NANOETHOS

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Abstract

In this report we focus on ELSA research that aims at affecting the course of events under the heading of engagement. This aim calls for a normative framing of engagement activities we seek to articulate. To do so we have explored the shift in the ELSA initiatives of genomics to nanotechnology, that we refer to as ELSA I and ELSA II initiatives, respectively. The ELSA II we envision consists of complementary approaches that enable engagement of the *ethos* in ways that lead forwards to subsequent viable social and material adjustments of the socio-technical system. We argue that such complementary approaches have emerged in the ELSA II context of nanotechnology, and our advice is to nurture the variety of approaches. Engaging the ethos calls for descriptive and normative understandings of past, present and future impacts of technological innovation, researched in the contexts where technology is being developed.

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Novel possibilities and challenges for ELSA studies

Nanotechnology has become a central arena for reflecting on interdisciplinary research on the ethical and societal preconditions and implications of technology. When we say preconditions and implications, we refer to past, present and future interaction and interplay between society and technology. We subsume the various research activities that engage these multiple set of interactions under the heading of ELSA (ethical, legal and social aspects) research. Nanotechnology is a particular interesting arena for reflecting on ELSA approaches because nanotechnology emerges in a research context conscious of the social and normative dimension of research.

Technology is not conducted in isolation from society that forms the background and environment of the research and use. The activity itself will be based on and express particular societal values. These statements might have been controversial, but not so much so in the historical context of nanotechnology as the field is presented and understood as a field with great societal transformative powers. The expressed innovative potential of the field do not only draw attention to potential risk of harm to humans or environment or the uncertainty regarding such risks. It also draws attention more generally to the social and cultural priorities and visions of nanotechnology.

These characteristics of nanotechnology may therefore provide a basis for genuine attempts to carry out traditional ELSA studies and social science based evaluations of the field. This includes providing grounds for exploring ways such ELSA research may intervene in ongoing scientific discussions and decisions, on how to include more stakeholders in the process as well as inform political regulation of the conditions for use. Thus, nanotechnology may be seen to take on a paradigmatic role for the studies of ethical and social aspects of technology in ways that also may provide empirical material for a discussion of how, whether and to what extent such ELSA studies can and should influence the way technology research and use is conducted and assessed.

We will argue that there are a variety of complementary roles to play for ELSA researchers, and that this is exemplary demonstrated in the case of nanotechnology. This report seeks to articulate a vision for ELSA studies by paying attention to the historical context for the ELSA of nanotechnology.

Nanotechnology as a novel arena for ELSA

Nanotechnology provides a new arena for ELSA studies. The old arenas have mainly been connected to medicine and biotechnology financed under the heading of genomic initiatives. The arena of nanotechnology differs in three ways with respect to the ELSA of genomics, differences that in turn have implied a set of novel possibilities and challenges for ELSA scholars. In the process of dealing with these challenges, in part by exploring novel possibilities, a wide variety of complementary ELSA approaches appears to have emerged. It is important to notice that these differences in approaches and methodologies to a large extent are based on experiences from the ELSA-studies of genomics, and can be described as differences in similarities.

First, genomics comprised early trends of what has widely come to be analysed and discussed as novel modes of knowledge production. There are contemporary trends, according to these analyses towards a more context driven research with focus on the context of application (Gibbons et al. 1994, Nowotny et al. 2001 and for similar analysis see Ziman 2002, Funtowicz and Ravetz 1993). Genomics and nanotechnology, in contrast to earlier icons for the frontiers of science like high-energy physics, seek socio-economic measures of legitimacy in addition to basic understanding. Nanotechnology appears in times where consequences of these trends and analyses, developed within fields like genomics, have increasingly become assimilated, reflected among other things in science policy documents accompanying nanotechnology initiatives worldwide. These documents call for incorporation of ethical and social considerations in research and developmental processes. The widely accepted call for an ELSA of nanotechnology appears to be based on an understanding of nanotechnology as a paradigmatic case for such context driven research strategy. The explications of such a strategy imply the need for an early discussion on how these contexts will shape and be shaped by the field.

Second, nanotechnology appears against a learning process of early attempts to integrate ethical and societal consideration at an early stage of the development process, among which we find the first ELSA initiatives. The most important arena for such attempts emerged from the rapid increase in genomics knowledge witnessed the last thirty years with its strong impact on issues of health, food production and economics. In this respect nanotechnology research encounters an already established field of nonintegrated as well as integrated ELSA research. When it comes to the ELSA research strategy of nanotechnology then, it is possible to imagine outcomes of different ELSA approaches, given the wide range of already established concepts and methodologies for dealing with this kind of technological research and development. The shift of empirical setting from genomics to nanotechnology adds to the possibility of rethinking goals and approaches of ELSA studies and thus what kind of knowledge and impact this research should aim for.

Third, the difference of the empirical settings of the ELSA of genomics and nanotechnology is substantial. It does not only concern shifts in the research objectives, technologies and networks of scholars. It also has a crucial temporal component. The call for ELSA research on nanotechnology appeared at a very early stage of the field. Unlike early genomics, the technology research groups, research council and political authorities calls for the integration of ELSA in research. This call comes before anybody clearly knows the ethical and social issues that may arise due to the development of these technologies. Thus, extending the idea of having an ELSA research component from the domain of genomics to the domain of nanotechnology focused the challenge of how to ethically scrutiny technologies as they evolve. This focus contributed to an increased variety of approaches being enrolled in ELSA type of studies.

In particular, nano-ELSA-studies are well suited for the constructivist tradition known as STS (Science and Technology Studies). The lessons and methods of STS are attuned to the study of processes where technology is being constructed (as opposed to a conception of science as ready-made). The ability to trace and understand the dynamics of developmental processes is one of the main strengths of constructivist approaches. As we do not know the socio-ethical challenges that will be raised by nanotechnology, as we do not know what the technology actually will do, it is a reasonable strategy to pay close attention to the how technology emerges in a range of different cases of nanotechnology as they evolve in practice. STS researchers are by far more the premise provider of the ELSA of nanotechnology in contrast to ELSA of genomics. The two successive ELSA programme of The Research Council of Norway is illustrative (NFR 2002 and 2008). The STS influence is seen in the shifts in focus of in the work programmes, calls for projects as well as differences in the compositions of the boards. Nanotechnology constitutes a significant arena for normative engagement of the scholarly work of the STS traditions. The increased influence of STS is an important factor in our account of how nanotechnology provides a new arena for ELSA studies.

These three elements, we suggest, make it reasonable to speak of a shift in the ELSA initiatives of genomics to nanotechnology we shall refer to as ELSA I and ELSA II initiatives.

Research and engagement

A nanotechnology ELSA research initiative in this historical setting did not appear controversial in itself. It was, and is, generally accepted that potentially powerful new technologies raises a number of social and ethical issues that should be mapped and analysed at an early stage. However, the early call went beyond this, and included arguments for, and attempts to develop, ongoing technology assessment.

Nanotechnology has become a powerful illustrative case of what has been referred to as the Collingridge dilemma of technology assessment, often referred in the context of nanotechnology (Collingridge 1980). The early call for an ELSA of nanotechnology appears to express a general acknowledgement of the problem of postponing ethical issues to a stage where the technology has reached a mature stage. But as Collingridge stresses, there are ethical issues one can hardly raise at the stage of ready-made technology because it is difficult if not in some cases impossible to undo changes brought about by entrenched technologies.

This represents a challenge for approaches associated with ELSA I, as they are typically marked by ethical discussions on particular bioethical topics raised by the characteristics of developed technologies, or raised by assumptions about interventions that future development of the technology would enable. ELSA I have often focused on identification of and careful attention to crucial ethical issues surrounding the application of a technology or products thereof. These issues may even have a genuine novel character. The detailed ethical analysis dominating the early ELSA I period was enlightening, but in terms of representing an ethics of technology it came too late, so to speak.

On the other hand, as marks the Collingridge dilemma here, coming too early faces an information problem as technological developments have proven very difficult, if not impossible to predict (see for instance Nye 2006). The widespread acceptance for the need for ongoing technology assessment can in part be seen as a result of the fact that the nano-field is not sufficiently developed to allow for extensive and detailed discussions of moral choices characterising the ELSA I approaches. Speculative discussions of possible consequences of future nanotechnologies like "grey goo"-scenarios or nano-enhanced weaponry and defence systems are illustrative. Discussions of imaginary nanotechnologies have limited value, as they tend to be too close to science fiction literature and too far from the real and present challenges of the emerging field.

The rich and varied constructivist approaches of the STS field that make these approaches of interest for ongoing technology assessment approaches, face in turn another set of challenges. As Jasanoff and others has pointed out, STS studies are not geared to explore the moral nature of the process studied. These difficulties of the field are rooted in the various methodological approaches of constructivism focusing on descriptive adequacy displaying a built-in scepticism to normative engagement (see Jasanoff 1996, 2004a, Radder 1992). A process oriented STS dominated ELSA II approach, faces a challenge of taking the step from descriptive to normative analysis that is partly based in the methodological history of the field. There does not appear to be a well worked out alternative to the shortcomings of either the "too early" or "too late" approaches that focus the attention of Collingridge's dilemma.

The call for ongoing technology assessment then, may be understood as a response to Collingridge's dilemma that became particularly cogent in the context of nanotechnology. This happens even though there is no clear and well developed understanding of how, where and by whom such ongoing technology assessment should be executed. This report addresses this challenge by discussing the characteristics of ELSA research under the heading of "engagement". Nanotechnology set an arena where we have witnessed a shift, or rather extension, from public engagement to the engagement of socio technical systems.

The policy oriented forms of public engagement objectives (engaging public or civil society like in citizens juries, consensus conferences, open meetings, focus group interviews etc) are widened to the objective of engaging the entire socio-technical system (as nanoscientists, funding and science policy agencies, industry and ELSA expertise).

