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Students' ontological security and agency in science education – an example from reasoning about the use of gene technology

This paper reports on a study of how students' reasoning about socioscientific issues is framed by three dynamics: societal structures, agency and how trust and security issues are handled. Examples from gene technology were used as the forum for interviews with 13 Swedish high-school students (year 11, age 17-18). A grid based on modalities from the societal structures described by Giddens was used to structure the analysis. The results illustrate how the participating students used both modalities for 'Legitimation' and 'Domination' to justify positions that accept or reject new technology. The analysis also showed how norms and knowledge can be used to justify opposing positions in relation to building trust in science and technology, or in democratic decisions expected to favour personal norms. Here, students accepted or rejected the authority of experts based on perceptions of the knowledge base that the authority was seen to be anchored in. Difficulty in discerning between material risks (reduced safety) and immaterial risks (loss of norms) was also found. These outcomes are used to draw attention to the educational challenges associated with students' using knowledge claims (Domination) to support norms (Legitimation) and how this is related to the development of a sense of agency in terms of sharing norms with experts or with laymen.

Keywords: reasoning; scientific literacy; science, technology, society ; Socioscientific issues; gene technology; structuration theory

Introduction

A good example of an educational context where understanding of the development of agency and reasoning is important is when discussions about societal use of gene technology take place. This article uses such a context to look at the development of agency in relation to societal structures when students handle trust and security issues.

New technologies such as gene technology should be areas for on-going educational debates that explore the benefits, potential risks, norms and values connected to the societal changes that such technologies bring to society. These debates have been characterized in terms of emergent anxiety and a loss of a sense of security as society is experienced as being more fragmented and difficult to understand (Giddens, 1984; 1990). Members of society are confronted with such issues through a variety of media, presented using the perspectives of different stakeholders (Gaskell, 1992). Furthermore, in societal discussions concerning

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2
3 technology, 'originators and instigators' try to portray themselves as trustworthy by
4 making truth-sounding claims, which laymen usually have tremendous difficulties
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6 scrutinizing (Kolstø, 2001b; Kolstø, Bungum, Arnesen, Kristensen, Mathiassen,
7
8 Mestad, Vedvik, Tonning & Ulvik, 2006).
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12 Science education can play a role in bridging the gap between experts and
13 laymen by creating a sense of trust in experts using convincing information, or by
14 providing tools for a dialogue where experiences, knowledge, and trust can be
15 exchanged. At present, education is expected to afford future members of society the
16 ability to participate in democratic discussions about societal development that is
17 likely to embrace new scientific knowledge and new technologies. However, students
18 come to class already submerged in a variety of views on the use of expert knowledge
19 and new technology (Bauer, 2005; Nelkin, 2001). Hence, their attempts to make
20 meaning of information, and negotiations about meanings, come face-to-face with
21 conflicts relating to values, norms and concerns about societal practice and to
22 expectations about participation in the reconstitution of society. At the same time
23 despite there having been some valuable progress here, modern science education
24 typically continues to provide little means for students to engage in discussions about
25 conflicts they have experienced and to develop their roles as participants in the
26 reproduction and transformation of society (Kolstø, 2001a; Zeidler & Sadler, 2008).
27
28 Much of science education still focuses on reproduction of society, giving students
29 little, if any, competency for such active participation (Brennan, 2008; Kalantzis,
30 2006; Szkudlarek, 2007). To develop a science education that embraces the idea that
31 students should share and construct knowledge alongside values and norms that
32 facilitate active participation in societal development with a sense of agency, more
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3 knowledge is needed about students' reasoning concerning socioscientific issues and
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5 how they use and appear to understand the structures in the societal system.
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8 In this article the term 'norms' is used to characterize moral or non-moral
9
10 societal rules (Hechter & Opp, 2001). The term 'values' is used to characterize
11
12 expressions of human requirements concerning needs and social group demands (cf.
13
14 Schwartz & Bilsky, 1987) that can be used as justifications or explanations for norms.
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18 19 20 **Focusing knowledge for a knowledge society**

21 Science education has historically focused on disciplinary content knowledge,
22
23 presenting science as 'objective' truth. For example, the Public Understanding of
24
25 Science (PUS) movement aimed at establishing an extensive support base for
26
27 technological development in society by informing the 'ignorant' public (Irwin &
28
29 Wynne, 1996) of the beneficial benevolence of technical development. In this spirit,
30
31 the use of surveys to gather information about the public attitude to science and
32
33 technology was initiated (Irwin, 2001). The use of surveys and interviews was then
34
35 given an aura of 'consulting the public' (Levitt, 2003). At the same time surveys have
36
37 shown that views held by adults and students are similar and that education that
38
39 symbolizes a high degree of knowledge tends to induce positive attitudes towards
40
41 societal practices using new technologies (Dawson, 2007; Gunter, Kinderlerer &
42
43 Beyleveld, 1998). The influence of knowledge is further seen from studies that show
44
45 that a low degree of knowledge coincides with a high degree of scepticism and fear
46
47 (Heijs, Midden & Drabbe, 1993; Kelly, 1995). In the setting of this article, the
48
49 association between a high degree of knowledge and positive attitudes to
50
51 biotechnology seem to depend heavily on trust (Christoph, Bruhn & Roosen, 2008;
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53 Knight, 2007). Thus, knowledge can be seen to have a positive effect on laymen's
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55 attitudes, as long as there is trust in authorities.
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The development of Science-Technology-Society (STS), which started some 30 years ago, introduced social and technological contexts to which students could relate (Fensham, 1988; Gaskell, 1982; Solomon, 1993). STS embraced new attitudes, inviting students to engage in scientific/technological issues using their experiences from everyday life and to draw on 'subjective views' such as ethical, social and political opinions in the discussions. This way, uncertainties about future societal change could be admitted under the guise of norms and potential risks. However, the extended discourse did not integrate subjective views, but merely acknowledged them. STS still focused on content knowledge and thus directly supported the notion of a *knowledge society*, a situation considered to be a challenge to many students' worldviews (Phelan, Davidson & Cao, 1991; Costa, 1995). It has been suggested that the resulting conflicts could be resolved by 'collateral learning' that includes the addition of a parallel worldview, a mix between personal and scientific worldviews, or a worldview somewhat changed with the help of scientific knowledge (Aikenhead & Jegede 1999). Changing of worldviews is considered an active learning process where students modify their one worldview instead of having multiple immiscible worldviews (Cobern 1996).

Integrating and discussing scientific knowledge with subjective views

STS took a step further with the introduction of Socio-Scientific Issues (SSI), which focused on students' decisions about controversial issues making use of morals and values as well as scientific knowledge (Driver, Newton & Osborne, 2000; Ratcliffe, 1996; Solomon, 1992; Zeidler, Lederman & Taylor, 1992). The introduction of SSI in science education encouraged new research into knowledge about students' reasoning and how to promote learning by using SSI (Fowler, Zeidler & Sadler, 2009; Sadler & Fowler, 2006; Sadler & Zeidler 2004; Sadler & Zeidler, 2005a; Tal & Kedmi 2006;

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3 Zeidler & Keefer, 2003; Zeidler, Sadler, Simmons & Howe, 2005; Zohar & Nemet
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6 2002). SSI provided the means for the development of a capability to participate in
7
8 democratic processes concerning societal use of science and technology. Engaging in
9
10 SSI would provide students with both scientific content knowledge and the
11
12 opportunity to develop reasoning capabilities. Successful SSI called for a scaffolding
13
14 of students' discussions to allow for a multitude of perspectives and solutions to
15
16 problems (Aikenhead, 2006; Klosterman & Sadler, 2010; Sadler 2004; Sadler &
17
18 Zeidler, 2005a; Taylor, Lee & Tal, 2006; Zeidler & Sadler, 2008). In such a scenario,
19
20 students' informal reasoning patterns need to be met respectfully in a way that
21
22 facilitates open and constructive discussion for the understanding of emotional, moral
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24 and rational reasoning (Sadler & Zeidler, 2005b; Zeidler & Sadler, 2008).

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29 Socio-scientific issues are open-ended, ill-structured, debatable problems,
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31 which are susceptible to multiple perspectives and solutions. They provide
32
33 opportunities for individuals to engage in informal reasoning as they try to negotiate
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35 possible solutions to the problems encountered. Doing so, they gain experiences that
36
37 are believed to support future participation in democratic decisions about socio-
38
39 scientific issues. The ability to participate in democratic discussion has been modelled
40
41 as part of scientific literacy, and a few studies have shown the advantage of using SSI
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43 for that purpose (Driver et al., 2000; Kolstø, 2000; Kolstø, 2001a). Here, the issue is
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45 to provide education for development of analytical thinking to be able to evaluate
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47 claims related to science and its use in societal practice. The idea that science
48
49 education should help students to develop a critical stance towards knowledge claims
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51 as well as an ability to participate in discussions with logical arguments is congruent
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53 with a modern definition of scientific literacy (Aikenhead, 2007; Norris & Phillips,
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55 2003; Roberts, 2008; Zeidler & Sadler, 2010).

