What's natural about nature? deceptive concepts in socio-scientific decision-making.

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Abstract
The conflicts between nature and nurture are brought to the fore and challenges socio-scientific decision-making in science education. The multitude of meanings of these concepts and their roles in societal discourses can impede students' development of understanding for different perspectives, e.g. on gene technology. This study problematizes students' use of "nature" and "naturalness" to further the development of the experience of science education in relation to the nature-nurture debate. We build on the social constructivism view that present conceptions of nature and naturalness emanate from historical and modern social constructions of nature. Claims presented by upper secondary school students in interviews actualizing the control of human actions pertaining to treatments for hereditary diseases by making use of concepts of "nature" and "naturalness were analysed. The students suggested control of human activity on different levels of biological organisation, either from within the Romantic view or the Enlightenment view on nature.

The Romantic view provided students with moral grounds for consistently preserve what is considered as nature and means to bolster their reasoning by referring to the balance in nature, the purity of nature, and the laws of nature. The Enlightenment view provided students with means to support gene technology by embedding "nurture" into the concept "nature" by using knowledge while implying that nurture is a natural way to overcome such imperfections of nature. We propose that these conflicting views should be addressed in biological education to promote students' understanding of contemporary discourses dependent on the different concepts of nature and nurture.

Keywords: nature, nurture, knowledge, moral, reasoning, decision-making

Introduction

As a part of the Swedish high-school biology curriculum students are expected to utilise their newly acquired biological knowledge to make informed decisions concerning socio-scientific issues. The production of resources for them to draw on for this educational goal are envisaged as being made available via a variety of societal discourses that facilitate historical conceptualizations of reality (Berger & Luckmann, 1967). In a science education context, students' development of their reasoning for the purpose of making informed decisions depends on their understanding of the concepts used (Zeidler et al. 2013). These concepts will have, to a greater or lesser extent, contextualized meanings for each individual and will have an impact on students' understanding of, for example, biological knowledge, information from media and fellow students' reasoning. The educational goals such as students' understanding and ability to negotiate meanings in order to make informed decisions therefore depend on how discernible the contextualized meanings of the concepts are to the students.

In biology education, nature is an essential concept since nature and processes in nature need to be understood and related to in many contexts, in particular in relation to socio-scientific issues concerning the environment and medicine. However, when dealing with such issues, students typically appear to use the concept of nature in a normative way in their argumentation (Nielsen, 2012). This creates potential generative teaching and learning challenges when dealing with issues pertaining to human activities that have a discernible effect on nature. The challenges are compounded by the broader constructs of "nature" and "nurture" being ambiguously used in many

school biology textbooks (Lemoni, Stamou & Stamou, 2011). This has manifested into a tendency for nature to be portrayed in terms of an orientation towards being pure, good and nourishing or in terms of an orientation towards something to control and to improve (for example, see Williams, 1983; Hansen, 2006). For the analysis we present in this article we have characterized these two orientations to nature as being grounded in a Romantic era or an Enlightenment era perspective (cf. Hansen, 2006). The dynamics of these portrayals have created intellectual challenges for both students and teachers as they grapple with what are often multi-faceted and value-laden socio-scientific issues in relation to the scientific endeavour to generate knowledge about the natural world and the more normatively-bound application of this knowledge. If educational experiences leave students without any meaningful understanding of the complex interplay of meanings that get embedded into ways of thinking about nature then students' roles in societal discourse that is related to socio-scientific decision-making must end up being limited. Consequently, there is a need for greater educational insight into the kinds of "epistemological commitments" (Sadler and Zeidler, 2009) that students are ending up constructing their views of nature on as they grapple with getting to make informed decisions concerning socio-scientific issues. To contribute to addressing this need we have explored the meanings of nature and "naturalness" that emerge in students' reasoning. To do this, reasoning concerning hereditary diseases and the relationship between nature and human cultural activities shaping nature are analysed and discussed.

The Nature and Nurture debate

The complexity of the conflicting concepts of nature and nurture
Within the Western cultural context the development of the complexity of the concept of nature, discernible in societal discourses today, can be understood by studying historical texts. By following the course of construction of the concept of nature over time, a long-standing conflict between nature and nurture (human culture shaping nature) emerges. This conflict is apparent in present debates on, for example, conservation biology and modern medical treatment.

The first text in which the terms "nature" and "nurture" were used as conflicting concepts is claimed to have occurred in the thirteenth century (Groff & McRae, 1998). During the 18th Century discordant ideas of nature and nurture coexisted. For example, Erasmus Darwin's Lamarckian and teleological understanding of evolution (Kormondy, 2011; Lehleiter, 2011; Smith, 2010), seeing evolution as nurture on an individual generation-to-generation level, was formulated at a time when Rousseau disregarded nurture in favour of nature.