Nanoethos

The authors of this report envision ELSA research as an activity that engages normative realities of science and technology. This reality will be referred to as the ethos of socio-technical systems. The ELSA II we envision consists of complementary approaches that enable engagement of the ethos in ways that lead forward to subsequent viable social and material adjustments of the socio-technical system.

One of our basic claims is that nano ELSA initiatives set a stage for exploring the question of how to integrate normative perspectives in the study of processes of technology development. This task can be articulated as a question of how to enact a responsible, just or good nanotechnology development process. The quality of ELSA activities should ultimately be measured in terms of its ability to do so. The question is not only to conduct studies that seek understanding, but also to take responsibility by evaluating this understanding in light of questions of how this understanding makes a difference. If we accept this normative role, one could say that the quality of the work of ELSA scholars should be measured in terms of its ability to make a constructive difference. Academic quality parameters such as originality, precision, consistency etc., are not sufficient quality measures but in this context seen as crucial for securing deliberation on questions of improvement.

Accepting this, the task becomes not only to understand the role of ELSA research in instigating morally accountable developmental processes able to withstand ethical and political scrutiny. The task is also to clarify what type of ELSA activity is needed to achieve this goal, and how the various activities should relate to each other.

We argue that nano ELSA research activities display a valuable variety of complementary approaches. The potential of ELSA II lies in the diversity in which assumptions and premises embedded in various approaches may be challenged and adjusted in the tensions between various approaches that arise in ELSA venues marked by a commitment to normative measures. The ELSA of nanotechnology appears to create new venues for mutual criticism and enrichment of scholarly communities that still tend to otherwise work side by side. We expect such venues to emerge if ELSA research is understood in light of and measured against the task of clarifying, articulating and shaping a viable ethos of nano as it is expressed in particular nanotechnology projects and aggregates of projects.

The first part of the report distils the problems and fallacies of existing public engagement strategies that became visible in and through the historical context of nano ELSA. The second part returns to a discussion of how nanotechnology constitutes an arena for revisiting ELSA goals and approaches resulting in a drift from public engagement to engagement of socio-technical systems.

Public engagement research revisited in the context of nanotechnology

Given that our argument that ELSA studies in a wide sense can be understood as ways of explicating and evaluating the ethos of socio-technical systems, we want to focus on a subgroup of such studies that are directly involved in explicating normative elements in technology development. Engagement studies are concerned with the perceptions of technology by stakeholders with the aim of explicating ethical, social and cultural values at stake. Moreover, it is argued that, as a lesson from the GM debate in Europe, that engagement within nanotechnology needs to serve different functions. Many scientists and policy-makers argue that there is a need to avoid a repetition of the European debate on GM crops and its outcome.

Several interpretations exist concerning what went wrong in the failed attempt to place GM crops on the European market (Craye, unpublished manuscript). Different interpretations emphasises different reasons for the resulting public rejection. When one discuss how to communicate with the public regarding the introduction of nanotechnology, the difference in approaches can be seen as derived from disagreement in interpretation of the European GM story. There are two main types of approaches. According to a first interpretation, emphasis should be on anticipating possible negative technological risk impacts. According to a second interpretation, emphasis should be on a wider set of issues such as social, distributional, desirability of innovations, cultural and ethical challenges and so forth, including debate about appropriate procedures for governance of emerging technologies. Whereas the first interpretation largely preserves the primacy of innovation and the basics of risk-focused decision making (perhaps with adding a ‘precautionary element’), the second is based on a need for fundamentally transforming the ‘modern’ model of science-policy relations, following the insight that techno-sciences and social orders (defining what distribution patterns, lifestyles, ethical norms are realised) are co-produced. Thus, we can say that European governments are caught between a desire to promote innovation, and the political need to accommodate a wide range of public interest groups with precautionary concerns about environmental and health issues. This ambivalence can be traced in the ongoing debate concerning technology regulation, which includes the adequacy of present regulative frameworks (e.g. REACH) and the necessity of soft law approaches. As we have pointed out initially, scientific and societal developments are interwoven to a degree that there are reasons to regard the second interpretation to be more in keeping with the empirical realities of modern technological democracies. Thus, we agree with a dominant trend within ELSA studies in holding that different public engagement forms are crucial to ensure a good technology development. But before we move on to an analysis of these engagement projects, it is important to notice that this does not diminish the requirement that ELSA research must deal with the issues of risk. This also raises the question of how to integrate risk assessments with engagement of other aspects of the socio-technical system.

The problem of risk

Risk regulation frameworks are considered means by which decision-makers may promote benefits and avoid non-desirable consequences. Risk may be defined as probability X consequence(s), and presented as a characteristic of a situation or action wherein two or more outcomes are possible. The particular outcome that will occur is unknown and at least one of the possibilities is undesired (Covello and Merkhofer 1993). The impacts of pesticide use, the BSE epidemic and the nuclear accident in Chernobyl have exemplified the imperative that one should consider the magnitude of consequences even when the probability is low. Risk governance includes risk identification, assessment, management and communication. Risk assessment can be further divided into hazard identification, risk characterisation and risk estimation. Risk assessment has been considered as a strictly ”scientific” process, while risk management and communication implies value judgement with regard to acceptability, the trade-off criteria and the adaptation of strategies for coping with uncertainty. However, several authors have pointed out that risk assessments are influenced by scientific, ethical, economic, social and political information (Mayo and Hollander 1991; Renn 1998; Wynne 1992). For instance, risk assessments include value judgements both with regard to consequences that should be avoided and the process of risk characterisation. These choices are most often made before the risk assessment has been initiated. To take this diversity into account, the present debates are envisaged as having two purposes (a) to firm up the probabilities and uncertainties involved in possible events and (b) to decide how to value the possible outcomes and select the most desirable one.

The key determinants with regard to risk perception are distribution of risk and benefits, voluntarism and consent, degree of familiarity, visibility and control (Schrader-Frechette 1991; Slovic 2001). The diversity of risk perspectives is also fostered by divergent value preferences and variation in interests. Many situations of risk are marked by controversy between stakeholders. Part of the controversy may be attributed to legitimate differences in value commitments, ranging from risk-benefit perspectives and societal issues to the preliminary value of whether the technology is permissible at all. In order to integrate these value aspects of the risk based approaches to technology assessment; we must take a closer look at engagement studies.

Engaging the public

The rationale for engaging the public has been described by Stirling (2008), and he separates the rationale into three arguments; it is necessary for restoration of legitimacy and public trust, it can lead to better results for decision making, and the normative which is that engaging the public is the right thing to do.

The “model” for any participatory decision-making can be described according to the classification suggested by Rowe and Frewer (2000):

1. The overall aims and objectives (i.e. consultancy, actual decision making, input to an ongoing process, satisfaction of free informed consent);
2. The participants (i.e. professionals, specialists, lay persons, ethical committees, stakeholders)

3. Their representative status (i.e. themselves, organisations, unions, or future generations or animals)
4. The procedure (i.e. closed or by invitation only, open, media access, accountability).

Public participation is in general considered to be important since this will increase transparency and legitimacy of the scientific research and development. Public involvement may also enhance learning about the benefits, for example ecological and economic, that the public consider important to pursue, and the 'harm' they consider important to avoid. Perception and acceptance of risk are closely related and are influenced by values held at the individual level, as well as by cultural and social values (Renn 1998). The debate over development and use of new technology or products is not related solely to health and the environment, but also encompasses economics, ethics, cultural and social aspects that may be equally important as the risks to health and the environment (Wynne 2001). Hence, public judgements in regard to the necessity of introducing a new technology build on explicit or implicit perceptions of risk, social aspects as well as community expectations of the benefits that may accrue.

In our context it is even more important to notice that these broad concerns draw an extensive map of values taken to be involved in the development and use of the issue at stake. Thus, these different kinds of engagement, whether they aim at consultation, decision-making, or satisfying procedural requirements, all do in practice engage with the ethos of the activity. Even when surveys arguably demonstrate that a significant number of respondents lack basic understanding of the technical issue, their presumably ill-informed basis for value-judgement form part of the ethos of the activity. An example of such apparent misconception is represented by the high number of Europeans that over the years have given their assent to statements such as "Ordinary tomatoes do not contain genes, while genetically modified tomatoes do"(Gaskell et al. 2006). If we assume that they actually believe this, their value judgements based on this misconception do have an impact on the GM technology understood as a socio-technical system. We have to discuss the significance of this aspect of the ethos and why such misconceptions persist. There are a number of possible interpretations of this factor and even more possible ways to deal with it. We will not go into this here, but it is important to note that negative value judgements associated with misunderstandings of the technical facts will not disappear simply by pointing out the truth of the matter. Mistrust associated with deficient knowledge is a complex phenomenon that cannot be fixed by public education alone. This is an important reason why nanotechnology can have something to learn from the GM controversy. The problem is that it is not exactly clear what there is to learn, beyond the assumption that public engagement can be beneficial for trust. But even that is not an incontestable claim.

There are other reasons than trust building for engaging the public in the regulatory debate, for example that it is morally required as part of modern democracy or that they may provide necessary perspectives on technology development (Myskja 2007). Although trust is necessary for a well-functioning modern society, as has been convincingly argued by a series of leading social theorists (Luhmann 1968), trust is not a good in itself, also when it comes to the relation between science and society. Here only well-founded trust is good. In some cases, mistrust is an essential prerequisite for reforms of poor management or deficient security systems. Trust is like an Aristotelian virtue in the sense that excessive trust is as bad as too little trust. Trust is good when the trustee is actually trustworthy. The reason for public engagement should not be seen as primarily directed towards building trust. It should be seen as part of the larger project of creating trustworthy practices within technology and science. Therefore, the point of engagement studies is not primarily doing something with the public and the participants' opinions and attitude. It is to do something with the ethos of the technology in a broad sense. That is, being part of the task of building a trustworthy technology understood in a broad sense as an activity that involves the relation between the technical practices and the natural and societal systems involved in the production and use of this technology.