Development and changing role of science education

The role of science education in society has shifted over time. The changes include norms and how these are conveyed to students, the societal use of science and how to participate in societal discussions about science and technology. The role of education in general has been described as reproducing societal practice (Giddens, 1984) and propagating societal development (Giddens, *ibid*; McWilliam & Lee, 2006) by constructing and supporting a knowledge society (Brennan, 2008, Szkudlarek, 2007). Levinson (2010) provides four frameworks for describing different ways by which the role of science education for democratic participation is described. For example, two of Levinson's categories, 'Deficit' and 'Deliberative democracy' fit well with the notion of a knowledge society. In a knowledge society most members of society still end up having to rely on experts in a way that reduces their direct participation in societal development. Brennan (2008) suggests that the role of education also could be to transform society, thus constructing a *critical society*. Critical society anticipates more direct participation in democratic processes since laymen are empowered by knowledge and negotiation skills to engage in discussions with experts about issues related to societal transformation (Kalantzis, 2006). The notion of critical society corresponds to the frameworks Levinson (2010) calls 'Science education as praxis' and 'Dissent and conflict'.

Towards science education for a critical society

The change from a science education for a 'knowledge society' towards a science education for a 'critical society' can be tracked through a changing and diverging scientific literacy concept and the development of new educational traditions (Aikenhead, 2007; Norris & Phillips, 2003; Roberts, 2008; Zeidler & Sadler, 2010).

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3 The concept of scientific literacy can be divided into derived and fundamental senses
4 of scientific literacy (Norris & Phillips, 2003). The derived form is content knowledge
5 in the form of disconnected facts and theories, whereas the fundamental form of
6 scientific literacy can be described as understanding how relationships between facts
7 and theories can be made to produce meaningful knowledge. Here, Roberts (2008)
8 describes how scientific literacy has developed and changed from, what he calls,
9 scientific literacy vision I to scientific literacy vision II; the former being focused on
10 knowledge and scientific goals whereas the latter also brings in understanding in a
11 way that facilitates some ability to participate in the making of democratic decisions
12 regarding science and technology. Aikenhead (2007) has, in addition, proposed
13 scientific literacy III that is a global variant of vision II, taking into consideration not
14 only western but all cultures on our planet.

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32 Zeidler and Sadler (2010) recently proposed 'functional' scientific literacy as a
33 development of scientific literacy vision II. 'Functional' scientific literacy broadens
34 the concept of scientific literacy to be more supportive of science education for a
35 'critical society'. This is achieved by including students' development of reflective
36 reasoning and morals in line with the quest to become active citizens personally
37 engaged in the decisions affecting their community, i.e. to have a sense of agency. By
38 promoting not only scientific knowledge, but also students' development of morals
39 and reasoning skills, with 'functional' scientific literacy as a goal, science education
40 has the potential to enable students to become active citizens who can reconfigure the
41 balance between experts and novices, as called for by Kalantzis (2006). Such re-
42 balancing, whereby citizens gain a sense of agency for the transformation of society,
43 is important for power relations and would impact on the view of expert knowledge
44 and the role of expert systems (Giddens, 1984, 1990). However, more knowledge
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3 about how students use and understand the structures in the societal system, as they
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5 reason about socio-scientific issues, is needed to support the development of science
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7 education in that direction.
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10 11 12 **Theoretical framework**

13 Previous research on attitudes to science and technology and views on socio-scientific
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15 issues has focused on students as individuals with a range of different views. They are
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17 seen as students who are not yet intrinsically part of society in the sense that they lack
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19 mature ideas about the kinds of societal development needed for participation in
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21 democratic decisions such as elections and referendums. The focus has been on the
22
23 here-and-now learning of knowledge, developing morals and acquiring
24
25 communicatory skills aimed for the participating in a future society as adults.
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28 Giddens' writing about the societal system refers to relations between people. These
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30 relations are organized and reproduced in social practices that are subject to change.
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32 The transformation of social relations is possible through acts of the individual agents
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34 that reproduce a societal structure. Such a societal structure consists of the rules and
35
36 resources belonging to the system, for example, laws, moral codes, tradition,
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38 established practices, authorities and institutions. These allow or constrain individual
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40 agents to participate in the transformation of social relations. Human agents reinforce
41
42 or transform social relations and societal practice, thus slowly changing the structure
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44 of the system to provide new conditions for societal relations. This iterative process is
45
46 known as 'structuration' (Giddens, 1984). In our study, Giddens' structuration theory
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48 is chosen for the purpose of relating the students' views to on-going societal
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50 discussions and of viewing the students as members of society with an emergent
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52 interest in participating in a developing society.
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4 Social systems have three types of structures, each of which has modalities:
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6 ‘Signification’, which can be described as the interpretive schemes and discursive
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8 practices used by agents, such as for example, ‘gene technology is a threat to society’;
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11 ‘Domination’, which describes how resources are controlled and how power is used,
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13 including, for example, the use of *knowledge claims*; and, ‘Legitimation’, which is the
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15 process of reinforcement of moral rules and other norms. These three structures
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17 constrain societal transformation potentials that more or less reinforce societal
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19 practice. If the result is a reproduction of societal practice, members of society can
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21 maintain their sense of security (Giddens, 1984, 1990). However, expert knowledge,
22
23 such as scientific knowledge, can have a transformative power in society (Giddens,
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25 1990). It emanates from a practice that is disembedded, i.e. lifted out from social
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27 relations and norms embedded in local contexts. Whereas in embedded practice,
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29 social relations are present and the context is familiar. The familiar is as important for
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31 students as for any member of society because one’s sense of security depends on
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33 how understandable changes in the environment are over time. The sense of security,
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35 or ‘ontological security’ as Giddens prefers to call it, is a sense of reliability on people
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37 and things in the environment, and an understanding of the life-world. Routines,
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39 routinized practice and traditions provide ontological security by tying together
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41 activities at different points of time, thus reducing the experience of ‘fragmented
42
43 existence’ (Giddens, 1990). This is caused by societal changes due to, for example,
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45 new technology. The resulting loss of ontological security can be counteracted by the
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47 ‘routinization’ of new practices and by the re-embedding of new knowledge and
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49 practices into familiar contexts.
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58 The ability to monitor and understand human action in society can produce a
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60 sense of security, which in turn can affect intended and as well as unintended actions

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3 for the reproduction or the transformation of societal practice. Subsequent activity
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5 aimed at understanding and governing these intended actions can then induce a sense
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7 of agency. The ability to judge the effectiveness of practices for the achievement of
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9 desirable objectives can also promote a sense of agency through the attainment of
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11 confidence in the ability of situated human action to obtain desirable outcomes.
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13 Although, when it comes to expert knowledge, for example, in an area such as gene
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15 technology, monitoring is usually not possible for laymen. However, scientific
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17 literacy has the potential to reduce this problem. An anticipated risk of societal
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19 transformation due to, for example, development of new technology may severely
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21 affect a sense of security, but trust can 're-install' a lost sense of security. Personal
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23 face-to-face encounters with experts can induce trust, which in turn can counteract the
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25 loss of ontological security. However, such encounters are constrained by the
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27 structures of a social system. For example, an inability to monitor an activity in
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29 societal practice – such as initiating genetic screening of citizens – can reduce a
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31 person's sense of security and accentuate the feelings of living with potential risks.
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39 Risk and trust are intertwined in the sense that, for example, a dialogue
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41 between experts and laymen can, by inducing trust, reduce the anxiety connected to
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43 the anticipated risk. Public information and science education have roles to play in
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45 enabling personal and public decisions concerning risk and trust. Thus, science
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47 education can be seen as having the role of bridging the gap between embedded and
48
49 disembedded practices in two different ways. Firstly, by inducing trust by conferring
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51 knowledge, norms and values, and secondly, by providing possibilities for
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53 constructing knowledge and the understanding of personal values and norms, as well
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55 as the reasoning skills that empowers students to engage in negotiation of social
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57 practice relating to science and technology (cf. SSIs). The development of knowledge
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3 enabling reflection on power relations, societal norms and scientific discourse
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5 supports agency, which may lead to re-balancing between experts and novices in
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7 society. Reflexive participation in societal practice describes a more profound form of
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9 agency that allows reflexive monitoring of action and participation in transformation
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11 of societal practice. Furthermore, meaning-making through a variety of interpretive
12
13 schemes resembles agency in such a way that it enables dialogues with implications
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15 for future societal transformation between laymen and experts.
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22 **Research questions**

23 Much knowledge about students' reasoning concerning socio-scientific issues has
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25 been accumulated to date. However, little is known about students' reasoning
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27 concerning SSIs in relation to their understanding of the interplay between societal
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29 structures. Such knowledge has implications for the organization of science education
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31 with the potential to enable students to further develop knowledge, morals and the
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33 ability to actively participate in societal development with a sense of agency. As
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35 students encounter conflicts through SSI they should be provided with opportunities
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37 to develop their roles as participants in the reproduction and transformation of society.
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42 Knowledge about the interplay between societal structures and their modalities can
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44 facilitate such a development as well as students' use of knowledge and skills in
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46 societal discussions.
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50 From this point of view, the aim of this article is about increasing knowledge
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52 about students' reasoning concerning SSI that is framed by their notion of societal
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54 structures. To do this, students' reasoning about gene technology is used as an
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56 example of technologies that can induce an anticipation of transformation of societal
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58 practice. A focus emerges on the discernment of how students draw on societal
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60 structures, and how they handle trust and security issues in their reasoning about

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3 societal use of gene technology. From here the following research questions are
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5 constituted:
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9 (1) What is the nature of the justifications that students provide for their
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11 significations of the societal use of scientific knowledge and technology?
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13 (2) How do students deal with loss of ontological security?
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15 (3) From an agency perspective, how do students relate to social systems and
16
17 personal agency when reasoning about societal decisions?
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23 **Methodology**