During the 19th Century a discord between the two parallel discourses started to grow as the Romantic era ideas turned against those of the Enlightenment, which were deemed to support an unjust tampering with nature (Stables, 2009). During the Enlightenment the concept of nature developed out of religious notions, which were comprised of a set of natural laws, and matter and objects to study and to control (Lehoux, 2006). This perspective went through a phase of change during the Romantic era through emphasis being put on nature as the original and the pure (Williams, 1983). A cultural divide became apparent as the Romantic era discourse mystified nature while simultaneously constructing an image of nature as being pure, good and nourishing (Hansen, 2006; Stables, 2009).

The Romantic era escapism perpetuated the divide between human culture and nature that had been developed during the Enlightenment, although with an ambiguous wish for integration between humans and nature. For the Romantics, nature was "sovereign" instead of just a subject to study and to domesticate (Hansen, 2006), and the Enlightenment idea that humans and human culture should shape and improve nature was heavily criticised (Macnaghten & Urry, 1995). Hence, Romanticism devalued nurture, in the sense of human shaping nature, (and by implication science) and viewed it as an unwanted manipulation of nature. Yet an insufficiently nuanced perspective on the nature-nurture relationship may lead to human interaction with nature being interpreted as disastrous for nature (Hicks, 1996; Purdon, 2003) or unwanted, irrespective of restorative and ameliorative effects (Czech, 2004; Teman, 2008).

Constructing nature and naturalness

Today, the concept of nature provides a number of ways to describe what is natural. One of which includes the "naturalistic fallacy" (Elliott, 2006; Macnaghten & Urry, 1995), an influence from the 19th Century Romantic view of nature. Here, "natural" and "naturalness", when borrowing value from nature as good and pure, imply that a process or the origin of something is good, right and even safe (Hansen, 2006; Ridder, 2007; Rientjes, 2002). The definition of nature as human-exclusive, self-organizing and in balance (Cuddington, 2001) typically contrasts with the unnatural, which includes human threats to natural processes and plausible risks.

A second way to describe the concept of "natural" is based in the 18th Century Enlightenment view of nature as having a potential for improvement. In this view, nature is seen as imperfect or in need of human attention. Subsequently, nurture, in the form of human shaping nature,is acceptable and even wanted (Nordqvist, 2010; Rientjes, 2002). Although, medical treatment and the protection and restoration of nature can be seen as counterbalancing practices in modern society, such activities are presented as caring in modern discourse. And caring can be performed in more or less natural ways with a range of views of what is natural or unnatural (Nordqvist, 2010; Purdon, 2003; Rientjes, 2002). From the contrasting Romantic view of nature, using natural resources, changing the landscape and using modern technology, would be regarded as tampering with nature (Hansen, 2006; Stables, 2009).

A third way of describing the concept of "natural" displays a modern and more pragmatic view of nature in that it is taken for what it appears to be. Here, "natural" and "naturalness" hold meanings that pertain to tradition, i.e. what is considered as usual or at least existing a few generations back in time (Coyle & Fairweather, 2005; Zwart, 2009). Normality, in the sense of what is deemed usual, can also be associated with this meaning of natural or naturalness (Lerner & Hofmann, 2011).

Nurture and human nature in debates on medicine and gene technology

A debate on inheritance with implications for viewing human traits and human development started in the late 19th Century. In James' functional psychology (Logan & Johnston, 2007) some human "instincts" are solely dependent on nature whereas others are dependent on both nature and nurture. The nature versus nurture debate is also concerned with if and how hereditary traits are influenced by environmental factors from conception onwards (Logan & Johnston, 2007). The relation between nature and nurture in this field was blurred through the 19th and early decades of the 20th Century, although the idea that some traits were inherited underpin, the orthodox scientific view is that the interplay between nature and environment can provide reasonable explanations for human nature, and even that nurture, i.e., human shaping of the environment, can be seen as natural (Plomin, 2011).

Today there are many parallel discourses regarding human nature, developing from constructions of human nature and nurture from historical discourses. One example is the social construction of "family" in which hereditary physical traits have been suggested to play a prominent role, typically observed in cases of adoption and fertility (Nordqvist, 2010). The choice of donors, based on physical resemblance, for the purpose of in vitro fertilization (IVF) or artificial (donor) insemination (AI/DI) is described as unproblematic, as is the reproduction of the concept of traditional family. Traditional family is legitimized by the physical resemblance between parents and children. Hence, nature is the guiding rule for the construction of "family". When nature does not provide the possibilities for reproduction, i.e. in same sex couples or in couples with one infertile spouse, the rule of nature is followed through imitation i.e. physical resemblance, to make necessary compensations (Ibid.). The societal discourse on artificial reproduction, such as IVF and AI/DI, reveals that biological kinship is stronger than social kinship (Burr, 2009), as "nurture" is guided by the concept of nature.