Nanotechnology as a test case for democratising science

Social science and ELSA researchers have made strong claims for the relevance of public engagement. With regard to nanotechnology it has been argued that it is a "test case for democratising science" (Toumey 2006). Macnaghten et al. (2005) have emphasised that engagement of the public is important for the involvement of social sciences in nanotechnology innovation and research processes. While Wickson et al. (2010) claims that for practising nano-scientists, communication and discussion of their work has become a key element of what it means to be a responsible researcher. If we take a closer look at the findings of what kind of issues that was typical of early nanotechnology engagement studies, we see that the framing was crude, giving a choice between ideals and nightmares (see table 1).

Table 1. Societal issues raised in the nanotechnology debate; ideals and nightmares (taken from van Est and van Keulen 2004)

Application area	**Societal issues**	**Ideals**	**Nightmares**
Nanomaterials / industrial production	Impact on human health and the environment	Sustainability	Nano-asbestos
	Self (re-) production	Universal assembler; personal fabrication	Grey goo (uncontrollable reproduction)
Nano-electronics	Privacy	Smart products and environments	Big brother
Bio-electronics	Human enhancement	A world without disability	Discrimination against the disabled
	Hybrid forms of living and non-living entities	Links with and via the internet	Dehumanization Alienation
Nanotechnology in medicine	Predictive medicine	Early diagnostics Personalized pharmaceuticals	Compulsion/exclusion Unequal access to healthcare
Nanotechnology in the military setting	Arms race	A safe world	Proliferation of terrorism
	Ethics of war	War without fatalities	Killer robots Star wars
	Human enhancement	Invincible troops	Cyber soldiers
Economy / innovation	Patents	Dissemination of knowledge and distribution of profits	Monopolization of knowledge and profits
	Distribution	Fair distribution of wealth and income	Gulf between North and South (the 'nanodivide')
	Governance / dialogue	Societal governance	Technological determinism

Clearly, this kind of engagement cannot give any kind of guidance for technology development beyond reinforcing tendencies towards hype and scare-mongering, respectively. It serves as a support for arguments against up-stream engagement. We do not know the true nature of nanotechnology applications, but we have reason to suspect that these simplifications do not represent any realistic picture of what we will get. Choosing polarised approaches like these means that we replicate one, perhaps crucial, mistake from the GM debate, namely to let the extreme positive and negative potentials of the technology become central to the debate. To illustrate this we will briefly describe some problems with public engagement before moving into the opportunities for providing more robust engagement with nanotechnology.

Problems with public engagement

As we have reviewed the literature on public engagement we have also found that there are several authors that emphasises that there are different problems with public engagement. Here we will briefly describe some of these problems from experiences with engagements within nanotechnology as well as use GMO as a case where that is relevant.

Problems with methods and models

The most prominent and repeated mistakes related to public engagements with emerging technologies, can perhaps be connected to the so-called deficit model: The presumption that the reason for public scepticism was lack of information and / or scientific illiteracy. But also the opposite mistake has been an easy trap to fall into, namely the assumption that lay knowledge represents a privileged access to crucial insights regarding technology developments. There have also been criticisms against the procedures that have been used in these participating processes, the set of participants that have been selected for the participatory processes, and with regard to the criteria for selection. It is also pointed out that the way in which policy guidance ought to be drawn from such procedures is very seldom specified. The argument is that some normative meta-rules would be required to do this, and specification is likely to be particularly challenging when participants in the processes indicated disagree. In fact, it may be impossible to satisfy some sets of norms or ethical values that on the surface look to be reasonable, as for example Kenneth Arrow's impossibility theorem indicates (Arrow 1950). These are not the only weaknesses of public engagements as sources of reflections on the ethos of techno-scientific systems. Some of the typical problems are presented in the table below.

Table 2. Problems with public engagement (Tait 2009)

Group thinking	The views of small groups will be easily swayed by participants with strong opinions or by those leading the engagement
Issue framing	Given our ignorance about the future, engagement can be a process of fictitiously framing new science and technology in the minds of the public
Recruitment bias	It is difficult to persuade uncommitted citizens to participate in hypothetical discussions about science and innovation a long time in the future –those who engage are likely to have a specific agenda
Conflict	Where there is polarization of views, engagement can lead to increased level of conflict
Engagement focus	Some topics –for example nanotechnology –are too broad and multifaceted to allow meaningful engagement
Engagement fatigue	There will be insufficient time and resources to engage on every relevant issue and people will become cynical about the process
Labile public opinion	People who do not already have strong opinions will change their minds over relatively short timescales, and much more so over 10-15 years. (in response to latest events, media campaign etc)

The design of the engagement exercise is important in determining whether these potential problems will become real and therefore weaken the value of the engagement studies. On the other hand, the extent to which these factors are perceived as problems is also a matter of perspective. When we wish to discover the range of values at stake, group thinking can help in formulated sharp perspectives and the bias can be adjusted by altering the size and the combination of participants in the groups. It is also acceptable that people who are unengaged are unwilling to participate in these exercises. If someone does not have opinions on potential applications of nanotechnology and have no wish to influence the policy processes, it can be morally wrong both for the recruiters and the unwilling participants to take part. One can claim that it is more appropriate to seek those who actually have opinions and wish to express them, even if the engagement groups become less representative.

Problems of framing the right question

In an analysis of the evolution of UK policy discourses on nanotechnologies Doubleday (2007) emphasises that after nanotechnology emerged on public and policy agendas, there were debates about a wide range of implications by nanotechnologies, while the policy discourses focused on environmental, health and safety risks. Hence Doubleday argues that the debates on nanotechnology are ‘too narrow and too broad’. They are too narrow because they fail to address the institutional questions, such as those about relationships between science-policy-society, about regulation and about innovation policy. Too broad because this debate use the term nanotechnology as a subject of public engagement processes and hence fails to take into the account the diversity of the nanotechnology field. Public engagement on specific developments and applications may provide more valuable input and hence be one strategy to circumstance the “too broad” characteristic. One important aspect of the “too narrow” which is related to the tendency of the policy debate to becoming focused only on environmental and health risk, as the toxicity of nanoparticles, is assessing what lessons that have been learnt from the GMO debate.

From debates over GM crops, a problem that has been acknowledged is the discursive power of framing that determines the range of possible alternatives and answers (Mayer and Stirling, 2004; Levidow and Carr, 2007). Similarly, the dominant paradigms and metaphors used in the research, discourse and communication of risk assessment often influences what issues that is relevant (Wynne, 2001).

Historically, technical “experts” have been given the role of designing and framing biotechnology innovation, research and risk assessment. The resulting memes have been largely reductionist in its science, and limited to technicalities. It is also reasonable to assume that risk/cost-benefit-approaches are easier to communicate and also to deal with in regulation. Typically in such cases, there are different, but equally plausible perspectives on what the problem is, evidence may be evaluated differently, and conclusions and recommendations assessed from contrasting perspectives and assumptions. This decontexualisation of technologies from the surrounding world effectively discounts complexity, both in natural and ELSA dimensions, and limits the consideration of unanticipated and unexpected effects on health, the environment and the society. The wider value questions concerning what kind of technology we want and what kind of society we envision this technology to be part of are questions that require a different kind of dialogue.

Problems with value incommensurability

One important problem with public engagement is the unavoidable value incommensurability between the cost (in terms of possible adverse effects on health and long-term environmental degradation as well as socio-economic implications) and the benefits (increased production and more environmentally friendly processes and products) by nanotechnology. We will here illustrate this by using the conflicting debates linked to the import and use of GM plants for food, feed and agriculture. Scientists and representatives of the biotechnology industry have often dominated the debates concerning risk issues, framing the debates as purely technical issues (de Melo-Martin and Meghani 2008). Jensen et al. (2003) has applied the concept "risk window" to illustrate that risk assessments view the world through a "risk window" that only makes visible that which has been predefined as a relevant risk. The size and structure of this window is determined by value judgements about what is considered relevant as adverse effects identified in the process by the involved stakeholders. Hence, it must be expected that stakeholders use different conceptual frameworks, defined as a set of basic beliefs, values, attitudes and assumptions creating a frame through which they see themselves and the world, in their identification of which values are important to protect.

The polarised debates surrounding GMOs has shown, as John Walls and colleagues have pointed out, that one problem with decision-making is the inability to weigh explicit social value judgements with the scientific facts. For instance, in the New Zealand experience, non-scientific arguments were implicitly marginalised because the questionnaire employed for interest groups made it difficult to use holistic arguments. A 'holistic argument' in this case might imply a concern for the implications for landscape and culture embedded in the agricultural system or consideration of the growing dominance of multinational corporations in the life sciences. These enterprises increasingly decide on options for the development of new medicines and food, they are part and parcel of the GM revolution – but somehow their role seemed 'beside the point' in the questionnaire developed to study the public debate (Walls et al. 2005). It is reasonable to say that without these kinds of argument supplementing technical cost/benefit-arguments, we will not be able to fully come to grips with what is at stake.

A similar view has been further elaborated by Sheila Jasanoff (2005), who points out how science–policy relations in the biotechnology sector are characterised by the growing absence of broad public participation and a lack of democratic institutions to deal with this.

Finding a way to balance competing values and accommodate those different values is a challenge, and although the examples used here to illustrate the problem with value incommensurability have been taken from the GM debate, there is no reason to believe that the challenge will be less with regard to nanotechnology. There are already some indications of similar tendencies in the regulatory debate on nanotechnologies.

Problems with hyping

Nanotechnology is at present one of the fastest growing segment in knowledge-based economy, a growth partly driven by promises of cheaper, stronger and more environmentally friendly processes and products. These promises have influenced innovation policy and strategy, and these promises have functioned as a means for attracting financing within both the public and private sector. Here hype becomes a problem, as these promises are easily oversold and may create unrealistic expectation concerning nanotechnology products. These expectations can be used as justification for financing, without a sober assessment whether nanotechnology actually provides the best means for solving the relevant problems, and also without analyses of potential benefits and opportunities as well as potential problems. The hyping of nanotechnology do also pose a problem for staging good and balanced public debates by creating a tension between the innovation policy for a technology and framing of a specific technological product, and the objective of organising a meaningful public debate.