24 *Participants*

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26 The 13 participants (average age, 17.9 years) were high school students (year 11 of a
27
28 12 year educational system) from two classes. These classes came from different
29
30 schools in a small city (50 000 inhabitants) in the south of Sweden. These were a
31
32 subset of students who had been involved in a socio-science study before (Lindahl,
33
34 2009; 2010), which greatly helped facilitate arranging their participation in this
35
36 research context. Nine students (7 boys and 2 girls) were studying natural sciences
37
38 and four (girls) were studying social sciences. We chose these classrooms because
39
40 there was nothing discernibly distinct about their educational environment,
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42 particularly in terms of content or the experienced approach to teaching.
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49 At the time of the data collection, 3-5 weeks had passed since the participating
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51 students had completed an introductory course in genetics. Each of the genetics
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53 courses were given by separate teachers and some aspects of the content differed
54
55 between them. The natural science students had a combined biology-chemistry course
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57 where DNA as a chemical was studied in parallel with genetics. Furthermore, the
58
59 natural science students were able to do laboratory work that consisted of a simple
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3 Restriction Fragment Length Polymorphism (RFLP) analysis intended to show how
4
5 dissimilar genes could be detected. Apart from that the genetic courses had similar
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7 content dealing with Mendelian genetics, genetic diseases, DNA replication,
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9 transcription, protein synthesis and gene technology. Neither of the teachers discussed
10
11 issues related to the research questions. Both classes had one group discussion related
12
13 to genetic diseases and ethics where the students were divided in small groups (4-5
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15 students in each group).
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20 21 *Data collection*

22 The study started after the students were given questions that were to be answered
23
24 privately at home. The written material was interpreted and this was captured in the
25
26 form of a mind map that we used to help frame semi-structured interviews. The
27
28 purpose was to create a rich simulated recall (Calderhead, 1981) environment that
29
30 could establish a good interactive environment for the planned interviews. As such, an
31
32 integral part of the interviews was an interactive working with the students to refine
33
34 the mind maps (when the students felt it was necessary) in order to better capture their
35
36 thoughts, reflections and positioning. However, these mind maps themselves did not
37
38 form part of the data set that we used for the analysis reported on in this article. The
39
40 data used consisted entirely of the verbatim transcripts of the interviews. Occasionally
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42 the mind maps were referred to to help the analysis process in keeping themes
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44 together that helped track the students' personal views.
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51 The semi-structured interview protocol had the following format: An
52
53 exploration of how the students valued and felt about the use of knowledge with
54
55 regard to examples A-E below? (These examples were taken one at a time).
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58 I. Describe the pros and cons you can foresee for each example.
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60 II. Describe if you think it is right or wrong and explain your stance.

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- III. Describe how you feel about the described examples.
- A. Prenatal diagnostics to find and to eliminate genetic disease.
 - B. Transgenic pigs as organ donors for humans.
 - C. Psychopharmacological drugs and other synthesized drugs for the well-being of humans.
 - D. Gene technology can be used to produce natural substances for medical use.
 - E. Gene therapy, using virus or genetically modified stem cells, for treatment of different diseases for well-being and to reduce the use of drugs.

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Each student was interviewed for approximately 30 minutes. At the beginning of the interview the student was reminded of the ethical grounding for the research, in particular the guaranteed anonymity for any descriptions that would be used as data, and that interviewer-interviewee cooperation would be an integral part of reaching an understanding of the meaning of the arguments presented.

The interview had a strong discussion-grounding where the students were asked to expand on what they had earlier written and to deepen their arguments. At the end of the interview the students were asked if the mind map that that they and the interviewer had looked at during the interview represented an 'accurate' outline of their thinking, knowledge and arguments. These interviews were recorded and transcribed verbatim.

Since all students agreed on the 'accuracy' of the resulting mind maps, we interpreted the data as reliably representing the students' views. As students were interviewed their reasoning was explored in order to deepen understanding and to probe for more viewpoints and explanations. The student's discussions were respected without any judgmental attitude, but rather with a genuine interest in their thinking, reflections and positioning and how it might be understood. All students discussed the

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3 topics eagerly and in a highly engaging way. Although we created a respectful
4
5 environment we are aware that the students could have, at times, experienced negative
6
7 power relations. Thus, the interview data cannot be regarded as providing a full
8
9 description of the views the participating students had at the time of the data
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11 collection. So we looked for similarities with other studies to strengthen the relevance
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13 and the validity of the data that we present.
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20 *Data analysis*

21 The analysis was done by collating pieces of description that well captured the
22
23 essence of the students' arguments for or against the use of new technology, and
24
25 regarding decisions about the use of new technology in society. These descriptions
26
27 were sorted and categorized by content and lines of arguments. Categorization of
28
29 students' views on the use of and decisions about gene technology was done following
30
31 themes that fit into the structural concepts describing 'societal structure' (Giddens,
32
33 1984). Hence, the structures *Signification*, *Legitimation* and *Domination* and their
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35 modalities, as they appeared to be manifested in students reasoning, were used to
36
37 create a grid for the analysis (Table 1). The modalities of each structure are part of the
38
39 theory of structuration (Giddens, 1984), but for the purpose of our analysis they are
40
41 grouped in categories.
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51 [Insert Table 1 about here]

52
53 Using the grid shown in Table 1, justifications for students *Significations* were sought
54
55 in the modalities of the structures *Legitimation* and *Domination*. The modalities that
56
57 the students drew on indicated which societal structure was relevant for their
58
59 interpretative scheme and for human actions in society.
60

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3 Democracy and laws are here used together as one single modality of the
4 structure Legitimation since they are highly interconnected in a representative
5 democracy such as Sweden. When students refer to impersonal rules, moral or not,
6 which are not laws, the analytic interpretation is in terms of drawing on norms.
7
8 Furthermore, the analytic interpretation also holds that students draw on knowledge
9 claims when they use scientific knowledge as a given fact to justify their signification
10 of technology. There are two criteria for such scientific knowledge claims here: first,
11 it has to be possible to interpret them as emanating from expert knowledge, i.e. from
12 disembedded practice; and, secondly, such scientific knowledge claims have to be
13 used by students as a non-disputable fact.
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27 Ontological security cannot be assessed by the methods we used in our study,
28 so they are hypothetically inferred as a theoretical entity supported by Giddens'
29 structuration theory (Giddens, 1984).
30
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33

34 Students' expression of confidence in the social system to regulate or stimulate
35 development and use of expert knowledge to maintain/reach desirable outcomes is
36 interpreted as an indication of students' agency. Students' descriptions of actions that
37 they believe can lead to reproduction or transformation of society are interpreted as
38 expressions of their reflexive monitoring. Their expressed confidence or lack of
39 confidence in their ability to affect or participate in actions leading to their desirable
40 outcome is interpreted as an expression of agency. The analytic descriptions show a
41 variety of students' ideas and arguments. There were conflicts between students as
42 well as, occasionally, within their own line of arguments. However, the conflicts
43 regarding use of and decisions about gene technology that were expressed by any
44 single student were typically related to context. Subsequently, the data presented are
45 valid for more or less specific contexts regarding societal use of new technology.
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Results

In this section, we first describe what modalities of societal structures the students used when they justified their arguments in support for either a transformation or a reproduction of society through expert knowledge. The analysis dealing with the students' justification of anticipated social transformation using a particular modality of social structure is followed by students' justification of the prevention of social transformation using the same modality. Starting with norms followed by traditions, modalities of *the structure Legitimation* are followed by the modalities of *the structure Domination*: first knowledge claims, then authorities.

The presentation of the analysis then moves on to dealing with the students' signification of decisions about the use of technology, either as enabling or as limiting human action in society. The storyline starts with the students' use of the modalities of Legitimation, norms, democracy and laws, and ends with the students' drawing on authorities, a modality of Domination.

Signifying gene technology as a threat to or as a development of societal practice

In this section we illustrate how the students conceive of gene technology as a threat and convey their desire to prevent transformation of society. This is in stark contrast to students who regard gene technology as a promise of a desirable development of social practice. In this process, they were found to draw on modalities of Legitimation (norms and traditions) and Domination (knowledge claims and authorities). The students' reasoning points to attempts to find trust in basic principles or experts, but also to maintain their lack of trust and to bring attention to risks and undesired outcomes. In contrast to students who welcome biotechnology, the students who hesitate to incorporate gene technology in societal practice do not seem to find trust in persons or principles of expert systems.

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Signification by drawing on modalities of Legitimation

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When students signify biotechnology as an opportunity to develop or as a threat to societal practice they refer to norms and traditions. Future actions for the ‘good of humans’ are supported by norms. However, prevention of actions that threaten values representing the good, such as personal relations and humanity, can also be supported by norms. By drawing on traditions students legitimize their stance, for or against societal transformation, while trying to connect the past and present with the future.

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Justifying societal transformation by reference to norms. Students draw upon norms such as to: ‘allow free will’; ‘strive for human well-being’ and ‘withhold human-supreme status among animals’, as they express their support for using new technology for the benefit of human health and well-being. The students either focus on one single type of medical treatment, such as xenotransplantation or gene therapy, or on a more general view including a variety of possibilities offered by gene technology, particularly for humans.

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‘Life is about having luck. Why not change things (by gene therapy) later if you want to be someone else - why stop someone from that?’ (Tony)

‘(The possibility) to change stem cells I think is terrific, since you get another chance. There should be no limits (for curing people).’ (Veronica)

‘There is a need for organs (about xenotransplantation), there are so many who are in need.’ (Charlotte)

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The new technologies mentioned here are described as possibilities for the future.