Medicine as a form of nurture challenges nature. The development from Hippocrates' view of diseases as being caused by the disruption of the natural balance (Smith, 2002), to modern medicine where, for example, hereditary diseases and cancer are regarded as having either natural causes or being the result of cultural habits, raises ethical issues that are complicated by the use of nature as a moral guide. The battle concerning the acceptance of germ theory during the 19th Century exemplifies the strong belief that makes up part of the idea of "natural balance" under the influence of evaluative connotations concerning diseases (c.f. Harvard University Library, 2014). Treating lifestyle diseases to

regain a natural balance could, according to the Romantic era perspective be taken to be morally right, at the same time treatment of medical conditions that could be regarded to be a result of bad cultural habits could be taken to be immoral. Thus, certain human cultural habits may be seen, not only as bad, but also as a threat to nature and the balance in nature. ~~In~~ From this perspective, modern medical treatment such as artificial insemination, in vitro fertilization, and the treatment or prevention of hereditary diseases would be considered as unnatural, and therefore morally wrong.

The debate on whether a zygote is a human or not (Burgess, 2010; Curtis, 2012) originates from the idea that moral status is granted when the zygote is considered a human being. A zygote can be considered as a human in the sense that natural events will result in a human being. Thus, from a Romantic era perspective, it would be morally wrong to subject a zygote to external interference. From this perspective, selecting zygotes for implantation or using embryonic stem-cells in research would be deemed wrong since a zygote has the potential to become a human (Marquis, 2007). The process of life is "nature", thus it would be unnatural to prevent a zygote from becoming a human through human interference. A position that contends that expected natural events should be used for moral guidance is at odds with the application of modern genetics in medicine. Since the 1990s, the nature-nurture dichotomy has become less clear, which today can also be observed in the medical field. The findings within the field of epigenetics demonstrate that environmental influence (such as stroking on the skin) can result in stable genetic changes (Francis, Diorio, Liu & Meaney, 1999). Hence, the understanding of nurture as a way of shaping nature appear "natural", which underscores the blurring of the distinction between nature and nurture (c.f. Stables, 2009). A maintenance of a polarized debate can be seen in the criticism of the determinist view of human genetics, in which Kerr and Cunningham-Burley (2000) point out the risk of excluding laymen from decisions regarding the use of modern technology. They describe modern human genetics as "new eugenics". Ettorre (2000) problematizes the defective gene discourse within human genetics. She claims that by making choices regarding which children should be born, based on medical knowledge, the social construction of the human body results in a genetic moral order in which there are good and bad human bodies. From her perspective, nature should be regarded as providing the guiding rule to society and societal discourse and consequently gene technology in medicine is viewed as an unwanted form of nurture and the cause of an unwanted societal discourse regarding human value.

Nature and nurture in Science education
Little research has been done on the nature-nurture relationship in an educational context. Cobern, Gibson and Underwood (1999) discussed ninth graders views on nature in a US science education context where the students described nature as having feelings and being complex, unpredictable, understandable, and mysterious, and a creation of God. The students expressed a yearning to experience "pure" nature, i.e. untouched by humans, and that nature needs to be protected from interference from human culture. Cobern, Gibson and Underwood (1999) concluded that the students' everyday observations about nature were not sufficiently framed by scientific knowledge to the extent that the students could be considered to be scientifically literate. In another study, amongst sixth and ninth graders, students displayed an anthropocentric view on nature (Palmer, 1997). Although the students used concepts such as interdependence to describe processes in nature, their understanding was limited. A prominent feature of their view was the importance of maintaining balance in nature. However this argument was used to explain why only organisms that, according to them, had a role in maintaining this balance should be protected from extinction. In an analysis of pictures used in Greek textbooks for first to fourth graders, a shift in the human-nature relationship was seen between the 1980s and the 2000s (Lemoni et al., 2011). The older books conveyed the divide between nature and humans through the conflicting views from the Romantic era and the Enlightenment. The newer books presented a more complex view in which humans interact with an unpredictable nature. From an analysis of group discussions among Danish upper secondary school students studying biology, Nielsen (2012) found that students referred to nature in an uncritical way and rarely used scientific facts. In the students' discussions the meaning of nature shifted, thus exemplifying the multitude of meanings that can be ascribed to the concept.

Aim

The relationship between human cultural activities and nature is an important issue for science education. Biology education deals with both knowledge of biological processes and with human use of such knowledge, as in medicine and biotechnology, both of which can be considered as manifestations of human culture shaping nature. Thus, these cultural activities could be considered as "nurture". While nurture in this sense can be considered as a problem, nature is not. The relationship between nature and nurture is usually, although implicitly, portrayed as being dichotomous in spite of the last two decades of research. Such a superficial understanding of nature and nurture and the relationship between them, can both impede the development of understanding of other peoples' stances and jeopardize informed decision-making regarding both research and the appropriate application of scientific knowledge – important goals of scientific literacy (for example, see Sadler & Zeidler, 2005). Although there are examples of data relating to the problematic relationship between nature and nurture in educational contexts (for example, see Sadler & Zeidler, 2004), little research has been done that provides the kind of insight needed by teachers to inform their classroom practice. In this article we will address this shortfall by studying what elements from historical discourses students use to address human activities that are aimed at shaping nature. Our study uses publications dealing with students' concepts of nature and nurture, and their relationship, in order to problematize students' use of "nature" and "naturalness" to help further the development of the experience of learning in the context of the nature-nurture debate.