As a consequence, the debate focuses on the end-product and thereby about unanticipated effects adverse effects as nano-toxicity. Although the hyping can be seen as an approach to increase acceptance for “nanotechnology” and by that evades the moratorium solutions seen for technologies such as genetic modification and xenotransplantation. In this respect, it is acceptable that some instances of nanotechnology is questioned and restricted based on more or less well-founded risk issues, as long as the general innovation process is not brought to a halt.

Problems with upstream public engagement

To facilitate more broad discussion to elicit social, ethical and legal implications it has been argued that it is necessary to arrange debates on future nano developments and that we should reduce the time lag, distance and power asymmetry between "upstream" and "downstream" innovation processes (Felt and Wynne 2007). This reflects the ongoing discussion concerning regulatory issues for new technologies, where one of the conclusions is that regulatory aspect should be subject to democratisation, and that this democratic discussion must be conducted at early stages. Joly and Kaufmann (2008) points out that:

> 'Upstream engagement' is now claimed to be a basic component of nanotechnology policies in various countries. 'Public engagement' is generally defined as a form of two-way communication between the public and those who have knowledge of, or power over, the particular issues at stake. 'Upstream engagement' means that two-way communication has to take place in the early stages of technological development and not only downstream, in the adoption phase.

Such upstream approaches depends on a conscientious dialogue with multi-stakeholders, were the intention is to address implications as well as the significance of uncertainty, for instance by asking questions about aims, purposes, controlling interests and conditions.

Proponents of 'open and upstream' debate point to the built-in ethics in technology developments, for which formally no responsibility is assigned. These normative choice processes should be opened up and influence the course of technological development, leading to shared collective responsibility or responsible development.

But there are sound reasons to ask whether upstream public engagement actually is unproblematic as solution to the problem of technology governance, as some seem to think. Delgado et al. (2010) has for example pointed out that by moving upstream it is difficult for grassroot groups to initiate locally grounded initiatives. Moreover that upstream engagement favours contextual experimentation in an invited form. Some critics, such as Tait (2009) is surprised that upstream engagement has been accepted so uncritically by the scientific community, given the lack of equivalent scrutiny of the assumptions, values and visions of those who have demanded it.

Table 3. Problems in applying upstream engagement to life sciences (Tait 2009)

At the stage of funding basic scientific research (timescale >15 years)	It is impossible to know, when funding of scientific research is being discussed, what the outcome will be. It is impossible to know what future developments will arise from the research and what their risks might be (ignorance of future outcome)
Developing innovative products or processes based on proven research outcomes (timescale >10 years)	Most of the ideas that seem feasible at this stage will fail. Innovation usually requires inputs from research in a range of disciplines (that might have been blocked or delayed by outcomes from other engagement initiatives)
Foresight	We are extremely poor at the long-range prediction of technology futures.

Wynne (2006) has some of the same concerns when he argues that moving upstream can cause the misinterpretation that research and development represent an linear and unidirectional process from innovation to the end product. One other important critique has been related to its failure to be open and participative (Levitt 2005), and that such engagement can be manipulated to achieve instrumental ends as legitimacy for technological innovations (Wynne 2006). But we must also take into account that there is a blind side of this critique in the sense that engagements can easily be too open and inclusive and therefore easily hijacked by interest groups. This was a common criticism of the large UK engagement exercise GM Nation (Coghlan 2003). It is obviously a need for social scientists and ethicists doing an interpretation and translation job in order to make sense of the arguments presented at upstream engagements. In this way it is better chance of these exercises having an impact on the scientists' self-reflection and thus contributing to a good technology development. If ELSA researchers take this role, they become intermediaries in the mobilisation of sentiment and reflection, a position that also entails responsibility for the STS researchers with regard to awareness of their own commitments (Williams 2006).

It is clear from the arguments in literature on different forms of public engagements, that upstream public engagement is a necessary but not sufficient ELSA contribution to nanotechnology development. Such engagement represents a way to access the concerns of those who will be the users of the new nanotechnology products, and will live in the environment where these products eventually will be released, and therefore they are key parts in the future nanotechnology society; assuming that we want a society where nanotechnology is an integrated part of human lives.

Engage public versus engage the scientific enterprise

We have analysed some crucial aspects of how ELSA scholar's different kind of public engagement research may play a role in affecting the course of events. This is not a full-scale discussion of the different methods or the particular results, but a generalised analysis of some of the strengths and weaknesses of the major types of public engagement studies. This analysis is based on a review of literature on different forms of engagement relevant to the emerging field of nanotechnology ELSA studies, leading to a general classification of such studies. The aim of the review was not to include all publications within this area, because that list would be outdated within short time. The aim was to include representative articles that could be used to illustrate the different themes and approaches (see Box 1).

Box 1. Classification of some central literature in the field of engagement studies

Typologies, models and/or strategies for public engagement in science

1. Public Participation Methods: A Framework for Evaluation (Gene Rowe, Lynn J. Frewer)
2. A Typology of Public Engagement Mechanisms (Gene Rowe, Lynn J. Frewer)
3. Organizer, observer and participant: What role for social scientists in different pTA models? (Gabriele Abels)

Theoretical discussions of public engagement in science (and especially nanotechnology)

1. Toward Anticipatory Governance: The Experience with Nanotechnology (Risto Karinen and David H. Guston)
   Nanotechnology, Governance, and Public Deliberation: What Role for the Social Sciences? (Phil Macnaghten , Matthew B. Kearnes, Brian Wynne)
2. Engaging nanotechnologies: a case study of 'upstream' public engagement (Phil Macnaghten)
3. Engaging with Nanotechnologies – Engaging Differently? (Tee Rogers-Hayden , Alison Mohr and Nick Pidgeon)
4. Meaningful Citizen Engagement in Science and Technology: What Would it Really Take? (Maria C. Powell, Mathilde Colin)
5. Strengths of Public Dialogue on Science-related Issues (Roland Jackson, Fiona Barbagallo, Helen Haste)
6. PEST or Panacea? Science, Democracy, and the Promise of Public Participation (David Demeritt, Sarah Dyer, James D.A. Millington)
7. Governing Nanotechnologies: Weaving New Regulatory Webs or Patching Up the Old? (Diana Megan Bowman)
8. Nanotechnology and Public Interest Dialogue: Some International Observations (Diana M. Bowman, Graeme A. Hodge)
9. Public engagement coming of age: From theory to practice in STS encounters with nanotechnology (Ana Delgado, Kamilla Lein Kjølberg and Fern Wickson)
10. Nanotechnology Governance: Accountability and Democracy in New Modes of Regulation and Deliberation (Monika Kurath)
11. Nanotechnology and Public Engagement: A New Kind of (Social) Science? (Sarah R. Davies, Matthew Kearnes & Phil Macnaghten)

Normative discussions (Why engage? What motivates public engagement in science, and nanotechnology specifically?)

1. Why Enrol Citizens in the Governance of Nanotechnology? (Alain Kaufmann, Claude Joseph, Catherine El-Bez and Marc Audétat)
2. Democratizing Nanotechnology: Intersecting the Philosophy of Science and Science Policy (Zachary T. G. Pirtle)
3. Avoiding Empty Rhetoric: Engaging Publics in Debates About Nanotechnologies (Renee Kyle and Susan Dodds)
4. Not again! Public perception, regulation, and nanotechnology (Sylvester, Douglas J, Abbott, Kenneth W, Marchant, Gary E)
5. Public engagement to build trust: false hopes? (Judith Petts)
6. Scientists' motivation to communicate science and technology to the public: surveying participants at the Madrid Science Fair (María José Martín-Sempere, Belén Garzón-García, Jesús Rey-Rocha)
7. Responsibility and nanotechnology (Elise McCarthy, Christopher Kelty)
8. Why Do We Need to Know What the Public Thinks About Nanotechnology? (Craig Cormick)

Models of engagement specific to nanotechnology

1. Lost in Translation? The Need for 'Upstream Engagement' with Nanotechnology on Trial (Pierre-Benoit Joly, Alain Kaufmann)
2. Replicating participatory devices: the consensus conference confronts nanotechnology (Brice Laurent)
3. Qualitative system analysis as a means for sustainable governance of emerging technologies: the case of nanotechnology (Arnim Wiek, Daniel J. Lang and Michael Siegrist)
4. Interpersonal Discussion Following Citizen Engagement About Nanotechnology: What, If Anything, Do They Say? (John C. Besley , Victoria L. Kramer, Qingjiang Yao, Chris Toumey)
5. Building citizen capacities for participation in nanotechnology decision making: the democratic virtues of the consensus Conference model (Maria Powell, Daniel Lee Kleinman)
6. Opening up nanotechnology dialogue with the publics: Risk communication or 'upstream engagement'? (Nick Pidgeon, Tee Rogers-Hayden)
7. Engaging citizens: The high cost of citizen participation in high technology (Daniel Lee Kleinman, Jason A. Delborne and Ashley A. Anderson)
8. Real-time technology assessment (David H. Guston and Daniel Sarewitz)

Engaging nanotechnology 'insiders' (downstream and midstream engagement and governance of/by the industry and practitioners)

1. Participatory Paradoxes: Facilitating Citizen Engagement in Science and Technology From the Top-Down? (Maria C. Powell, Mathilde Colin)
2. Midstream Modulation of Technology: Governance From Within (Erik Fisher, Roop L. Mahajan)
3. There is plenty of room downstream: Industrial dynamics and the governance of nanomaterials (Patrick van Zwanenberg, Ismael Rafols)
4. Missing links in nanomaterials governance: bringing industrial dynamics and downstream policies into view (Ismael Rafolsa, Patrick van Zwanenberga, Molly Morgana, Paul Nightingalea and Adrian Smith)
5. A Midstream Modulation of Nanotechnology Research in an Academic Laboratory (E. Fisher, R. Mahajan)
6. CSR in the UK Nanotechnology Industry: Attitudes and Prospects (Chris Groves, Robert Lee, Lori Frater, Gavin Harper)
7. 'Governing' nanotechnology without government? (Diana M. Bowman, Graeme A. Hodge)

