nemet, 2002), was not limiting. What came into focus in article 1 was that all perspectives were not given the same space and relevance, issues such as ethical and political impacts were marginalized as the molecular biology community has been shown to do previously (Gisler & Kurath, 2011). Is it necessarily so that science teachers enable exploration of SSis from all perspectives? Socio-scientific disputes hinge less upon the scientific uncertainty (although the uncertainty may be a necessary condition) than upon legal, political and moral considerations (Turner, 2008). Students positions on socio-scientific issues have been shown to be determined by their ethical assumptions (Sadler & Zeidler, 2004), and research scientists and professors based their decisions primarily on personal values, moral/ethics and social concerns (Bell & Lederman, 2003). Still, science educators argue for inclusion of socio-scientific issues in schools to enable "scientific habits of mind", "responsible" and "informed" citizenship, coupled to "critical" (Liu et al., 2011) and "rational" thinking (Sadler & Zeidler, 2005; Laurence Simonneaux & Simonneaux, 2009; Zeidler et al., 2006, 2005). What does that imply of the ones not having undergone the same "treatment"? Are they irrational, irresponsible decision makers? Does it mean that scientists are rational, responsible, informed and critical? Although rationality does not constitute a consensual neutral body that is superior to conflicts and power relations (Stengers, 1999) it is still used as some kind of ideal to resolve socioscientific reasoning. Kolstö has warned against the notion that solution to socioscientific controversies can be resolved by rational means (2001). This way of thinking is traditionally named technocratic and implies that collective decision making in society is better left to experts as they are the only ones who have mastered rational methods for problem solving. Already in 1985 Aikenhead (1985) in his article about collective decision making in the social context of science, argued for the use of "thoughtful" instead of "rational" decision making characterized by an explicit awareness of the guiding values and the current knowledge relevant to the issue. Referring to Toulmin (2003), Aikenhead claimed that watchdogs of rationality tend to have a narrow and absolute view of rationality and an erroneous assumption that the more science people know the greater will be their agreement on decision related to science and technology. Just as economic, political and ideological values can influence the testimonies of scientific experts, it can influence science teaching itself. Teachers tended to assume that a deeper understanding of science leads directly to more thoughtful decisions on social issues related to science (Aikenhead, 1985).

Levinson (2010) discussed the dominant discourse of scientific literacy and citizenship as reflected in school curricula – arguing that the seemingly uncontentious aspiration to emphasize the importance of educating a scientifically literate public for democratic participation is more complicated. I have not seen the idea to achieve scientific literacy being problematized in research reports by the SSI movement, although ideas about literacy has been connected to strengthen support for science, gaining acceptance for scientific activities undertaken in the name of societal needs and to bridge the gap between science and the public (Gisler & Kurath, 2011). In the 1970s and 1980s social scientists were debating whether protest and public dissent around biotechnology were connected to science illiteracy (Gisler & Kurath, 2011) such debates were nurtured by large-scale public attitude studies, reporting a low factual knowledge of science. The field of Public Understanding of Science was criticized for its biased conceptualizations of the public as deficient in contrast to a knowing and homogenous scientific community (Irwin & Wynne, 1996). To strengthen support for science, the mass media and school education were typically seen as a means of increasing scientific literacy (ibid). Even if ideas of socially distributed knowledge have challenged the deficit model, the idea of a significant knowledge gap between experts and laypeople have been fixed over the years and protest and public dissent around biotechnology have been thought to be connected to science illiteracy. Ideas about scientific literacy depend on the conception of knowing and learning that one associates with it (Roth & Barton, 2004). Roth and colleagues see scientific literacy not as individually acquired skills such as “responsible” sophisticated reasoning, but literacy as socially distributed knowledge. Sadler and Zeidler (2009) made use of the concept of Gees Discourses, still they think that scientific literacy can be productively considered in terms of “individual competencies and practices”. Roth emphasizes the need to focus on the individual as integral and constitutive part of the collective, and on the distributed nature of knowledge and skill.