Our research questions are:
1) What meanings of nature and naturalness emerge when students reason about medicine and gene technology in relation to hereditary diseases?
2) What is the nature of the relationship between nature and nurture that students convey in their reasoning?

Analytical framework

In order to investigate the research questions we have drawn on social constructivism (Berger & Luckmann, 1967) because the concepts in focus in this study are regarded as being socially constructed and open to multiple interpretations. It is clear that the ways that the concept of nature, as well as the concept of nurture get to be understood cannot be taken to be an educational "given", hence the historically derived diverging concepts of nature and the associated on-going debate about nature versus nurture discussed earlier. In this dichotomous relationship nurture, in contrast to nature, is understood as being the actions undertaken in a situation.

Conceptions of nature are culturally driven and reflect how ideas and thoughts about nature have been socially constructed, maintained and transformed, concurrent with changes over time in Western culture (Hansen, 2006; Stables, 2009; Williams, 1983). Present "typificatory schemes" (Berger & Luckmann, 1967) for nature and naturalness, i.e., how they are conceptualized, have emanated from historical and modern social constructions of nature. Over time these constructs have been imbued with, for example, rational, emotional, normative and religious aspects, which are conveyed in modern discourses about processes associated with nature. As such, they confer important meanings in negotiations about present and future human interaction with nature, and the relationship between "nature" and "nurture". Thus, nurture, which can be used to contrast nature, can be understood as any changes due to individual, cultural or societal human action for the purpose of improvement or restoration.

"Nature" as a social construct is imbued with multiple meanings, with the influences from the Enlightenment and Romantic eras being the most prominent. There are meanings of nature as well as of nurture, deriving from these eras, which are opposing and as such fuel the nature/nurture debate. For this reason we have chosen to let these opposing meanings of nature guide our analysis of student reasoning about the use of medicine and gene technology in society. The social constructions of nature can be considered as being institutionalized by present subcultures. Institutionalized constructs control human actions by being accepted and, at the same time as resulting in habitualized human

actions, they confer liberation from decisions as well as provide security (Berger & Luckmann, 1967). This, in turn, reduces anxiety and induces a belief of "understanding" the world. The embedding of human actions into institutionalized constructs by modification of typificatory schemes sustains security and provides legitimacy. Hence, by using a wider definition of, for example "nature" or "naturalness", an action can easily be embedded and legitimized (Berger & Luckmann, 1967; Giddens, 1990).

Present societal discourses on nature and naturalness display a complexity implies that different constructs can be interspersed with each other, thus blurring the boundaries between the concepts (Hansen, 2006; Macnaghten, 2004; Sherry, 2004). The complexity indicates a high variety of typificatory schemes (c.f. Hansen, 2006) and in turn an on-going modification of typificatory schemes for making new meaning or for embedding into institutionalized constructs.

Nurture is a set of actions that are socially controlled. From a social constructivist perspective it seems reasonable to analyse how nurture is controlled by "nature". However, since there are many possible typificatory schemes available for nature it is of interest to analyse how they are used to control nurture as human action. Meanings of nurture, if seen as partially stemming from the Enlightenment era, can also be used for the purpose of controlling nature by rational argumentation based on what is considered objective knowledge, another social construct.

Method

Drawing on social constructivism, this qualitative study focuses on interpreting students' different conceptualizations of nature. Data was collected from interviews with Swedish high-school students who had participated in their last high-school course on genetics and gene technology. The analysis of the interviews focused on the relationship between nature and nurture as expressed through students' use of the concept "nature".

Participants
The 33 participants (17 boys and 16 girls) were drawn from 103 students in four classes at two different high schools located in the south of Sweden. At the one school, the two classes were first year and second year students of a natural science programme (seven and ten students respectively). The remaining 16 students were drawn from two classes at the other school. They were engaged in the third year of a social science programme. All students had participated in a five-week block of a science education course that dealt with the topics of genetics and gene technology. The course was delivered through a series of lectures; in addition all students participated, either as debater or as audience, in two debates on socio-scientific issues. The first debate dealt with the use of "Golden rice" (genetically modified rice) and the second, the treatment of hereditary angioedema. In preparation for the debate, students were encouraged to supplement the information provided in class with that drawn from other sources, including the Internet. All students in the study participated voluntarily and were informed that they, at any time, could decline from answering questions or withdraw from the study.

Data collection
In order to be able to analyse what meanings students associate with nature and nurture after having studied genetics and gene technology the students were given a questionnaire to complete at the end of the course. The questionnaire consisted of open-ended questions dealing with various aspects of the use of gene technology for reproductive purposes in both humans and animals. For example, one question in particular linked directly to the topic of the debate on hereditary angioedema. It dealt specifically with the choices faced by parents when having to decide whether or not to have a child knowing the risk of the child being born with a hereditary disease. When answering, students were requested to include their emotive responses to the issue at hand. In addition, the students were made aware that their written responses to the questions would form the basis for a follow-up interview.