Engagement of NGOs in nanotechnology governance

1. Nanotechnology in context: Science, non-governmental organisations and the challenge of communication (Janina Schirmer)

2. From Transmission toward Transaction: Design Requirements for Successful Public Participation in Communication and Governance of Science and Technology: Chapter 8, The Role of Societal Organizations and NGOs in the Dutch Debate about Nanotechnology (Lucien Hanssen)
3. Governing nanotechnologies with civility (Diana M. Bowman and Graeme A. Hodge)
4. What do civil society organisations expect from participation in science? Lessons from Germany and Spain on the issue of GMOs (Maria Paola Ferretti, Vincenzo Pavone)
5. Nanobiotechnology and Ethics: Converging Civil Society Discourses (Alexandra Plows, Michael Reinsborough)

Prior to project start we had identified two approaches and used these to classify the literature on engagement. The approaches are:

- ***Good science by engaging the public***: ELSA scholars engaging the public through deliberative arenas such as citizens juries, consensus conferences, open meetings, focus group interviews etc. In this way one can get an outsider perspective on the scientific activity, which may serve as a corrective to dominant techno-scientific ideals.
- ***Good science by engaging scientist***: ELSA scholars engaging scientist; like enhancing reflective capacity captured in the notion of midstream modulation (Fisher et al. 2006). Midstream modulation seeks to enforce the scientist's reflexive capacity to understand the social significance of scientific choices as well as their imaginative capacity to look for alternative.

It turned out that our literature survey to some extent confirmed our assumptions about the centrality of these two engagement groups, but we discovered that there are good reasons for further subdivisions. It is, for example, useful to classify engagement from NGO and pressure groups as a separate kind since they have power to enforce change. Still we will hold that a useful distinction within engagement studies is the one between public engagement and science group engagement, although the latter is less developed than the former

Admittedly, there are important distinctions between the purpose as well as the form of engagement exercised in public and scientist engagement exercises. Engaging scientist, as we perceive it, take the form of having a social scientist or humanist embedded in scientific workplaces, and thereby engaging the scholarly work of social sciences and the humanities. The common form of scientist engagement is longitudinal, following a project over time. In the midstream model, scientists are engaged in deliberation in order to stimulate their own reflection on the purposes of the project, its impact and alternative ways of doing this concrete project. The ultimate aim of the engagement in this model is to build reflexive capacities within scientific communities that in turn may influence the way scientific projects are conducted. The Human Practice model, developed by Paul Rabinow, is one of a few alternative experiments in scientist engagement. This is a more demanding form of engagement as the social scientist/humanist more actively engage the analytic capacities and repertoire of the social sciences and humanities (Rabinow and Benett 2008, 2009).

Public engagement is generally restricted in time, either to one or a restricted series of meetings. The aim of the deliberation is not for the public to see some particular point, but rather for the public to reflect on a general development or practice, usually in order to influence on the political regulation of the practice in question. In this case it is usually not concrete projects that are to be influenced but rather more general aspects of the science or its application. When the engagement is upstream, i.e. prior to or in the early stages of research, it is usually intended to influence on what kind of research should be done or the regulatory framework for this research, whereas downstream the target is primarily the application of the research in nature and society. Simplified, we could say that public engagement is usually up- or downstream, whereas scientist engagement is mid-stream, i.e. during the research process.

Even if there are these differences in the general tendency of engagement practices, the conclusion is not that scientist and public engagements are practices that differ too much and therefore should not be classified together. Rather, these engagement forms do belong together as complementary attempts to induce qualitative improvements of science.

Engagement needs for ELSA II

The point of engagement exercises, we suggest, is not primarily to ensure representativity in the same way as we want it in political surveys. There are sound reasons to say that we are seeking something different in public engagement, as for instance pointed out by Burgess and Tansey (2005):

> The point is to understand underrepresented or unarticulated perspectives, not to assign frequencies to well-articulated or pre-conceived perspectives. This form of representation in ethics requires substantive engagement with the values and meanings that may not readily be represented in the market or dominant culture, or in many approaches to public consultation or education.

Accepting this as a major purpose, the question is not primarily whether the participants are representative in a demographic sense, but whether their arguments are representative in the sense that we capture the important issues at stake. But we should be careful not to miss valuable input to the analysis by missing marginal groups when recruiting to the engagement exercise. When we focus on the range of arguments rather than demographic representation, the fact that people do change their opinions over time is not problematic. It is the public discussion and analysis on a sound argumentative basis that is important, not to capture particular stable opinions.

A similar point is valid for engagement with nanotechnology researchers. In engagement exercises with scientists and technologists, the aim should be to capture valid expressions of their arguments and other articulations of the implicit values and goals of their practices on an encompassing scale. Studying their practices and interactions may be as useful as interviews. In the following, we will discuss these engagement forms within a broader analysis of a new turn in ELSA studies.

Engaging socio-technical systems

Nanotechnology provides an arena for extending the policy oriented focus of engagement research. If ELSA studies is to make a difference for the course of events, for the way science and technology is produced and taken in use, this calls for both science internal and science external engagements, that will be referred to as the engagement of the socio-technical systems. We clarify the background for this shift or extension of the call for engagement activities (from public engagement to socio-technical engagement) by taking a closer look at the historic setting of nanotechnology ELSA studies – of what we argue represents a shift from ELSA I to ELSA II approaches. Nanotechnology provides an arena that focused the attention on ongoing technology assessments. Engagement research came in this setting to represent a solution to the challenge of ongoing technology assessment. This implied that all questions regarding the why's and how's of ongoing technology assessment became translated into research questions of proper engagement of socio technical systems. We acknowledge that this extension of the scope and rationale of engagement research have several roots, such as sociological and philosophical analyses of the role of science in deliberative democracies, but in this context our main focus will be the STS informed approach to engagement studies, which can be seen to contain three main elements. In the following we discuss this as we return to the three characteristic element of the ELSA of nanotechnology presented in the introduction.

Background for ELSA II

First, as the analysis of transformations in the science system (like in the analysis of the shift from Mode1 to Mode 2) became an integral part of established science policy of nanotechnology, a proper response appeared to be captured in the call for engagements to ensure socially robust knowledge production. This enforced a shift to thinking engagement in terms of supporting well functioning socio-technical systems rather than policy bodies. Second, the ELSA research on nanotechnology could build on experiences from the ELSA studies of genomics. A critique of professionalism of bioethics followed the experiences of ELSA I of genomics leading to a framing of the role of ELSA scholars as facilitators for engagements of relevant stakeholders. This role as facilitators are in turn marked by what engagement research is meant to achieve, discussed in the third and last characteristic element conditioning nanotechnology ELSA research. The nano-ELSA call appeared in times where nanotechnology was in its infancy that enforced a focus on the transitional nature of ethical evaluations of science and technology. As ethical judgements emerge over time engagement research may facilitate a more socially robust process measured in terms of ideals of procedural democracy.

We argue the role of ELSA researchers should not be limited to the one of facilitation, as we shift the attention of what is to be achieved by ELSA engagement research. The goals of engagement research, as we understand it, is to deliberate a viable ethos of socio-technical systems, implying recognition of some form of complementary division of labour among ELSA researchers. The varied academic background of ELSA researchers that have appeared in the context of nanotechnology is an important resource for the field. The challenge is to find constructive venues that bring the different disparate ELSA communities into mutual cross-fertilisation, which has been strongly emphasised to be a necessity in the field of nanotechnology ELSA research.

Our account of what we consider to be the main elements of the ELSA I to ELSA II lead forward to our vision for ELSA II (for overview see Table 4).

Table 4. Research challenges relevant for ELSA II

Questions, topics and challenges for ELSA II, given the lessons of ELSA I	
Ethical Issues	How to identify good, pertinent ethical questions? Who are in a position to do so?
ELSA scholars' role in technology development	Avoiding harm or effecting good Negative and/or positive ethics Facilitate engagement or participate in substantial engaged debates.
Early ethics and procedural focus or late ethics and engaged human activities and practices	
Take part in the process of shaping science: new dimension to integrated ethics	
The challenges of nano-ELSA, that possibly could be said to have a novel character, follow from the role ELSA scholars has to play as responsible co-constructors of the emerging field	
Issues concerning engagement as part of ELSA research	
Who to engage	Engaging general public Engaging core expert group Engaging wider scientific community
Who are the engaging ELSA scholars	Social scientists Humanities researchers Natural scientists
Why engage	Democratisation of S&T Stakeholder involvement in policy process Ensuring political legitimacy of the research and its applications Transferral/sharing of responsibility Ensuring a wide range of perspectives on the research In order to deal with risk In order to handle ethical and social implications In order to enhance quality

What to engage with	Opinions Arguments Values – the ethos

Engagements and the analysis of socially robust knowledge production

We have in the last decades witnessed a shift in prevailing conceptions of science. Michael Gibbons and his colleagues (1994) suggested we should speak of it in terms of a shift from Mode 1 to Mode 2. This shift could imply a shift not only to discuss scientific quality in terms of robustness within the walls of the laboratory but also in a contextualised application setting, captured in the notion of socially robust knowledge. They aimed at analysing what they in their introduction to *New production of knowledge* called "trends" seen in the work of a minor group of working scientist - trends that nevertheless should be taken seriously as these communities were recognised as leading the "frontiers" of science.

The influential analysis of Mode-2 conditions does not only pretend to be a descriptive analysis of changes in means of knowledge production where the industrial, academic and political activities are being reorganised with respect to each other. It is also an analysis reflecting a process of "Re-thinking Science" as it in Ziman's terms has reached a "post-academic" stage or increasingly marked by post-normal research conditions (Ziman 2002). What once was analysed as vague trends in science, and attempted captured in various terms like mode 2, post-academic or post-normal research conditions, seems to have become part of official discourse on science ten years later, as nanotechnology appeared at the frontier. The social and economic context of science is for instance presupposed in the EU report on the transformative powers of modern science: "Convergent technologies – shaping the future of European societies (Nordmann 2004)".