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Tony argues for agency as he stresses that striving to reach personal desirable outcomes could be facilitated by the new technology. Drawing on the norm of striving for human health, Veronica and Charlotte are likely to agree, as long as it is a health

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3 issue. In their view, the new technology provides an opportunity to better care for
4
5
6 members of society needing help with their medical condition.
7

8
9 'But that's the argument I have for most of these issues: to reduce human
10 suffering and to raise the standard of living and make more happiness in the
11 world.' (Oscar).
12

13
14 Oscar also points out the importance of human action for increasing health but he
15
16 broadens his view to hold a striving for human well-being in a general sense as a
17
18 norm for societal practice.
19

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21
22 'I think its right in every aspect. It is worth sacrificing the life of a pig for the
23 sake of a human.' (Carl)
24

25
26 Carl draws on the norm of putting human interests before that of other animals, based
27
28 on a comparable higher value of a human life, compared to that of a pig. The different
29
30 values of lives follow a moral order, which is used here to legitimize the use of
31
32 animals in a new way.
33

34
35 For these students the use of new technologies provides expectations of a
36
37 better future since societal practice will be transformed by incorporating
38
39 biotechnology. They picture biotechnology as a welcome means to achieve desired
40
41 outcomes. Their norms, which may well be familiar rules for their daily life, are used
42
43 here to support the acceptance of biotechnology for the development of societal
44
45 practice. Societal transformation by the exemplified uses of biotechnology here does
46
47 not seem to evoke any fear of unforeseen risks or need for regulation, among these
48
49 students. The students express agency by showing that their reflexive monitoring of
50
51 actions of disembodied societal practice, i.e. experts' development of technologies,
52
53 are supported by their norms and lead to desired outcomes. Apparently they trust the
54
55 experts and that the societal system can be improved by transformation.
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3 *Justifying the prevention of societal transformation by reference to norms.* When
4
5 students expressed a desire to prevent societal transformation, they showed disinterest
6
7 in the development of new knowledge, fear of losing individuality, an urge to care for
8
9 and prevent disrespect for animals, as well as a desire to strive for equality between
10
11 generations and between animals and humans.
12
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14
15 One of the students exemplified disinterest in the development of new
16
17 knowledge and new technology like this:
18

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20
21 'It is unnecessary/.../In my view, we don't need to develop more things than we
22
23 already have.' (Gabrielle)
24

25 She stresses that we should be content with the present societal practice. She seems to
26
27 ground her view in the norm: 'be satisfied with what you have'.
28
29

30
31 'You shouldn't change just anything because in the end we will all be
32
33 identical.' (Hanna)
34

35 The dissatisfaction with our bodies, especially the characteristic parts by which we are
36
37 judged by others, is here acknowledged as the driving force for genetic modification
38
39 of everyone, including children. Hanna fears that we will lose our individuality as a
40
41 result of such action. Her argument against allowing genetic modification of the
42
43 human body is based on the norm to 'cherish personality' and therefore she wants
44
45 society to protect the uniqueness in human appearance.
46
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49 Animals also need to be protected and cared for. For example, animals should
50
51 not have to suffer.
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53

54
55 'If I could, I would decide that animals should not have to suffer. No one could
56
57 feel bad about animals being treated well.' (Gabrielle)
58

59 Gabrielle has observed that pigs in pig farms suffer and fears that breeding genetically
60
modified pigs for future xenotransplantations might cause even more suffering. Her

1
2
3 argument is based on the norm to 'care for animals'. Other ways to express caring for
4
5 animals are seen in the two following interview excerpts.
6
7

8
9 'Every individual has a right to live. Pigs are also individuals and obviously
10 they have a right to live.' (Benny)
11

12 'No, I think animals, I think breeding of animals shouldn't be allowed, you
13 know, just because we humans want their organs. I think it's wrong.'
14 (Veronica)
15

16
17 The students draw on norms to 'respect the right to live' (Benny) and that 'animals
18 and humans should be treated equally' (Veronica). Transformation of society by
19 introducing biotechnology is seen as a threat to norms prescribing that animals should
20 be respected and have rights in society just as humans. Thus, a transformation of
21 societal practice leading to the killing of individuals (in this case, pigs) can never be
22 legitimized. Here, it is not the use of expert knowledge or technology *per se* that is
23 problematic, just the killing of animals. Transformation through the use of gene
24 technology might be acceptable, but only if the norm 'respect the right to live' is
25 followed. The risk of not achieving equality in the interaction between pigs and
26 humans justifies the prevention of introducing some uses of gene technology.
27
28 Prevention of societal transformation justified by 'attempting to achieve equality' is
29 valid for relations between animals and humans, as well as between generations.
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46 'Our generations have no more rights than previous generations to make these
47 improvements of our species.' (Victor)
48
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50 According to Victor, equality between generations, i.e. equality in a stretched
51 timeframe moulding history and the future together, should be protected. By referring
52 to equality between generations, historical circumstances are used to argue for the
53 hindrance or control of societal transformation and to reinforce present common
54 practice. Thus, transformation of societal practice cannot be legitimized if it breaks
55 away from the present norms.
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5 For all these students the new technology is conceived as unnecessary and of
6
7 little benefit to society. Furthermore, expert knowledge is seen as a societal resource
8
9 that threatens to exploit animals, nature, and to threaten our attempts to achieve
10
11 equality. According to the students' observations and reflections, societal practices
12
13 should not be transformed by new technologies, but rather reproduced by reinforcing
14
15 present common practices.
16
17

18
19 The use of new technologies provides a threat since valued norms may lose
20
21 their importance if biotechnology is incorporated in societal practice. Although some
22
23 of these students understand that society can benefit somehow by making use of the
24
25 described examples, they deny that the anticipated societal transformation could lead
26
27 to a desired outcome. The imminent societal transformation seems to urge students to
28
29 call for necessary regulations in the use of technology. In the case of disinterest in
30
31 new technologies *per se*, this would mean a total halt in scientific and technological
32
33 development. Apparently there is a fear that the social system might be transformed
34
35 and thereby lose important norms. The students doubtfully express agency by
36
37 showing that their reflexive monitoring of actions of disembedded societal practice,
38
39 i.e. experts' development of technologies, implies a clash with familiar norms of
40
41 specific or general significance. However, students' agency is likely to remain if
42
43 negotiations for keeping their familiar norms seem to be possible.
44
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50
51 *Justifying societal transformation by reference to traditions.* The anticipation of
52
53 societal change, no matter if it is for better or worse, does reduce the sense of
54
55 ontological security. One way to counteract this is to reduce the apparent irregularity
56
57 by finding resemblance with traditions and present practices.
58
59
60

1
2
3 'By tradition we have always eaten meat and animals, and so I feel that a
4 development in some way for the use of organs in a new way is a natural step.'
5 (Henry)
6

7
8 'It's the same thing - we slaughter pigs for food - so I mean, why not slaughter
9 them to get organs.' (Pamela)
10

11 These positions are based on the acceptance of slaughtering pigs as being common
12 practice in society. Referring to tradition legitimizes the new practice, which is
13 described as similar to the common practice. Students interpret the two different
14 procedures as being similar, and xenotransplantation becomes acceptable based on the
15 historical tradition of slaughtering animals for food. This counteracts the loss of
16 ontological security caused by disembedded practices and their transformation of
17 human action in society. These students extend the organization of beliefs and
18 practices, held by tradition, to include new ones in order to legitimize the societal
19 transformation.
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33 The students' reflexive monitoring of actions, such as routines embedded in
34 tradition, help them to find support for experts' development of technologies leading
35 to desired outcomes. The congruence between students' expectations for development
36 of new technologies that can transform society, and their reasoning to find acceptance
37 for such new technology imply agency and a trust in experts.
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46 *Justifying the prevention of societal transformation by reference to traditions.* The
47 idea of using new technology may be seen to conflict with common practice. In such a
48 case tradition can be used to legitimize the prevention of introducing new practices in
49 society.
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55
56 'We are not used to doing like that you know.' (Hanna)
57

58 'But this is different. We haven't been doing this for ages.' (Veronica)
59
60

1
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3 The above quotes are said with emphasis. The students' perceive the transforming
4 effect of new technologies as detaching future practice from that of the present way of
5 living. The anticipated change of societal practice induces strong reactions from the
6 students. Their anxiety about a possible future transformation of the social system, in
7 discord with familiar practice, is a sign of loss of ontological security. Students draw
8 on tradition when they argue for keeping and reinforcing present practice, thus
9 legitimizing the prevention of societal transformation. A sense of agency can be kept
10 as long as negotiations for keeping familiar routines, organized by traditions, seem to
11 be possible.
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27 *Signification by drawing on modalities of Domination*

28 As these students provide their *significations* of gene technology they draw on
29 modalities of *Domination*, such as knowledge claims and authorities. In so doing they
30 signify expert knowledge as trustworthy or not trustworthy. By referring to
31 knowledge claims students express their trust, or lack of trust, in the basic principles
32 of biotechnology, thus bringing to the fore ideas of risk and monitoring of expert
33 practice. When students refer to authorities they indicate if they have trust in experts
34 as competent members of society.
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46 *Justifying societal transformation by reference to knowledge claims.* Students can find
47 trust in principles by adhering to different kinds of knowledge claims. By picking up
48 knowledge claims to ensure the safety, as well as support the basic principle for the
49 technology, students can justify introduction of technology into societal practice.
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51
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53 Here, students seem re-assured that procedures are safe if they follow natural laws.
54
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59 'Since you put in genes, your body will build things, and then, well it has to be
60 better than to put in something that doesn't belong there. It's good for the body
since it's the building blocks that were there from the beginning'. (Henry)