For each of the participating students the questionnaire responses were analysed and depicted as a mind-map representation (Lindahl & Linder, 2013) of the salient features of their thinking on the issue, see the example below in Figure 1.
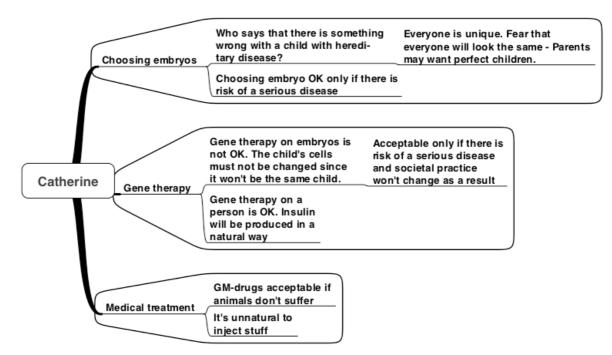

Figure 1. An example of a mind-map representation of a student's thoughts.

The three topics in the figure represent main areas discussed by the student and the sub-topics shows the students main concerns. This mind-map was by the student acknowledged as representative of her thoughts in the issue.

Each mind-map was seen as a "work-in-progress", open to revision upon engagement with the interviewer in the follow-up interview. These semi-structured interviews lasted around 30 minutes and each followed a similar protocol – in which the student was asked to elaborate on what they had written in their questionnaire responses, using the mind-map created in the analysis, as a prompt. This process of using the data created from the responses from the initial questionnaire in the subsequent interview is a form of simulated recall (Calderhead, 1981). The simulated recall facilitated further exploration of the student's views and opinions and a re-working of the students' mind-map. If the concept of nature was brought up by the student in the interview the dialogue was turned into an exploration of the limits of the concept of nature as understood by the student. At the end of the interview the student was asked to confirm that the re-worked mind map was an appropriate depiction of his/her knowledge and arguments. Interviews were recorded and transcribed verbatim.

Analysis
For our analysis "nature" and "nurture", and subsequently their relationship, are considered as social constructs present in societal discourse today. Hence, students' reasoning about socio-scientific issues is expected to reflect a variety of meanings for the concepts of nature and nurture. From their reasoning about human action concerning medical interventions, i.e. nurture, the students' meanings for both concepts, as well as their relationships can be interpreted. For the purpose of this study, students' reasoning in which they explicitly refer to "nature" or "naturalness" was analysed. The analysis of transcripts from the interviews revealed that 27 out of the 33 students dealt explicitly with the issues by referring to "nature" and/or "naturalness". The parts of the transcripts where the students used these concepts were chosen for further analysis. The mind-maps were used as a guide to confirm that the chosen claims and explanations were used only to represent the students' views on the issue within the context conveyed by the student.

Students' justifications for their claims were used to categorise their individual interpretations of the concept of nature as falling broadly within either the Romantic or Enlightenment paradigm. While it is acknowledged that individual students' may well display quite idiosyncratic and/or inconsistent use of such concepts, they nonetheless can be characterized as belonging broadly to one of the two paradigms.

Before discussing the results of the analysis, it is important to state the definitions of the Romantic and Enlightenment views of nature used for the analysis: The Romantic era view of nature holds that nature and what originates from nature is natural, good, morally right, and in balance. Hence, nature is seen as self-organizing and should be left without human interference. Subsequently, humans should not attempt to dominate or tamper with nature because this could go wrong and result in retribution from nature, for example, in the form of natural disasters. In contrast, in the Enlightenment view nature is seen as having the potential to improve. Nature is imperfect and in need of human help. Hence, humans should with the help of scientific knowledge make necessary improvements and correct faults and battle "cruelties" of nature.

Results

The results show how students use meanings from both the Romantic and the Enlightenment era as epistemological resources to explain the stances that they took during the interviews. In their reasoning, the students employed the concepts of nature and naturalness as well as the implied relationship between nature and nurture at a number of different biological organization levels. These levels ranged from the population level through to the individual organism, cellular then gene level. Knowledge in terms of biological organization levels serves the purpose of conveying a context to support the students' stances. The students' suggestions for control of human activity on the different biological organizational levels are considered as their expressed opinions on the limits of the concept of nature in the context of the use of medicine and gene technology in relation to human hereditary diseases.

Of interest is that some students were able to acknowledge that concepts of nature and naturalness are not static and may well change over time. In the following excerpt the student describes how she thinks the view on nurture in the form of gene therapy might change when it becomes fully integrated into medical practice.

> 'Well, it's not natural, but let's say in a few hundreds of years, then, then it might be natural. I mean, you might think its natural to change or to modify genes.' (Lene)

This is an example of students' awareness of on-going changes of cultural conceptions of nature and nurture as well as the relationship between the two. Lene's utterance also presents a pragmatic view that conflates natural with normal.

As mentioned earlier, we were able to categorise students' responses using the concepts and level of biological organization discussed. Below, the students' responses within each of the categories identified are exemplified by excerpts from the interview transcripts bearing in mind that no single excerpt from the category can provide the full characterization of the category. Pseudonyms are used to provide anonymity to the students in the study.