Mode 1 is, in our understanding, a placeholder for what usually has been identified as science, including traditional ideals for and professional identities underlying established divisions of labour. Mode 2 would in turn comprise ideals yet to be articulated in light of how scientific activity has been transformed which itself need to be researched. The cognitive content and embedded social norms of Mode 1 would in this perspective not necessarily be fully clear even for the ones that are committed by the Mode 1 conceptualisation of science. This content may be seen as attempted articulated in various discussions in the Nineties on the so called social contract between science and society.[1] The notion of social contract situates science in a social context underlying the established ideals often discussed as “the linear model” or expressed in terms of ideals of sharp institutional and conceptual boundaries between politics and science. A normative diagnosis, we suggest, generally motivated these attempts to articulate the commitments that are underlying the contract. Gibbons et al. (1994) indicate in their introduction that better analysis is needed in order to clarify what part of the trends are “good and to be encouraged, or bad and resisted”. The social contract may not serve the purpose it is designed to do, namely to unleash the powers of science while simultaneously preventing abuse of power. Mode 1 then contains norms and commitments that partly have been taken for granted and sustained in established practices, conceptualisations and professional identities, norms and commitments that now nevertheless have been put in question. Articulations of the terms of the social contract, or mode1, normal or academic-conditioned science, are articulations of prevailing norms and commitments that in turn makes it easier to discuss them.

The alternatives to Mode 1, as they appear in the literature in various forms (like Mode 2, post-academic or post-normal conditions), emphasise the eroding of traditional boundaries between scientific, technical and political activities. These analyses have to a varying degree both descriptive and normative elements as they emphasise that more individuals and institution have come to be part of contemporary forms of knowledge production leading to a discussion of how this participation should be moderated in terms of engagement activities. In this setting, one may talk of engagement of the bits and pieces that make out the socio-technical system within a perspective understanding science and society as coproduced. Technology assessment needs to take place in parallel with the process in which technology is produced.

[1] Guston and Keniston (1994), Lubchenco (1997), Gibbons (1999), Demeritt (2000) and Gallopin et.al. (2001).

The critique of professionalism and ELSA researchers' role as facilitators for engagements

The ELSA of nanotechnology appears against a background of a fifteen-year long learning process since the first ELSA programme was launched in the US. Experiences from this ELSA programme are important because it was a large programme that also sparked a lot of debates on how the ethics of science should be done. The goal of this programme was "to anticipate problems before they arise and develop suggestions for dealing with them that would forestall adverse effects". Projects funded by the programme, focused on topics like how to handle surplus information on gene testing, genetic counselling, genetic research involving humans as well as public educational programs. The human genome project sought knowledge about our genetic inheritance, and the ELSI component of the project focused on positive potentials as well as possible negative side effects of such increased knowledge, with the aim of providing better knowledge basis for policy (Meslin et al. 1997).

During the first 13 years 125 million ELSI dollars had been allocated, having a considerable influence on the field of bioethics in particular and the field of doing applied ethics in general (Genome Biology 2003). During the first ELSI period the attention was drawn to the question of what it means to include ethics into a scientific programme. In hindsight, there are reasons to question to what extent this inclusion of professional ethicists is the best way to handle the challenges of new technologies. Many, like Langdon Winner in his often cited talk in the U.S. House of Representatives in 2003, are concerned with how ELSI of genomics sponsored the building of bioethics as a professional field in its own right, and argue that this should be avoided in the field of nanotechnology:

> Although the new academic research in this area would be of some value, there is also a tendency for those who conduct research about the ethical dimensions of emerging technology to gravitate toward the more comfortable, even trivial questions involved, avoiding issues that might become a focus of conflict. The professional field of bioethics, for example, (which might become, alas, a model for nanoethics) has a great deal to say about many fascinating things, but people in this profession rarely say "no." (Winner 2003)

This critique concerning a professionalised ethics of technology is implied in an often quoted statement of the ELSI initiative as amounting to a “Full Employment Act for bioethicists”(Schrage 1992) It is obviously that to be employed by the same institution may cause a problem if the role one is given is to give a critical corrective. If they criticise the fundamental assumptions of the institution, they undermine their own future employment, and few people are willing to do that. In addition, they gain knowledge of the technology and are often immersed in the same culture as the technologists, and therefore easily come to share a range of the values that drive the technology development, perhaps making it difficult to keep a critical distance.

The problem that became apparent here was the question of what the good and pertinent ethical questions were, and who were in the right position to articulate them. As Francis Collins came in charge of the human genome project he stated in an interview that “we’re going to shift our emphasis more in the direction of topics that we know we need people to work on”, indicating that the ELSA communities at least needed some corrections (Genome Biology 2003), in partial agreement with Winner’s claim that ELSA research had tended to gravitate towards trivial scholasticism that hardly made a difference for the course of events at all (Winner 2003). Thus, both Collins and Winner drew attention to the question of who “we” were that were in a position to know what was needed and able to make a positive difference.

The worry of professionalism may also concern the issue of timing. The goal of the Human Genome Project to “forestall adverse effects” suggests that bioethicists take on the traditional professional role of the scientists: Ethicist should produce knowledge with the aim to inform policy at the stage of application, where ethics have a legitimate place.

Ethics then, appeared as something external to science, or as Ziman (1998) expressed it, assuming a “no ethics” principle of science. A professionalised ethics community stood not only in danger of coming to late, but also masking the immanent ethics of science inherent in the messy process where courses of science and society are formed. One could object that these two lines of criticism are incompatible with one claiming that ethics is too close to technology, while the other claims it is too much of an outside activity. But it is possible to be too involved in an economic and social sense while still being insufficiently involved with respect to the most important issues. This generalised critique does not necessarily hit the target when it comes to the particular projects, but there are good reasons to question to what extent the model for ethical and political research developed by the Human Genome Project and adopted in many countries after that, has been an adequate approach to the challenges raised by emerging technologies in modern democracies. Even if these criticisms are only partially correct, they provide us with reasons for exploring alternative ways to deal with the ethical and political challenges raised by emerging technologies such as nanotechnology (Maclean 1993).

ELSA research on nanotechnology set an arena for STS scholars to explore normative lessons of STS studies based on the insights gained during the Eighties and Nineties - a period where empirical investigations of scientific knowledge production dominated STS research (Galison (1987), Latour and Woolgar (1986), Pickering (1984), Rheinberger (1997), Knorr-Cetina (1999), Fujimura (1996)).

These studies emphasised the materiality of science linking the peculiar ordering powers of science to the laboratory as a stabilising working unit. In exploring implications of the societal aspects of this stabilisation process, notions like – "speaking back" or "democratisation of science" gave substance to a return to political matters that have been one of the driving motors of STS research: the criticism of the hegemony of science – in what David Edge (1995) referred to as carried by the "received view". David Edge worried about STS insights not being taken into account following the constant re-discovery of the problematic social status of science and technology.

The central tenets of STS studies should now be possible to put into practice in nanotechnology ELSA initiatives. Knowledge is shaped over time and includes the formation of material and social structures which challenges established distinction between scientific and political activities, and moreover, the science enterprise have an open ended character and are formed in unpredictable ways. Given these perspectives, it seems to follow that ELSA scholars should: a) Recognise the difficulties of forestalling and conduct an informed discussion of ethical problems of future science and technology developments, b) Be oriented towards facilitating a just, reliable and morally accountable process where technology is shaped, and c) Pay attention to the way patterns of action for citizens will be framed by the socio-technological systems being formed.

Based on these ideals, the role of the ELSA scholar could be seen as the one of facilitating enrolment of stakeholders through engagement activities.

In clarifying the lessons of the first ELSA projects, one should not forget that the field of bioethics could itself be seen as born out of a worry of professionalism. Steven Toulmin's (1982) telling title "How medicine saved the life of ethics" is a story of how pressing topics of medicine forced ethicists to demonstrate the relevance of their profession in terms of how they could contribute to better understanding and handling of the ethical challenges of modern medicine. Applied ethics/bioethics then, also represents a field that have gained valuable experiences in contextualising science and inducing reflexive processes in the organisation of science. The key entry point for applied ethics, one should keep in mind, was obvious ethical challenges that had no obvious solution (abortion, in vitro fertilisation, stem cell research, euthanasia etc). These questions called for research and interaction across disciplines, and therefore came to challenge the ethicist's theoretical apparatus and methodological approach given the challenge of interacting with medical and biological expertise, stakeholders and contributing to the public debate. Pertinent ethical questions conditioned the arenas for interdisciplinary cooperation, which arguably fostered interactional and reflexive capacity of biomedical communities of a kind not seen in other fields of natural science. The rise of bioethics did not merely change the focus of moral philosophers and theologians, it also turned a significant group of physicians and other health professionals towards systematic ethical reflection.

The rise of professional ethics in Norway is also an interesting and illustrative case. There were a handful of philosophers, theologians and physicians doing research on theoretical and applied ethics questions, especially within medicine, from the Sixties until the mid-Eighties. Then the Research Council of Norway established the Ethics Programme in the early Nineties with the explicit goal of stimulating Norwegian ethics research, both theoretical and applied. To avoid the idea of applied ethics as merely the application of theoretical knowledge, they distinguished between basic ethics and "area" ethics, i.e. the ethics of a particular problem area or research field. The programme wanted to train people with professional competence in theoretical ethics as well as researchers with different disciplinary backgrounds in order to gain "double competence". "Double competence" meant having PhD-level competence in their professional field as well as in ethics (Stephansen 2006). The initiative supported a conception of ethics as belonging to a wider range of human practices and enquiries, not as part of a particular discipline such as philosophy. Still, philosophers dominated the Programme board and philosophers conducted the majority of research projects.