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5 Although transferring genes from one cell to another may seem unnatural if humans
6
7 are doing it, since a cell's natural function is used for the production of, for example
8
9 proteins, the products can be considered to be natural.
10

11
12
13 'As long as it's produced in a natural way we are re-assured that it has been
14 functional and safe in nature for a damn long time since it has been developed
15 by evolution.' (Oscar)
16

17
18 The long history of development according to the rules of evolution implies that the
19
20 process is safe. Furthermore, since evolution is natural it follows that procedures that
21
22 apply the natural rules of evolution are safe. By making use of a knowledge claim
23
24 built on the historical circumstances of evolution, students are able to build an idea of
25
26 security concerning the societal use of new technology. The new technology is seen as
27
28 a resource for transforming societal practice.
29
30

31
32 These students exemplify how knowledge claims induce trust in a principle.
33
34 Thereby, they can also find trust in the social system making use of the principle. The
35
36 ontological security can be further restored by connecting natural phenomena with
37
38 new technology, thus moderating the notion of potential risks related to the
39
40 anticipated transformation of societal practice. Knowledge claims that enable
41
42 reflexive monitoring of outcomes, here exemplified by the moderation of potential
43
44 risks, can be used to justify new practices since they induce trust.
45
46
47
48

49
50 *Justifying the prevention of societal transformation by reference to knowledge claims.*
51

52
53 Not all students can find trust and moderate the notion of risks by using knowledge
54
55 claims. Instead, they advocate knowledge claims that challenge principles of the new
56
57 technology, and they use knowledge claims to justify limitations or even prevention
58
59 of the use of new technology. Knowledge claims are used to describe a threat.
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‘You are what you are. That's the way it should be. It's unnatural to change/.../Because you change by adding and subtracting, and disturb the order of the events that should have come.’ (Hanna)

‘Evolution has not given us the right to make changes in our genetic development.’ (Victor)

Both these interview excerpts relate to knowledge of what is natural and that human action needs to follow some natural law. The new technologies are threats to naturalness and they do not belong to common practice, and never have. The dichotomy natural/unnatural is used to show that the basic principle is not trustworthy and is a threat to the functional material environment.

The anticipated risks, as a result of unforeseen uncontrollable circumstances, are important arguments against the use of new technologies. This is more explicitly expressed in the following excerpts.

‘Suppose you put in a, well genes, for example in the pancreas for the production of insulin, and it starts to produce enormous amounts of insulin, well that might give negative consequences.’ (Charlotte)

‘If you treat everyone (with gene therapy) then the quality of our genes will slowly decrease since there is no natural selection, and in the end maybe we will be totally dependent on this method.’ (Johnny)

New medical research and medical treatment may result in conditions that are out of control on both personal and population levels. On a population level, the technology may lead to new diseases, and even deterioration of the human species. Knowledge claims seem to enhance the notion of potential risks related to the expected transformation of societal practice. The view of scientific research here is that it breaks away from common practice and what is ‘natural’. The natural order is considered to be safe, that is, it is necessary to follow natural laws to have a sense of security. The idea of security cannot be restored as long as new technology is interpreted as a threat to what is natural.

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2
3 Knowledge claims are seen as an expression of a reduced ontological security
4 and possibly as a means to reject the expected transformation of societal practice. By
5 reflexive monitoring, the basic principle is judged as less than trustworthy and could
6 lead to undesired outcomes. The new technologies present uncontrollable risks that
7 outweigh the benefits. The students seem worried about risks they claim exist but
8 cannot monitor. They apparently do not trust the principles of expert knowledge and
9 stress that its use is unsafe. This turns these students against the use of expert
10 knowledge and the transformation of the societal structure towards one that comprises
11 unsafe societal practice.
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26 *Justifying societal transformation by reference to trust in authorities.* While the
27 students acknowledge the existence of risks related to the use of new technology, they
28 want the risks controlled. They expect experts to have and to use the necessary
29 competence to handle potential risks.
30
31
32
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35

36 'It's a matter of being cautious and careful, the scientists should be meticulous
37 in their investigations before we start operation on a larger scale.' (Oscar)

38
39 'The risks are very small because they (medical doctors) are educated and
40 know what to do I think.' (Benny)
41
42

43 The experts are described as professionals and seen as trustworthy since they are both
44 educated and careful in their practice. It is likely that these students have a sense of
45 ontological security since they do not expect any uncontrollable risks. The students
46 acknowledge distinct roles in society since they consider monitoring and controlling
47 of expert practices to be for experts, not for laymen. They find trust in experts by
48 seeing them as authorities of scientific knowledge and disembedded practices. The
49 students' trust in experts counteracts a potential loss of ontological security and their
50 judgment seems to hold that desired outcomes will be attained with acceptable risks.
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Justifying the prevention of societal transformation by reference to lack of trust in authorities. It is likely that new practices to some extent create risk scenarios.

Students seem to anticipate future risks on personal as well as population levels.

Authorities have the power to regulate or prevent future use of new technology that might lead to undesirable outcomes.

‘But, if they (the scientists) start to fiddle with it (DNA of cells) just to, if they do it for fun; I mean it should be for a purpose, they mustn't sit there and fiddle with cells just to see what happens.’ (Charlotte)

‘I mean, if we proceed further (with research on genetically modified organisms) maybe we get rather negative outcomes and face worse things and get worse cells which not only like cancer, but even worse.’ (Charlotte)

The uncontrollable risks of the new technology outweigh the benefits according to this student. She seems worried about risks she believes exist but no one, not even experts, can monitor. Expert knowledge appears to be unreliable or its use may be unsafe for some reason. This student apparently does not trust experts and expert knowledge to have the ability, or even the intention to control such risks. The lack of trust in experts leaves the students with a reduced ontological security that can lead to the rejection of societal transformation. The anticipated risks turn students against transformation of the societal structure towards one that comprises unsafe societal practice. The fear that science and technology can result in disastrous outcomes is grounded here in lack of trust in both experts and in disembedded practice.

Signifying decisions as enabling or limiting human action in society

In this section we illustrate how the students draw on modalities of *Legitimation* and *Domination* in their *Signification* of decisions as enabling or limiting human action.

Legitimation is established by using norms, democracy and laws to justify their view of human free will and action in society. By referring to authorities the students

1
2
3 express their support for authorities exertion of power, i.e. Domination, by decisions
4
5 made through their specific role in society. The students' reasoning implies a conflict
6
7 regarding the degree of laymen's participation in decisions about the new technology.
8
9

10
11
12 *Signification by drawing on modalities of Legitimation*

13 The students' dialogue reflects an interesting dimension of trust in the social system as
14
15 they draw upon norms, democracy and laws to legitimize how decisions on the use of
16
17 technology should be made. The perspective on "trust" here includes "both emotional
18
19 and cognitive dimensions and to function as a deep assumption underwriting social
20
21 order" (Lewis & Weigert, 1985). The results presented in this section can be seen to
22
23 reflect a possible conflict concerning the sensibility of personal decisions considering
24
25 free will on the one hand and the need for limitation of choice on the other.
26
27
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29

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31
32 *Justifications by reference to norms.* Legitimation of decisions about new technology
33
34 can be made by referring to norms. In the following example decisions about the use
35
36 of gene therapy is discussed.
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38

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40 'It's a personal decision, and you should not be forced to do it either. I mean, if
41
42 you are a criminal, you should not have to submit to treatment if you don't want
43
44 to.' (Hanna)

45 The decision, whether for or against using gene therapy, should be personal and not
46
47 forced upon a person by any authority. Instead laws should protect free will and
48
49 personal decisions.
50
51

52
53 'Laws should be made to permit parents to make any decisions concerning
54
55 their child.' (Benny)

56
57 We have a right to decide over our own and or our children's' bodies and it is implied
58
59 here that the social system should sanction norms which enable human action based
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1
2
3 on reflexive monitoring, i.e. agency should be granted to any human being. However,
4
5
6 there have to be limits for human action.
7

8
9 'You can't only see to what the parents want because then they can demand to
10 make just any changes they like to their child. You have to have something
11 else, laws or something like that.' (Pamela)
12

13
14 Pamela claims that constraints are needed. She seems to acknowledge the variation of
15
16 norms as she questions the norms of some fellow members of society. Here, personal
17
18 decision, at least when it comes to a parents' responsibility towards their child, is
19
20 questioned since all parents are not trustworthy. The right to decide over one's
21
22 children's bodies is contested on the grounds that certain norms need to be sanctioned
23
24 by laws to limit human behaviour in order to protect against undesired outcomes.
25
26 Thus, laws should restrict human actions considered to be unjust. It is expected that
27
28 what is regarded as a societal norm will be protected by democratic practices.
29
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32

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34 Trust in the social system is strengthened if it endorses personal agency.
35
36 Subsequently, if, as a result of new technology, the social system is believed to
37
38 restrict free will, i.e. personal decisions, trust will be lost and there will be a
39
40 reluctance to accept imminent transformation of society. However, trust in the social
41
42 system is also dependent on limitations of personal agency. Laws sanction norms and
43
44 such limitations on human action induce trust in the social system as it protects
45
46 norms. In the above context, trust in the social system depends on how the conflict
47
48 concerning the degree of free will is resolved, which in turn affects the sense of
49
50 agency.
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56 *Justifications by reference to democracy and laws.* Views about decisions drawing on
57
58 democracy can actualize the function of laws to regulate the use of new technologies
59
60 in society. Democratic procedures provide familiar resources to govern the societal