The nature-nurture relationship displayed from a Romantic concept of nature
Population level
On a population level the balance in nature appears to be a salient part of the typificatory scheme for the concept of nature. What happens in nature is "right" and human life should follow the course of nature. Tampering with nature through any nurturing action that, for instance, reduces the proportion of humans with hereditary diseases is considered to cause an imbalance in nature.

> 'If we should start to choose, to get only healthy children, then Earth will be overpopulated because the sick children would have died young, but instead more and

> more would live longer. So I think nature must take its course even if it is harsh.'
> (Marie)

In this characterization, the student objects to the form of nurture suggested because it interferes with nature that is seen to be self-organizing. Similarly,

> 'If the child is sick and then, well it is, and then it won't survive for long. That's more natural I think. I mean that you sort of don't do anything, just establish how it is. To me, that's like nature takes its course and its the strong ones that survive – that's the rule of the jungle.' (Susanne)

What occurs in nature is "right" and this is an example of "self-organizing nature", which lets the weak and sick perish. Although it is not spelled out here, the view that nature should take its course implies that humans should not interfere.

Organism level
The conflict between nature and nurture as exemplified by human actions that interfere with nature is more apparent on the organism level than at the population level. Human action that intervenes in nature is more conspicuous on this level. In the excerpt below, the student refers to the conventional medical treatment of diabetes mellitus type 1 with insulin injections. This utterance exemplifies that even though students accept conventional medicine, i.e., practices that exclude gene technology, they do not think of it as being natural.

> 'Stuff you sort of inject and such are unnatural.' (Catherine)

Injections into the body, i.e. the crossing of the bodily boundary, deprive the natural body of its purity, which within the Romantic era concept of nature means a loss of naturalness.

Cellular level
There are techniques that can be used on a cellular level to ensure that a future child will not get a hereditary disease. One such possibility is to actively select embryos for implantation, so called pre-implantation genetic diagnosis (PGD). However, this procedure is characterized as unnatural, as is seen in the excerpt below.

> 'This is difficult because I feel that, well it it's not really, I mean the natural way to make a baby, just picking and fiddling around.' (Louise)

PGD is not only considered as excessive interference with nature, but also viewed as wrong according to a morality derived from nature.

> 'It's almost like breaking against a natural law.' (Fatime)

The student views the selection of embryos as unnatural in this characterization because this would not have happened without human interference. Interference on this level is viewed as morally wrong since the guiding principles for human action should be guided occurrences in nature are guiding principles for human actions should be in accordance with the course of nature.

Gene level
Gene therapy on embryos is seen as an even greater intrusion then just choosing embryos. Gene therapy is conceptualized as not being natural because the genes of cells are changed.

> 'It's unnatural when you enter and change genes.' (Margret)

Manipulation beyond the limits of the cells is unnatural. Here, nature as the original is incompatible with gene therapy because the characteristics of the original cell are changed.

The nature-nurture relationship displayed from an Enlightenment concept of nature

Organism level
Students did not characterize nature from an Enlightenment view, on a population level. However, on an organism level, illness is regarded as an imperfection of nature. In the following excerpt Lynn defends the use of gene therapy to cure hereditary diseases.

> 'Because if you are ill, you can't honestly say that you are really natural, I would say.' (Lynn)

Illness is according to Lynn not natural. Hence, her view of the nature-nurture relationship is that of improving nature to make it natural. Hence, "natural" appears to be associated with the meaning of good or in balance, thus showing an overlap with the values connected with the Romantic view of nature. However, nature cannot be good or in balance without nurture through human action.

Cellular level
From an Enlightenment view, nurture, on a cellular level, by choosing embryos without genes that might lead to the development of a hereditary disease, is viewed as imitating nature.

> 'Well, it's the same, I mean like miscarriage for those embryos. That's natural.' (Lana)

> 'It's almost the same, I mean like practically natural I think, because you just choose, you know, it's still their own genes.' (Joyce)

Lana and Joyce seem to use their knowledge of processes in nature to embed nurturing human actions. Hence, the nature-nurture discrepancy is diminished and the suggested human action is accepted as natural.

Gene level
Gene therapy on embryos is presented as one possibility to cure hereditary diseases such as diabetes mellitus type 1. This form of nurture means that the resulting child does not have to be medicated by insulin injections from an early age.

> 'To me it is the same thing as taking insulin injections, but you get it naturally like everyone else.' (Catherine)

The administration of insulin by injection is not characterized as natural (see excerpt under "Organism level"), whereas cellular release of insulin is natural. Curing, i.e. nurture, by gene therapy would repair the natural process. This is an example of a blended discourse (both Romantic and Enlightenment discourse). Catherine does not characterize the administration of insulin by injection as natural (see excerpt under "Organism level"). Neither does she consider gene therapy natural, but since cellular release of insulin is natural she accepts the result of gene therapy, but not the treatment as natural. In the excerpt above correction on the gene level appear to be unimportant since curing, i.e. nurture, by gene therapy would repair the natural process. This is an example of a blended discourse (both Romantic and Enlightenment discourse). Hence, gene therapy is an unnatural means to restore a biological function but the result is considered to be natural. Here, the nature-nurture discrepancy is reduced by embedding nurture through the means of knowledge on processes in nature.