By and large it is not precise to say that this research programme stimulated interdisciplinary research, but it did foster interdisciplinary dialogue and opened up the possibility of new forms of research drawing on different kinds of competence. Some of the researchers, either with science or with social science/humanities background funded by the programme, did research on topics within interdisciplinary areas[2]. Due to the focus on normative ethics, a substantial part of the research funded by the programme was within theoretical ethics and political theory. The research within interdisciplinary ethics included media ethics, environmental ethics, medical and health care ethics and ethics of different areas of science and technology, such as nuclear power and genetic modification. The research within these areas was dominated by case based approaches, drawing up concrete dilemmas and problems calling for concrete political solutions through regulation.

The first ELSA programme in Norway followed a few years after the Ethics Programme and can be regarded as its offspring. The programme research topics were restricted to biotechnology, widely conceived, and the programme board and administration cooperated closely with the research programme in functional genomics - FUGE. The latter programme used approximately 5 % of its funds on ELSA projects. The research projects funded by the ELSA programme were led by researchers from a broad range of fields, such as philosophy, anthropology, theology, sociology, political science, psychology, law, biology and biotechnology. There were normative and descriptive projects, as well as some transcending this divide. Several of the projects were genuinely interdisciplinary, although few could be described as integrated projects. Still, some projects funded by the ELSA programme or by FUGE were carried out in more or less

[2] For an overview over projects funded by the program, cf homepages of The Research Council of Norway.

close collaboration with research groups in biotechnology, and can be classified as partially integrated. Some of them drew important inspiration from STS research, and can be classified within this tradition.

The overall impression is one of pluralism in approach and disciplinary background. Despite this pluralism, ELSA research still could be charged with being dominated by what we can call *the ethics of restriction*, where dilemmas and normative problems served as entry points for research. This is partly because such problems have been the entry points for the invitation to participate: pertinent ethical questions calling for answers. But common for such approaches is that the dilemma is already present. Whether the issue is biobanks, stemcells, new reproductive technologies or genetically modified food, we know some applications and have a sound basis for a more or less accurate projection of the future development of the field. Therefore it is reasonable that the focus has been one of restriction, in the sense that we ask which instances of these technologies are wanted and should be further developed, and which are harmful in one sense or another, and should be subject to close scrutiny and restrictions. The nano–ELSA creates a challenge compared to this established ethics research, as the early call for ethics prior to well-founded knowledge of different applications and their impact, implies a shift of focus to a constructive positive ethics.

The critique of professionalism then includes two strands with different lessons for what the professional role of ELSA scholars should be. One strand of critique, discussed under the heading of applied ethics, are concerned with the pitfalls of analysing normative aspects of technology detached from the context within which it is appreciated or resisted. Another strand of critique, discussed under the heading of STS, are concerned with the pitfalls of restricting normative analysis to a narrow core group of experts, calling for the need to factor in a wider range of perspectives and arguments.

Both strands articulate a critique of the analysts taking on a distant disengaged analytical professional role. The analysts need, as argued in both strands, to be informed by the sciences and engage in questions of desirable technological pathways. Where the two strands tend to differ; it seems, concerns the question of what they understand as their core expertise, what they bring to the table. The applied ethics strand seek better ways of getting hold of normative issues, articulate what is at stake in disagreements, scrutinise moral claims or moral intuitions and possibly suggest solutions to moral issues. The STS strands seek better understanding of social and material organisations, identify and analyse why some groups dominate the course of event and search for ways of including perspectives and concerns not taken into account.

The role of both strands may be discussed in light of an overall goal of facilitating a more inclusive and robust democratic process. If the primary deliverables of the STS strand is seen as the one of facilitating due democratic procedures based on social analysis of the dynamics of the sciences in question, the applied ethics strand focus can be seen as the one of delivering substantial input to the deliberations that needs to take place in the social arenas being studied. The respective objectives of the two strands are difficult to separate. In order to facilitate a more inclusive and democratic process presupposes some sense of what is at stake and what the good and pertinent ethical questions are. Such normative analysis needs in turn to rely on social understandings of what is affected and being affected by the research being studied. Three fields of expertise intertwine here, the normative and cultural analysis of the humanities, the empirical and structural analysis of the social sciences as well as the technical and scientific knowledge of the research field in question.

Transitional ethical evaluations – ongoing ethics

This brings us to the third element of how and why nanotechnology came to constitute a novel challenge for ethics. Ethics were to enter at a stage where there were no ready-made science to discuss. The call for nano-ELSA studies was raised at a very early stage of the development of the field. The various national research policy documents that appeared in many countries (e.g. EC Sanco 2004; Nanoforum 2004; The Royal Society & Royal Academy of Engineering 2004), identifying nanotechnology as a crucial strategic research area, also argued the need for discussions of ethical questions raised by these potentially powerful range of technologies. The argument was that if nanotechnology really has the transformative power its proponents promised, some of the massive investments in the field should be reserved for scholarly reflection on the ethical and societal impacts of the field. This research could not be limited to questions of side effects that where to be avoiding in the context of application. Radical social transformations also called for democratic deliberation of the priorities involved in, the directions for, and the desirability of, such transformations.

The expectations for ELSA research appear to have shifted in this situation as the research to a larger extent where expected to make a difference for the course of events, of ongoing "real time" technology assessment. This focus on transitional evaluations that followed from the high expectations of radical social transformation by nanotechnology appears to have, possibly for the first time, put the scholarly STS tradition at the centre for normative analysis. The methods and theories of the constructivist approaches of STS, one should expect, provide a promising platform for dealing with the questions of how science and technology developmental processes should be moulded. The STS tradition have been situated at the centre of Nano-ELSA also because of the field's theoretical analysis of socio-technical systems having resonance in various other overlapping analyses of the need to enforce socially robust knowledge production, captured in slogans like society "talking back" or science being "democratised".

Engaging scientists: review role of ELSA scholars in engagement

Technology development can be seen as a process that involves diverse groups of actors with different degrees of proximity to the technicalities of the development process. Closest to the technicalities are those scientists, technologists and technicians who work in the laboratory. They make out the core group of a particular instance of technology development. In the case of the development of nanoparticle delivery of fish vaccines for instance, the group consists of a few researchers with competence in fish health and specific branches of biotechnology, that have cooperated with researchers who have competence in making and using suitable nanoparticles. Connected to this group are researchers who do research on fish vaccines, immunology and in biotechnology. Further from the core of this research project are other nanotechnologists and biotechnologists, marine biologists and expertise on other aspects of fish farming. These take different expert roles, and may therefore make a crucial difference for the course of events of the fish vaccine project. One may get a wider picture of who affects (or could have affected) the outcome of the vaccine project by taking a closer look at the contingency of the involved financial structures, institutional organisation and collaborative structures. A full picture of the dynamics of such a project would not be given without paying attention to how material constraints temporally unfold in course of the research process.

This type of analysis of a projects development is one of the kinds of analysis a trained STS scholar would typically present. It is a constructivist analytical approach developed mainly through numerous laboratory studies, which in turn provide an important background for understanding STS ELSA approaches.

By studying the core group of scientists involved in a specific technological project, the surrounding expertise along with the accompanying social, institutional and material contexts it is possible to get a better understanding for the dynamics of actual research process. Such understandings could in turn be important tool for science policy. However, once such analysis is conducted, it may already actually be too late for policy regulative intervention. The nature of research, following these constructivist analyses, is open ended. The work of understanding research process then, needs to come alongside the work of deciding pathways of research developments.

As research is considered as an open ended process where socio-technical systems are constructed, the ELSA research of nanotechnology needs in this perspective to be seen as an integral part of the nanotechnology strategy. The focus of attention of the research challenges identified as ethical and political shifts or rather it is broadened. It is not only about the need for a well informed and engaged public, or well informed and well functioning political bodies. It is not only about engaging sectors of the civil society in order to enable society to "speak back" and shape the trajectories of the work of core technological communities. As the focus lies on how research is actually governed, how socio-technical trajectories are actually shaped, the focus of attention for science policy issues is broadened. It is not only the public and public bodies that need to be engaged, but also scientists and scientific bodies.

The understanding nanotechnology being a potentially extremely powerful engine of societal transformation appears to be part of the notion of nanotechnology. Expectations of catalysing changes comparable to the a next industrial revolution are part of what Ashley Shew and Davis Bird identify as the 'standard story' of what nanotechnology is and why it is worth pursuing (Shew 2008; Shew and Bird 2004). Given this, the claim that we need to "democratise science", or at least a need to counteract a possible democratic deficits, appears to be less controversial in the context of nanotechnology than what has been the case elsewhere.

Such calls for democratisation, or in the weaker form; worries of existing democratic deficits, express or presuppose a normative diagnosis of current state of affairs. This normative diagnosis is reflected in the way engagement research is targeted and designed. Now we are returning back to the case of nanoparticle vaccines since we can again use it as an illustrative case. Nanoparticle vaccines have the potential of affecting one of the most important export industries of Norway, namely aquaculture. Worries of democratic deficiency express a worry for the legitimacy of the process in which a successful research is conducted and eventually translated into an industrialised context. As in our case, aquaculture is a growing industry in Norway, where the development of good vaccines are necessary to avoid diseases, increase fish welfare and ensure workplaces and economic profit. One of the main challenges becomes then to find the best arenas for engagement that may foster discussions and contribution to the normative and societal reflection that is a necessary part of the technology development process. Latour (1983) describes the laboratory as a crucial arena for social transformation in tone of his most influential articles "Give me a laboratory and I will raise the world". But obviously, not every laboratory manages to raise the world. Core sites for crucial developments are hard to predict although possible to identify in retrospect. On the contrary, most laboratory work can hardly be argued to be a leveller of social change. Even if one recognise the social transformative powers of research, the questions of how, and where to engage in the scientific enterprise remains a challenge that has become a research topic in its own right that have been enforced in context of nanotechnology.