1
2
3 system. The laws passed enable as well as constrain human actions in society.
4

5
6 According to these students, laws that can regulate the use of new technologies should
7
8 be passed by popular vote in some manageable way.
9

10
11 'Evidently, it has to be a democratic decision. It should be what the majority
12 decides, but of course it's difficult so you should have maybe 5 given
13 alternatives to choose from.' (Tony)
14

15
16 'I think laws about these things should be decided on by popular vote. I don't
17 think the people need to know basic genetics but rather see the future
18 consequences'. (Pamela)
19

20
21 The students suggest the use of both binding and non-binding referendums. The
22
23 opinion of the majority is given the role of reproducing societal structure, which of
24
25 course might lead to transformation of societal practice. The statement made by
26
27 Pamela that people do not need to know basic genetics implies the importance of
28
29 reflexive monitoring by laymen to consider the potential outcomes of incorporating
30
31 new technologies into societal practice. Here, students typically relate to laws as rules
32
33 that legitimize human action by enabling or constraining it. Laws are outcomes of
34
35 democratic disembedded practice, although they may as well be seen as exertion of
36
37 power by the authorities. The constraints on minorities, as a result of democratic
38
39 decisions, appear unproblematic to Tony and Pamela, who apparently trust the
40
41 democratic principle. Thus, democracy can legitimize any human action and the
42
43 outcome will be regarded as trustworthy. Democratic decisions induce and sustain
44
45 trust in the social system since they enable agency by reflexive monitoring, here
46
47 interpreted as the choices given for a decision about biotechnology.
48
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53
54
55 *Signification by drawing on Domination*
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57
58 When it comes to decisions about the use of technology, the students accept
59
60 authority's exertion of power on an abstract, general level in society. Such authority is

1
2
3 grounded in either political or scientific status and reflects a trust in the societal
4
5 system. On a concrete level, decisions by medical experts should be preceded by
6
7 negotiation to include personal knowledge from laymen such as patients.
8
9

10
11 *Justifications by reference to authorities.* To some students, decisions about the
12
13 reinforcement or transformation of society appear to be taken by those in authority.
14
15 Authority is conceived of as being grounded in political or scientific status.
16
17

18
19
20 'It is the politicians who decide what you are allowed to do within the health
21
22 care system.' (Linda)

23
24 This student refers to the present regularized practice in Swedish society when she
25
26 suggests that the power to decide resides with the political institutions controlling the
27
28 resources. She does not describe politicians as necessarily being trustworthy, but
29
30 rather shows an acceptance of politicians exerting power over human action. The
31
32 description confirms the role of societal facilities such as institutionalized
33
34 organizations in the structuration of society. The view that officials have specific roles
35
36 in society controlling the health of our bodies leaves the decisions for future
37
38 transformation of society to those with political power. The student's acceptance of
39
40 the present practice indicates a trust in the social system.
41
42
43

44
45 When students justify decisions by referring to authorities with scientific
46
47 status they state that decisions should be made based on facts, not on opinions.
48
49

50
51 'Scientists and the like, they know everything. Not politicians and those who
52
53 (have no knowledge), because then it's only opinions you know. Scientists have
54
55 all the facts.' (Veronica)

56
57 'Medical doctors and maybe patients, they (MDs) consider someone's need,
58
59 someone who lives a life with a need of a new organ.' (Charlotte)

60
Here, scientist and medical experts are given the role to decide since they alone have
sufficient knowledge. Opinions, although not specified here, are distinguished from

1
2
3 knowledge. Subsequently, most members of society are not knowledgeable, at least
4
5 not when it comes to new technology. Instead, expert knowledge is 'seen as being
6
7 trustworthy' in contrast to politicians' and laymen's knowledge. Based on this view
8
9 then, experts should decide about future transformation of societal practice based on
10
11 expert knowledge. Charlotte's description implies the possibility of mutual agreement
12
13 when it comes to medical treatments. The focus here is a decision for the benefit of
14
15 the health of a person, who also happens to be a knowledgeable patient with personal
16
17 ideas of a desired outcome. The specific situation allows a person-to-person
18
19 negotiation where a decision can be reached based on mutual understanding, and
20
21 where the patient's agency should be sustained. Here, the distance between
22
23 knowledgeable laymen and experts may be reduced and trust may be built between
24
25 real persons. The power to decide over one's own body is reinforced and follows
26
27 common societal practice.
28
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33
34 Trust in political authority is grounded in trust in the social system through
35
36 which resources can be provided for desired outcomes, which in turn, can be
37
38 monitored and judged by members of society. When students express trust in expert
39
40 knowledge by referring to authorities on scientific knowledge, they suggest both trust
41
42 in the scientific principle and in experts as persons. Furthermore, a stronger trust can
43
44 be built by negotiating face-to-face and here, as agency is promoted, the building of
45
46 trust is typically facilitated.
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48
49

50 51 **Discussion**

52 In this section some methodological aspects will be discussed, followed by a
53
54 discussion of the results. The results discussion deals with: 1) how students deal with
55
56 their loss of ontological security, and 2) how students relate to agency when reasoning
57
58 about anticipated changes in societal practice. Each section is followed by a
59
60

1
2
3 discussion of the pedagogical implications of our results concerning that section. We
4
5 end our discussion with concluding thoughts where the possibility of sustaining and
6
7 promoting students' agency in science education is considered.
8
9

10 11 12 *Discussion of Methodology*

13 Since the aims of the study are grounded in an interest to interpret students' notions
14
15 about societal structures, Giddens (1984) modalities of Legitimation and Domination
16
17 were used as categories for students' justifications of their significations. Here
18
19 democracy and laws were chosen as one single modality of Legitimation since laws
20
21 and democracy are interconnected. However, if any of the students had used laws as a
22
23 modality of Domination, which is conceivable, the merging of the two could be
24
25 questioned. The fact that laws can be used as Domination by referring to laws as
26
27 typically made by authorities, without considering social norms, means that future
28
29 studies in Sweden, as well as in other countries, may need to add to, or extend, the
30
31 category system. Knowledge claims are constrained to scientific knowledge in this
32
33 study since the purpose of the study is to describe how students use scientific
34
35 knowledge, i.e., the disembodied knowledge that can be interpreted as initiating a
36
37 socioscientific issue. There are two criteria for such scientific knowledge claims here:
38
39 first, it has to be possible to interpret them as emanating from expert knowledge, i.e.,
40
41 from disembodied practice; secondly, it has to be used by students as an apparently
42
43 non-disputable fact.
44
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51
52 It can be argued that the concept of ontological security is vague and
53
54 impossible to study. This study does not claim to measure any ontological security but
55
56 rather, by inference, use it as an attempt to describe problems the students, according
57
58 to theory, have to cope with when dealing with the different topics. However, the
59
60 actual experiences the students have are concealed from us.

1
2
3 The impact of what is interpreted as the students' reflexive monitoring and
4 agency is difficult to estimate since the discussions were hypothetical in the sense that
5
6 the students were not in a situation to decide or take action on any of these issues.
7
8 However, the students' reasoning could still be relevant for a real situation, at least
9
10 partially, depending on the context and how much later it may occur. Their reasoning
11
12 is of course more relevant for science education although dependent on the classroom
13
14 activity.
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19
20 Finally, The number of students in this study may appear to be limited.
21
22 However, the analytic approach ensured that saturation was reached, and this helped
23
24 strengthen the validity of the study. The validity of this study is further strengthened
25
26 by the presence of similar arguments about gene technology in other studies. For
27
28 example, see Bates, Lynch, Bevan & Condit, (2005), Barnett, Cooper & Senior
29
30 (2007), Chen & Raffan (1999), Gunter et al. (1998), Kolsto et al. (2006), Pearce,
31
32 Thomas & Clements (2006), Saucier & Cain (2006), Sadler & Donnelly, (2006)
33
34 Sadler & Zeidler (2004), Walker & Zeidler (2007), Zeidler, Walker, Ackett &
35
36 Simmons (2002), Zohar & Nemet (2002).
37
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43 *Discussion of Results*

44 There are many issues that could be discussed from our analysis, however, space
45
46 constraints have led us to focus on what we regard as the most interesting and
47
48 worthwhile aspects that we see arising from our analysis: students' ontological
49
50 security; trust and agency and their promotion in science education. We begin by
51
52 dealing with students' counteracting their loss of ontological security as new
53
54 technology is anticipated to result in a transformation of societal practice. We discuss
55
56 the possibility to reduce loss of ontological security by building trust in authorities in
57
58 relation to the social structures Legitimation and Domination. We then deal with how
59
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2
3 these results may be linked to the notion of agency, which is perhaps the most
4
5 interesting aspect of the ensuing discussion.
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10 *Counteracting loss of ontological security and building trust*