Discussion

In biology education, morals and scientific knowledge are expected to be included when socio-scientific issues are discussed (Sadler & Zeidler, 2005). However, this is a difficult task both for teachers and students. The concepts of nature and nurture, as applied to man's relationship to nature, are socially constructed. The multiple and inter-related meanings of these concepts present in discourses in media (Hansen, 2006; Sherry, 2004) and textbooks (Lemoni et al. 2011) can be interpreted from other studies on students' reasoning about socio-scientific issues (c.f. Sadler & Zeidler, 2004;

2005). Our study confirms the findings of others (see, for example, Nielsen, 2012) and shows that within any given group of students it should be expected to find multiple interpretations and understandings of "nature" that need to be taken into account when dealing with socio-scientific issues in the classroom. This is particularly important when they involve an ethical or moral dimension such as in considerations of gene therapy and the like. In the following we will discuss the results in relation to the apparent conflict between nature and nurture, which partially reflect the conflict between the Romantic and the Enlightenment views on nature, a conflict that to some extent can be described as that between morals and knowledge. The first part of the discussion deals with students' views on human interference with nature by choosing embryos. Here the students' use of the population, organism and cellular levels in their reasoning is included. The second part focuses on students' reasoning concerning gene therapy and intrusive medicine in which they refer to the organism, cellular, and gene levels as limits for human interference with nature.

Choosing embryos - The good in nature as morals or as a commodity characterizations
In the present study students claim that on the population level, human lives should not be spared since there is a risk of overpopulation if human intervention inhibits nature's self-organization. This is analogous to the Malthusian catastrophe debated at the beginning of the 19th Century (Hofmann, 2013; Malthus, 1798/2000). The students' view of nature as self-organizing matches the Romantic view of nature in the sense that nature is "good", i.e. morally right. This is known as the "naturalistic fallacy" (Elliott, 2006), a claim that what is natural is inherently good or right and that what is unnatural is inherently bad or wrong. In line with the Enlightenment perspective on nature, the students in this study reasoned about natural processes on the organism and cellular levels in ways that could be associated with the meaning of "good", although without relation to the universal meaning of the word. Instead, "good" appears to relate to a purpose – for instance, medical interventions that imitate natural processes are natural in the sense of "good". Hence, according to the students in the present study, the decision to act belongs to humans – not to nature – and is justified by the resemblance with natural processes. For example, it is suggested that embryos lost when choosing embryos resembles a natural miscarriage. However, it is possible that the notion of imitation is informed by both morals and biological knowledge in the sense that it is used by the students in their attempts to integrate knowledge with morals in order to find support for the suggested human intervention. While some students call for protection of nature since it is seen as original, pure and self-organizing, others support the use of knowledge of natural processes, i.e. gene therapy, since nature is reliable even though it is imperfect. These differences show that on the one hand some students see nature as perfect due to its origin, and on the other, nature is imperfect since natural processes may not always be functional. Hence, what is "good", according to the students in this study, seems to be determined by either the origin of nature or by its functionality as determined by its usefulness for humans. This interpretation of the students' reasoning, when considered as a reflection of social constructs for nature present in the societal discourse today, may well shed light upon why the benefits of new medical treatments are sometimes in dispute, particularly when the development of medical treatments are acknowledged as part of human progress.

Choosing embryos - Natural as an inherent value or something to evaluate
The students in this study displayed conflicting ideas about the fate of fertilized embryos depending on their different views of nature. Within the Romantic views of nature, embryos should meet their fate according to natural laws – i.e., nature should be allowed to take its course without human intervention. To the students in this study, medical treatment of children born with hereditary diseases such as diabetes mellitus type 1 would appear unnatural within this line of reasoning on the grounds that the purity of the child's nature cannot be sustained when injected with insulin. Hence, there is a risk that such children when given medical treatment, even despite being conceived in a natural way, will have less value since their naturalness could not be sustained. Within the Enlightenment view, *in vitro* fertilization (IVF) and pre-implantation genetic diagnosis (PDG) are human practices based on knowledge of natural processes that endow us with possibilities to compensate for natural imperfections and to ensure that children are born healthy. Students who adhered to this line of reasoning seemed to imply that children with hereditary or other diseases are less natural, since from a medical point of view their body is not fully functional. Subsequently, treatment is necessary to restore nature. This stance is problematic since there is a fear of devaluation

of individuals with a disease, as articulated by Kerr and Cunningham-Burley (2000) and Ettorre (2000), and should be scrutinized regardless of which view of nature is held. However, since the Enlightenment view of nature does not provide any moral guidance and nature is considered subordinate to humans, a presumed devaluation of children with a disease would affect functionality, something the development of medical technology is trying to restore. Hence, nurture in the form of medical technology is "good" in the sense that nature can and should be improved when there is a need.