The inclusion of SSIs in the science classroom can have several purposes and learning outcomes. Using genuine public controversies to help students discuss and envision political possibilities can be a way to create an atmosphere of intellectual and political freedom (Hess, 2009). SSIs can be used to problematize the social hierarchy of knowledge that put scientific knowledge on top (Roth & Désautels, 2004). They can also be used to socialize students into their professional identity and get a sense of what makes biotechnologists different from others. Sometimes the goal of teaching is deliberative discussions (Englund, 2006); other times it is productive disciplinary engagement (Engle & Conant, 2002). There is another study reporting that inclusion of SSIs in science classrooms resulted in students privileging the scientific point of view over others (Pouliot, 2009), the students ascribed to citizens deficits of knowledge and authorized a limited participation of citizens in public debates even when socio-scientific issues were introduced using the teaching model "interdisciplinary rationality islands". Lemke (1990) reported how students in school were often told very subtly that science is opposed to common sense, that it is a special truth available only to experts and mainly in-comprehensible to the layman. Lemke coupled the unequal status of topics in the classroom to the growing technocracy**.** Lemke saw it as a part of a larger social pattern: the acceptance of "expert views" on policy by people who do not understand the basis of those views. A growing technocracy in the 20th century tried to control policy decisions by selective appeal to experts thereby bypassing inconvenient disagreements about basic values. Science education convinces students that the experts who talk science are smarter than the students are. By its silence on questions of social values science education also helps foster the misconception of science, on which technocrats rely, as value free or value neutral. When there is a policy debate these days it usually turns out to be a debate over what the facts are, a debate between rival groups of experts. It is rarely a debate over values, over choices, between alternatives. Rarely did public debate or debate within institutions (schools, universities, corporations, and governmental departments) openly recognize that different social groups have conflicting interests (Lemke, 1990). Has the inclusion of SSI in classrooms changed the problematic practices that Lemke pointed to more than 20 years ago? Does the Discourse about SSI amongst science educators contributing to helping students see how different groups have conflicting interests, scientists and different "publics" alike?

The present investigation revealed ways of stating and supporting claims accepted in this university community rather than reporting on beliefs held by individuals. Discourse analysis can lead to fundamental changes in the practices of an institution, the profession, and society as a whole. However, discourse analysis does not provide definite answers; but an insight/knowledge based on continuous debate and argumentation. This study focused on a specific science, plant biotechnology. Which sciences we are thinking of, makes a difference when making claims about what can be learned from science. I cannot generalize about science as such, since different sciences are unique. It is remarkable how science is often thought of as a singular concept, while certain strands of research such as genetic engineering and stem cell research are widely contested, whereas others have much more support.

Studying a practice and understanding teaching and learning of biotechnology in a particular context does not result in a list of recommendation for how to teach. Nevertheless I believe that reflecting on and gaining meta-knowledge of the Discourses we belong to and Discourses in general is a foundation for change since our Discourse models are often unconscious. I have reflected on the biotechnological Discourse and the SSI movement´s Discourse. This study has illuminated aspects of an expert Discourse that Wynne (2001) has proposed create public alienation by exaggerating how much "we scientists and rational beings know", and this lack of institutional self-reflexivity has been a major problem for the institutions promoting genetically-modified crops and foods. It could possibly serve not only students, but also biotechnology if teachers reflect upon teaching and the way we talk about ourselves and others. One might more plausibly argue for scientists to become more understanding of the citizen than to ask the citizen for increased understanding of ordinary science and thereby get better solutions. Biotechnology experts need input from citizens. Society needs to create better social and cultural organization that recognizes and favors the citizens' active participation in problems that interest them and not letting experts tell them what is best by educating them. A vision for the future involves developing the best solutions for society with interest-based stakeholders and individuals from within and outside of science making decisions regarding current trends and developments in science and technology in place of the old assumption of a general public that are opposed to science. We can begin thinking about how individuals with different expertise co-participate in resolving the complex problems that communities face today.

When it comes to science education in general it might provide students opportunities to make different decisions and changing their minds to ideas that are based on scientific evidence for instance. And if we want more diverse groups of students to enter into science we can consider whether we reject elements of the students identities and values that link them to other communities that they want to keep belonging to. It is not only hard work and logical thinking that is asked for when entering science. It is also inviting students into a particular Discourse and systems of beliefs and values. In times where interests to present a picture of independent and proactive science in a time of intensive commercialization of biotechnology and increased pressure to legitimize research activities, we in the science education research community might reflect more on what it means to claiming "scientific habits of mind" as a goal for teaching. We could start talking more about schools role in helping all students to use science in their own interests and give students practice using science to decide policy issues according to their own values and interests. Maybe introduction of discussions of SSIs in the science classroom left unresolved and complicated can enlighten students into becoming more comfortable with paradox, contradiction and ambiguity.

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