11 The anticipated societal change arising from gene technology supports or challenges
12 how students expect the social system to be reproduced or transformed. Modalities of
13 Legitimation are essential for students' building of trust in the societal system and for
14 their notion of participation in societal reproduction or transformation. Modalities of
15 both Legitimation and Domination are important for the possibilities of building trust
16 in people representing disembedded practices, i.e., authorities such as experts and
17 politicians.
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28 As shown by other studies, a variety of norms is expected to be found among
29 students. (Sadler & Zeidler, 2004). When the students participating in our study used
30 norms to legitimize their signification of gene technology they focussed attention on a
31 variety of interesting norms that uncovered potential latent conflicts for science
32 classroom discussions. At the same time, students' expressions of norms and values
33 may change between situations and the negotiability of norms and values could be
34 quite substantial (Macrae, Milne & Bodenhausen, 1998), and they can choose which
35 norm is the most important in one specific context and disregard the same norm in
36 another (Zeidler & Keefer, 2003; Zeidler et al., 2002). Norms are socially enforced
37 rules (Horne, 2009) and a person's subset and ranking of norms depends both on
38 which social group they belong to (Nagda, 2006) and to the social group where the
39 discussions are situated. Therefore, in a discussion about new technology, any
40 conflicts concerning ranking of norms must be considered as negotiable. However,
41 norms sanctioned by moral obligations (Hechter & Opps, 2001) have to be considered
42 as less negotiable than norms related to social expectations without moral obligations.
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3 Still, even though a certain norm can be of high personal importance, it will have
4
5 limited impact on ontological security because norms are not routinized (Giddens,
6
7 1984). Hence, discussions aiming at resolving conflicts between different norms are
8
9 likely to have only limited effect on the counteracting of reduced ontological security
10
11 among the students.
12
13

14
15 The threat to norms is less fundamental than that to traditions since societal
16
17 sanctioning of norms changes more rapidly and because stereotypical expressions for
18
19 norms are easily overruled in a social context (Macrae et al., 1998). Legitimation by
20
21 using tradition as a justification has more impact on ontological security than norms.
22
23 This is because tradition both counteracts fragmentation in time and it is highly
24
25 routinized (Giddens, 1984). But traditions are not only routinized, they also carry
26
27 norms and morals integrated in the specific practice. By relating to tradition, more
28
29 meaning is connected to the new practice. The new technology is not seen here as
30
31 having any interwoven norms or morals itself, and can therefore easily be defined as
32
33 either belonging to tradition or not. The students in our study used subject content
34
35 knowledge to interpret how the morals integrated with tradition are in concordance
36
37 with the application of the new technology. Their ways of reasoning display not only
38
39 a potential conflict but also how knowledge and norms can be linked together in
40
41 different ways. It could be argued whether or not they use knowledge to support
42
43 traditions or vice versa. Thus knowledge can be used to explain how human action is
44
45 made legitimate in a post hoc way. However, according to structuration theory,
46
47 traditions, and to some extent norms, are habitual rules integrated in embedded
48
49 practice that can be explained by knowledge without depending on it (Giddens, 1990).
50
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58 Students who are positive to the new technology use the tradition as a way to
59
60 bridge the gap between embedded practices (traditions and routinized practices) and

1
2
3 disembedded practice (i.e. new technology) (Giddens, 1990). In our study the
4
5 students' interpretation is that the new technology can be seen as being embedded in a
6
7 pre-existing tradition. This was crucial for their stance to use gene technology for the
8
9 development of societal practice. Hence, the students' reasoning about new
10
11 technologies and traditions are of high importance for their sense of ontological
12
13 security and thereby their interpretation of gene technology as a threat or not.
14
15

16
17 Since the students drew on norms, democracy and laws to regulate human
18
19 action in society a conflict regarding agency seemed to emerge. This is a conflict
20
21 between personal freedom of action, based on personal free will and personal norms,
22
23 and societally sanctioned actions (Hechter & Opp, 2001; Horne 2009). Thus, they had
24
25 a notion of the discrepancies between embedded practice and disembedded practice
26
27 where trust in either people or societal institutions, such as referendums or other
28
29 democratic legislatures, is at hand. The students showed a trust in the societal system
30
31 and that the democratic principle will solve conflicts about norms and morals in an
32
33 acceptable way.
34
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37

38
39 When it came to modalities of the societal structure, the students drew on
40
41 modalities of Domination, such as knowledge claims and authorities, when discussing
42
43 future use of gene technology. Their justifications imply an awareness of a risk-
44
45 benefit conflict where students focus on trust and physical safety. Scientific
46
47 knowledge is an important issue here, since students use their knowledge to interpret
48
49 the safety of the technology as well as to build trust in basic principles and experts.
50
51 They moderate their potential loss of ontological security through trust. This is where
52
53 the discussion of safety is meaningful, i.e., how to escape undesired material
54
55 outcomes (Giddens, 1990). The students use knowledge claims, related to natural
56
57 sciences, in support of social norms. This is an important problem to bring to the fore
58
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1
2
3 in classroom discussions since knowledge claims usually cannot be used as the cause
4
5 for social norms in any logical reasoning. Knowledge claims are of course useful to
6
7 describe material outcomes, which in turn can be judged as desirable or not in relation
8
9 to norms in a social context.
10
11

12 The students used knowledge claims to strengthen or weaken their trust in the
13
14 basic principles of the new technology. A trust in the basic principle comes with a
15
16 sense of security. Students who embrace the new technology are the ones who trust
17
18 the basic principle, experts and their knowledge. However, students who want to
19
20 prevent the use of the new technology showed no trust in the basic principle. The
21
22 latter group of students could be described as the target for the PUS and STS
23
24 movements (Irwin & Wynne, 1996; Irwin, 2001) in their quest for education for a
25
26 'knowledge society'.
27
28
29
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31 When drawing on authorities, the students classified experts in terms of
32
33 perceived competence. Here, judgements about competencies, and perhaps even the
34
35 intentions among experts, became guesswork. The students who desire a change in the
36
37 societal practice by the new technology felt no need for the monitoring of experts.
38
39 Similarly to laymen, students are seldom in a position to monitor experts' activities,
40
41 and so they just have to trust them and/or the capacity of the social system to control
42
43 the experts. The students with little trust in experts and disembedded practices were
44
45 anxious about the possibility of disastrous outcomes. Their lack of trust in
46
47 disembedded practices may lead to less trust in the societal system and loss of agency.
48
49 The students with a low ontological security, as expressed by doubts and fear of
50
51 uncontrolled risks, recognise experts as authorities with power (Domination).
52
53 However, they do not trust experts and so they seek in vain to monitor experts'
54
55 practice to counteract their loss of ontological security.
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Pedagogical implications regarding students' ontological security and trust

In a discussion where conflicting views about traditions are disclosed, the loss of a sense of security is likely to be an important issue. By strengthening such discussions, where both emotional and intellectual aspects can be used to understand the conflict they constitute, possibilities for participation in future societal discussions have a good possibility of being developed (Sadler & Zeidler, 2005a, 2005b). Important directions for such discussions are about the search for intelligible relations between modalities of Legitimation and Domination. This could be done by raising the awareness of norms as socially constructed and that they, as such, can become less understandable if scientific knowledge claims (Domination) are used to 'prove' that a norm (Legitimation) is right.

To reach understanding of the conflict concerning Legitimation, a discussion needs, at least initially, to be limited to just Legitimation issues and to acknowledge laymen's knowledge. Discussions based on embedded practice facilitate personal interaction where trust can be built in people - not in abstract principles or disembodied practices. This can be of vital importance for future opportunities to build trust and to counteract loss of ontological security. Such a discussion concerning Legitimation issues can bridge the gap between embedded and disembodied practice. However, this opportunity may be jeopardized if, say, two opposing student groups jump to conclusions drawn only from disembodied practices such as either scientific knowledge or legislatures.

In the classroom, risks can be addressed by dealing sceptically with the knowledge claims of basic principles and expert practices (Domination). Science education can also deal with risks as a matter of Legitimation by bringing more attention to the capacity of the social system to control the development and use of

1
2
3 disembedded practice. An integrated classroom discussion could arguably be more
4
5 beneficial for the students who need to counteract their low ontological security by
6
7 creating a focus on scientific knowledge claims that are not given priority over
8
9 Legitimation and immaterial outcomes. If it is made acceptable that norms and
10
11 traditions also can be the basis for signification, then knowledge claims and experts'
12
13 knowledge, or their lack of it, is not the issue. Rather, a discussion for counteracting
14
15 loss of ontological security and building trust should concern Legitimation. This
16
17 interpretation finds support in the findings where students call for legislative
18
19 regulations of experts' actions.
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24
25 The problem of not addressing such aspects in science education has already
26
27 been identified (Kolstø, 2001b, Sadler & Zeidler, 2005a, Zeidler et al. 2009). The
28
29 students' different stances concerning Domination in this study, suggest that a
30
31 classroom discussion focusing on physical safety and knowledge claims might bring
32
33 attention to incorrect-correct or sufficient-insufficient knowledge and ignore other
34
35 aspects, such as norms, morals and emotions. The emphasis on Domination may give
36
37 a structural perspective to clarify parts of a classroom discussion. In a discussion,
38
39 knowledge claims could be used to build trust in basic principles and to feel
40
41 physically safe, but if knowledge claims instead are used for the purpose of
42
43 supporting or defying norms and values, then the conflict instead needs to be
44
45 understood within the realms of Legitimation. Legitimation and Domination are not
46
47 mutually exclusive (Giddens, 1984), but if there is more than one discussion, i.e. a
48
49 discussion about one societal structure implicitly framed by another, then a
50
51 constructive dialogue can be hampered, thus negatively impeding development of a
52
53 functional science literacy. Such framing can be the result of science education in
54
55 classrooms that do not openly permit aspects other than scientific knowledge (Driver
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2
3 et al., 2000; Sadler & Zeidler, 2005a; Zeidler & Sadler, 2008), as in traditional
4
5 science education.
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9
10 *Promoting agency through reflexive monitoring*