Gene therapy and intrusive medicine - Natural functions or deterioration of the original
Gene therapy is seen as one way to restore natural functions, at least according to the students adhering to the Enlightenment view of nature. According to the Romantic views of nature gene therapy is a form of interference with natural processes that deprive nature of its original forms. Hence, there are diverging meanings of nature since the Romantic view accepts genetic imperfections as part of the natural scheme of things which should not be interfered with, whereas from the perspective of the Enlightenment, these are to be acted upon. This could be understood as the students with the Romantic view characterized as having a holistic idea of nature where processes in nature belong to certain contexts whereas students with the Enlightenment view more easily fit natural processes into new contexts. In our study, examples of students reasoning by making use of aspects from both the Enlightenment and the Romantic views of nature were found. Gene therapy, for example, was seen by some students to change the original and threaten the purity of an embryo by intrusion through a natural border, but when done the resulting restored natural function was still considered natural compared to conventional treatment using intrusive medicinal products. This example of blended discourses shows how new medical treatments introduce dilemmas that need to be understood both from a moral perspective and from a biological knowledge perspective, since knowledge can be given value in different ways. On the one hand, knowledge can be used to sustain morals no matter if the knowledge is correct or even applicable and this is exemplified by students who support their claims by referring to natural laws. On the other hand, knowledge can be used to define what is "good": resemblance with natural processes or usefulness for a medical purpose.

Pedagogical implications

The results from this study highlight two educational challenges. The first can be described by means of the two different views on the relationship between humans and nature. The second can be understood as the conflict between morals and scientific knowledge.

The relationship between humans and nature when it comes to human action, nurture, in relation to hereditary diseases could be described as the humans being part of or apart from nature. When humans are viewed as apart from nature, i.e. not natural, human action can be very limited when it comes to socio-scientific issues being considered "morally wrong". Then, knowledge of biological processes, at least on cellular and subcellular levels, will be of limited use for decision-making since students' concepts of nature stand for what is "morally right". Here, humans should not intervene with processes in nature by making use of such knowledge. However, if humans are viewed of as being part of nature, all human action, i.e., nurture, can be valued as "morally right".

We suggest that more attention needs to be given to how humans can be understood as a part of and apart from nature in order to promote students' further understanding of different perspectives in debates on socio-scientific issues. The students in this study did not discuss the definitions of nature *per se*, so there is no possibility to interpret whether the students understand humans as part of or apart from nature. However, the relationship between nature and humans seems clear in the sense that the students drawing on the Romantic era views of nature consider humans as subordinate to nature, whereas students drawing on the Enlightenment discourse seem to put nature subordinate to humans. This exemplifies the apparent conflict between nature and nurture, which can be understood as a controversy between stances grounded in aspects of the concept of nature pertaining to morals as opposed to those pertaining to scientific knowledge. If science education aims to promote students' development of understanding of both morals and scientific knowledge as well as how these can

influence socio-scientific decision-making (c.f. Sadler & Zeidler, 2005), this conflict needs to be addressed.

By providing different views on the human relationship to nature, the Romantic and Enlightenment discourses on nature also provide guidance for the students' use of 1) morals and 2) knowledge, to justify human action. First, considering the students' use of morals, they are guided by the moral principles that acknowledge the primacy of nature, thus putting humans second to nature. Such reasoning can of course be important for students' engagement in socio-scientific issues where their notion of nature is threatened. However, if aspects of nature such as "self-organizing" and "laws of nature" are part of the foundation of students' reasoning, teachers have to address these aspects in manners that provide opportunities to build understanding for the dynamics of processes in nature. Such understanding is crucial if the goal is to enable students to utilise their scientific knowledge alongside their moral stances in discussions on socio-scientific issues. Secondly, students guided by the idea that scientific knowledge can remodel (nurture) nature into something better, i.e. more natural, consider nature subordinate to idealized nature. Their reasoning conveyed more value to what could become of nature than what nature was. They seemed to believe in the perfection of natural processes as described in a scientifically controlled environment, i.e. decontextualized. The students claiming imperfection of nature as a justification for human intervention would benefit from a deeper understanding of processes in nature. This could, for example, be accomplished by scrutinizing the meanings of imperfection and perfection in relation to macroevolution and genetic diversity, and decontextualized biological processes, such as DNA replication.

Subsequently, and in line with previous findings (Lindahl & Linder, 2013), students have difficulties integrating morals and knowledge into their socio-scientific reasoning. Since the students' concepts of nature can have aspects of morality as well as knowledge, they need to learn how to discern these different aspects. This will enable them to develop new understanding through socio-scientific discussions in order to find additional possibilities to form well-grounded decisions on issues where the concepts of nature and nurture are being actualized. Hence, students should be provided with opportunities to develop understanding of how different aspects of the actualized concepts can be and are being used in society to make meaning and to communicate a stance. To further understand debates on socio-scientific issues in the media, students should also be given the opportunity to discuss what relationships between aspects of morality and knowledge can be interpreted from the given information, thus building an understanding of how morals and knowledge are given value. In addition, to be able to fully participate in discussions about socio-scientific decision-making, students need to build awareness of the different and sometimes blended discourses present in media, as well as in classrooms, and how different meanings of nature are being used.

Acknowledgements

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