11 Agency through reflexive monitoring is implied when students state that their norms
12 are congruent with those of experts and experts' practice. Agency is also implied
13 through students' belief that a transformation of societal practice is likely to lead to
14 desired outcomes. However, reflexive monitoring using personal investment in the
15 understanding and appraisal of the new technology might still be absent (May &
16 Finch, 2009). Thus, such expression of agency can be deceptive since the trust in
17 experts does not call for any need to participate personally. This implies the need for
18 science education that stimulates scepticism of scientific knowledge (Kolstø, 2001b;
19 Kolstø et al., 2006; Zeidler & Sadler, 2010).
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33 Students who express a desire to prevent transformation of societal practice
34 recognize a conflict between their norms and that of experts. They have little trust in
35 the ability of the societal system to prevent the anticipated transformation of practice
36 and subsequently fail to express agency in the interview situation. These students
37 would benefit from education for a 'critical society' since they are searching for trust
38 in the system; focusing on modalities of Legitimation, rather than in experts. Science
39 education could help students to place their trust in the social system by providing
40 students with chances to invest actively in their understanding of the function of
41 Legitimation in relation to human action and changing social practice. Furthermore,
42 such knowledge could broaden their opportunities for reflexive monitoring and in turn
43 help them to gain a sense of agency.
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58 The students in our study pointed out that laymen do not need to know much
59 about genetics and the basic principles of gene technology to make decisions about
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3 desired changes in societal practice. So, it seems that students may generally consider
4 laymen as knowledgeable persons who can participate in Legitimation without much
5 scientific knowledge. This is in line with the notion of a 'Critical society' (Brennan,
6 2008; Kalantzis, 2006; Szkudlarek, 2007). However, students also brought attention to
7 a conflict between personal desires and laws. In classroom discussions, such conflicts
8 are likely to promote students' engagement in SSIs, and the development of agency
9 for democratic participation in decisions for the reproduction or transformation of
10 societal practice. Such discussions are well suited for SSIs since they include both
11 personal positions grounded in embedded practice and general, political positions
12 grounded in students' understanding of disembedded practice and the societal system.
13 Here the issue seems to be able to define grounds for Legitimation in both embedded
14 and disembedded practice. By understanding how the interaction between different
15 grounds of Legitimation can lead to new regulations and laws in society, students can
16 improve their reflexive monitoring whereby their sense of agency will be facilitated.
17 By negotiating moral as well as amoral norms in different contexts as they discuss
18 interactions between norms on the one hand and democracy and laws on the other,
19 they get an opportunity to understand the workings of democratic legislature and to
20 build trust in the societal system.

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46 Decisions that were justified by modalities of Domination, such as expert
47 knowledge, were students' expression of trust in experts and in the system, where the
48 power of authorities is acknowledged and accepted. According to some of the
49 students, authorities such as experts in gene technology and medicine exert their
50 power when given a regulatory role. Their trust in experts, built on appreciation of
51 what is *expected* to be their knowledge may well be a result of science education and
52 medial influence sustaining ontological security. The downside is that such trust can
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3 prevent the sense of agency. Students drawing on modalities of Domination describe
4
5 disembedded practices where authorities have specific roles and laymen have to trust
6
7 them for some reason. The students who accept the decisions made by authorities also
8
9 trust them. They do this either on grounds such as expert knowledge or on democratic
10
11 political grounds. Here, the conflicts between students' positions puts politics and
12
13 expert knowledge in opposition to each other, claiming that political views are not as
14
15 'reliable' as expert knowledge. This, in turn, puts laymen's participation in decisions
16
17 into question because laymen are as knowledgeable as politicians when it comes to,
18
19 say, gene technology.
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26 *Pedagogical implications regarding students' agency*

27 Science education that promotes the understanding of SSIs as multifaceted problems,
28
29 which need to be defined, has the potential to help students to develop reflexive
30
31 monitoring of social practice, which covers more than just material outcomes. One
32
33 possibility is to describe and make use of both of the societal structures Legitimation
34
35 and Domination. For example, the 'fear' of potential degeneration of humans, as
36
37 indicated by a student in our study, is a material safety risk and a matter of resources
38
39 (Domination), whereas the risk of losing the norm which celebrates human
40
41 uniqueness is an immaterial risk and an issue concerning rules (Legitimation). Each
42
43 could be addressed and appreciated separately to build an insightful understanding of
44
45 how they depend on the interaction between societal structures and human action.
46
47 Such differentiation is likely to help students in their reflexive monitoring, thus
48
49 supporting their agency by clarifying which societal structure an outcome of human
50
51 action is typically dependent on. Students' agency can be supported due to the fact
52
53 that interaction with a specific societal structure makes reflexive monitoring of an
54
55 issue more intelligible. Thus science education can support students' development of
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3 agency through better scientific knowledge and through knowledge about how social
4
5
6 practice depends on societal structures.
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8 A developed knowledge of the social system applied in a context can also
9
10 bring awareness of intentions in a negotiation. This could increase students'
11
12 understanding of why their perceptions of new technology as a threat can make them
13
14 prone to turn to regulation through Domination by calling for legislatures and political
15
16 authorities to save their socially embedded norms and practices and to compensate for
17
18 loss of ontological security. Knowledge about the social system might also be of
19
20 importance to students perceiving new technology as a promise to see beyond
21
22 material benefits and instead include reflexive monitoring of social norms and how
23
24 they interact with human action in society.
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31 *Concluding thoughts*

32 The modalities of Domination are the enactments of traditional science education,
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34 where students are envisaged as building trust in both basic principles and in experts
35
36 (Irwin, 2001; Styles, 2002). Unfortunately the modalities of Domination have been
37
38 confused with those of Legitimation, a problem apparent in the description of so
39
40 called collateral learning (Aikenhead & Jegede, 1999). It cannot be denied that with
41
42 specific scientific knowledge, outcomes on a material level can be scrutinized and
43
44 found to be desirable or not. However, the issue raised here is one of science literacy
45
46 as an integral aim of science education for a 'knowledge society' characterized by
47
48 Roberts' (2008) Vision I or II modelling of scientific literacy. In contrast to traditional
49
50 scientific education, a Vision II based science education has the potential to support
51
52 reflexive monitoring. Although Vision II may be only for strictly material outcomes,
53
54 it does support the generation of agency when dealing with issues concerning societal
55
56 use of scientific knowledge. From our study we would argue that students need
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3 knowledge about specific basic principles in such a way that it is useful in given
4 contexts. The students in this study use for example, evolution, natural selection and
5 natural/unnatural as principles for their judgments, but their understanding of these
6 terms does not seem to allow them to understand the full meaning in these contexts.
7
8 Here the full-fledged use of SSIs in science education can give further support to
9 students' development of understanding for the use of knowledge in a context by
10 including aspects other than scientific knowledge. This would promote reflexive
11 monitoring of material as well as immaterial outcomes.
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22 In science education, students can learn to trust the basic principles of expert
23 knowledge as well as to trust experts. However, if experts are seen as authorities, not
24 only in their scientific field but also when it comes to norms (or that norms are not an
25 issue), there will be little possibility of a sense of agency. Such reliance on experts
26 corroborates scepticism of scientific knowledge claims and experts intentions, and
27 preserves naive attitudes towards immaterial outcomes of societal transformation.
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36 This could be counteracted in science education by promoting an awareness of
37 how permissive laws (Legitimation) through Domination would not only mean giving
38 experts freedom to carry on their work for technical development, but also to change
39 social norms through disembodied practices without democratic discussions.
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41 Although trust in authorities will facilitate regaining a sense of ontological security, it
42 will be at the expense of agency and the participation in societal transformation or
43 reproduction.
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52 Students signifying new technology as a threat seem unlikely to find trust in
53 experts through basic principles of expert knowledge. For them, modalities of
54 Domination, such as scientific knowledge, do not counteract their loss of ontological
55 security or help to build trust. Instead, they need to learn to understand how to use
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3 face-to-face interactions for building trust through Legitimation, instead of
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5 Domination. Trust in the system together with a sense of ability of reflexive
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7 monitoring of immaterial outcomes can counteract these students' loss of ontological
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9 security as they see the opportunity to negotiate their threatened norms and traditions.
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11 Science education debates (Kolstø, 2001b; Zeidler et al., 2009), or even better, the
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13 meeting between students and politicians for authentic discussions about SSIs
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15 (Jiménez-Aleixandre, 2002), provide excellent possibilities for development of
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17 students' ability to participate in societal discussions, to build trust as well as to gain a
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19 sense of agency. An important subject for discussion in science education then, would
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21 be the discrepancy between embedded and disembedded practice. This is because
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23 sceptical trust in the societal system and in disembedded expert practice can be built
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25 together with specific knowledge for reflexive monitoring of the support for the sense
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27 of agency concerning SSIs. However, since trust, being of importance for ontological
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29 security, leads to Domination, it needs to be balanced by supporting the development
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31 of a sense of agency.

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34 We would argue that our discussion provides the basis for enhancing the kind
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36 of progressive development of students' ability to participate in societal discussions
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38 that must be embedded in a modern democracy. Furthermore, perhaps most
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40 importantly, such engagement has the distinct potential of being able to significantly
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42 contribute to building trust, as well as to gain a sense of agency as part of a modern
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44 science education setting.

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Table 1. Societal structures with the modalities used for analysis of data

		Structures		
		Signification	Legitimation	Domination
Modalities		Interpretative schemes	Norms	Knowledge claims
			Traditions	Authorities
			Democracy & Laws	

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