One of the crucial difficulties concerns the way scientific and political issues are mangled, to use Pickering's metaphor (1995), in course of the research and development process. The challenge of scientists working at universities and commercial companies may be sincerely focused on a the pursuit of generating better understanding of technical and natural processes in order to deliver the social and commercial benefits that the research seems to promise, like a novel fish vaccine. Even if they are, such pursuit is not apolitical. Technology, viewed as an isolated artefact is in itself not good or bad, but viewed in context of the socio-technical systems that makes it possible, can hardly be seen as value neutral. Regardless of the intentions behind a research project or research field, the resulting product, process or knowledge can be employed in different ways. In some cases the use is good, for example materials that are strong and flexible for safer and lighter construction work, and in other cases the use is weapons serving to destroy or subdue innocent people. But regardless of good and bad intentions and motivations of the users, the actions of the technology is always mediated and maintained in and through a socio-technical system. Technologies need to be distributed, sold, repaired, fuelled and so forth. The ethical-political concern of a technology is in complex ways entangled with the epistemic and ontological concerns of what the world allows and how the world need to be organised in order for the technology to thrive.

Some research and development project eventually lead to well developed socio-technological systems that radically change our way of life. Modern communications technologies may even have changed our lives in irreversible ways. Even though it has proven difficult to foresee such changes foresight studies may play a role in the work of creating a better understanding and articulation of the visions and values embedded in current research strategies. Some effects may not be easily detected when doing research but which may nevertheless arise due to limited framing of risk assessment or due to the complexity of the environmental systems it can be released into. A series of engagement research are directed towards affecting the research processes. There are several related approaches to this kind of engagement exercises that are presented in Box 2.

Box 2. Different approaches for engagement of scientists

Technology assessment

Technology assessment (TA) is a collective term that goes back to the 1960'ties and comprises a wide range of approaches that included ethical and social concerns in evaluation of technology (van Est and Brom 1997). TA aims to bring to the table broader issues than instrumental propositional questions like how we can achieve more and faster innovation or identification of what the risks involved are. Analysis of modernity, like the one provided by Anthony Giddons (1990), Ulrick Beck (1992), or Bruno Latour (1993), often form a background against which the rationale for TA is explained. These analyses substantiate a call for institutional responses that may enhance reflexive capacity within the enterprises of technological innovation of modern societies. The National Committees for Research established in Norway in the 1990'tes may be taken as examples of bodies that are to take measures to enhance the integrity of research, to ensure deliberation about the scale and speed of innovation, and also about its directions, its purposes as well as the different normative questions concerning who owns and controls the process, and for whose benefit it will be pursued. Hence, TA can take many forms that may be seen as ways of engaging various parts of the scientific enterprise as it has become.

Constructive technology assessment

Constructive Technology Assessment (CTA) is one of the most developed methodological platforms of TA, a method that originated in the STS communities in Netherlands in the Eighties. The aim is to contribute to a constructive modulation of technological system at a stage where it is still possible, but yet not too early. The aim is not primarily to forestall negative effects, but to make the research innovation agenda able to reflect the priorities of the society or of the authorities. The idea behind this approach is that management of technology is a shared responsibility, not limited to the scientific-technical community. The purpose and shape should be identified, specified and deliberated by a broader public. By creating different venues of engagement (like workshops, conferences) CTA aims at the construction of a viable and desirable path for technology development by putting focus on design, development, and implementation processes that is widely agreed upon, thus shaping the technological future (Schot and Rip 2007). Constructive TA approach has been developed and validated in the TA NanoNed program (http://www.nanoned.nl/)

Real time technology assessment

Real time technology assessment is a TA strategy of a research centre in Arizona, mandated to seek integration of nanotechnology research with research on societal, ethical and environmental concerns. The strategy comprises a vision for "anticipatory governance" that, like CTA, expresses the need to enhance capacities in order to manage emerging orders. The research vision seeks unity along three axes, analysis of present and future research and innovation systems in order to enhance capacities of anticipation (foresight research) as well as building reflexive capacities outside science (through public engagement), and inside science (through efforts of integrating the research of the social science and the humanities). Foresight research plays an important role in the vision for anticipatory governance, but it is not to be understood as attempts to predict the future so that actions can be aligned accordingly. It is rather a way to put emphasis on the need to discuss technology as it emerges. Foresight studies may involve efforts to develop future scenarios or study analogical cases of previous innovations and use this to anticipate future interactions between society and new technologies. It may involve mapping the resources and capabilities of the relevant technological initiatives in order to identify research and development trends, major participants and their roles, as well as organizational structures, assumptions and relations (Guston 2010).

Foresight exercises

Foresight exercises are widely used and generally aims at providing visions of the future to explore effective strategic policy (von Schomberg 2007). For instance, foresight framework that encompasses a checklist of pre- and post-release assessment needs can be used to ensure that precautionary and ELSA strategies are integrated as early as possible in a technological project. The purpose is to improve technology development, and produce more sustainable and sound conclusions that relevant actors will have confidence in. Hence, foresight knowledge has an action-oriented perspective by identification of threats/ challenges/ opportunities for a particular technological project.

Soft law and codes of conduct

Soft law represents one way to utilise the lack of information with regard to risk and other ethical issues that is available for researchers at an early stage. Soft law and a pragmatic take on precaution may be particularly useful when the governance focus is shifted upstream. The "Code of conduct for nanoscience" (CEC 2008) represents an example of soft law that includes the principles of precaution, accountability, inclusiveness, meaning and sustainability. Such codes of conduct may function as a way of organising and deliberating collective responsibilities (von Schomberg 2009).

These forms of engagement activities have enriched the verities of ELSA approaches. It is not only a about stimulating reflective awareness in order for researchers to be able to communicate some of the issues at stake to the general public or enable the scientists to reflect on the conditions they perform their research under as well as the choices they make. It is also about enhancing deliberation on the course of action of all stages of the development process that leads to the context of the end user in ways that for instance will realise the expressed deliverables promised to and endorsed by public bodies.

The ELSA field then has developed from different roots and consists of a wide range of approaches today. Some are explicitly normative, including those related to action research (Reason and Bradbury 2001), while others are descriptive. Some are theoretical, analysing normative challenges or hypothetical potentials of the technological practices, others are empirical, studying the laboratory work practices or the way people conceive of the new possibilities and threats arising from technology research. Some engage with the technologists and work integrated within the research projects, whereas others study the outside, the societal responses to the projects or their applications. Some focus on the risks and uncertainties, others deal with the overarching values within the scientific practices. A large number of research projects are combining different methods, and normative aspects are taken up in sociological approaches and empirical data are used as material for ethical analyses.

We believe the richness of the field is important and should be nurtured. Some will hold that we should prioritise analytical ethics, while others hold that STS research captures the essentials, but there is little evidence supporting such restrictive approaches. The same goes for those who think we should pursue only integrated projects or those that argue ELSA studies should remain independent, because integrated research will lead to problems with loyalty, conflicts of interest or even corruption. We believe that there are sound arguments for all approaches, the plurality is important in order to avoid obscure research with poorly asked research questions, inconsistent frameworks or shaped by unreflexive ideological presuppositions. Therefore we need the whole spectre of different approaches and to seek ways of constructive interaction in-between them. Nurturing such diversity however will create challenges of fair quality control and a well-functioning peer review system.

The ELSA of nanotechnology could be seen as a test case for how proper ELSA research could be organised. ELSA research on nanotechnology could be considered as a model system for discussions of how to handle other such technologies, for example synthetic biology. We propose a measure for such a test. The wide range of international exercises and initiatives should, in our proposal all be considered in light of the same aim; at contributing to the same goal of instigating a socially robust development of socio-technological systems. We now are in a position to assess and critically evaluate the success of the various approaches, including an analysis of their obstacles, problems and future potentials of interaction with other approaches. Such critical evaluation is required so as to identify weaknesses, build strengths and create new alternatives where required. Even if we argue that research pluralism is necessary in order to gain knowledge and critically evaluate various approaches, of the ELSA field, we hold that a variety of approaches constitute a kind of core approach to ELSA research as far as the goal of ELSA is understood as the one of engaging what we in the following will describe as the ethos of socio-technical systems.

Ethos of socio-technical systems

In our account, nanotechnology has for various reasons come to provide an arena for a rich variety of approaches. We have organised a discussion of this variation under the heading of engagement, arguing that the context of nanotechnology accommodates an extension of the scope of engagement following an extension of who is targeted as the communities to be engaged. Efforts to develop modes of public engagement arose in part out of a critique of public educational programs that run under the heading of Public Understanding of Science. Communication and learning needed to go both ways. Efforts to develop modes of engaging the scientific enterprise (like working scientists at the laboratory floor or at an institutional level of science) affect a shift in the understandings of science policy. It is not only a matter of moving upstream, or of society talking back in order to improve science policy, it is also about engaging and improving the work of science from within. What we have, we propose, is a shift from public engagement to engagement of socio technical systems.

We suggest that the notion of ethos of a socio-technical system may express a metric of the generated outcome of all these engagement efforts. In order to argue the case we will in the following focus on the STS tradition that fostered the notion of sociotechnical systems. We believe we might as well have worked our way from other points of entrance to what we propose to be a synthesising umbrella perspective for ELSA studies. This point of entrance allows us to focus on what we see as a crucial feature of the shift, or widening, of the focus from public engagement to the engagement of socio-technical systems. At stake is the relation between the two basic normative concerns, the epistemic on the one hand and the ethico-political on the other hand.

One of the remarkable features of the ELSA of nanotechnology is the way STS scholars have come to be mandated to play an important role in science policy. STS communities have during the last decade been confronted with the problems of producing constructive deliverables for science policy. The field has, however, not to the same degree faced the expectations of having important normative contributions to offer. In course of the development of the STS field in the 1980s and 1990s, its proponents tended to bracket off normative questions. One crucial explanation for this avoidance concerns the way STS scholars came to undermine the crucial distinction between the technical and the social. The blurring of this distinction implied a critique of the way both epistemic and ethical-political normative issues had been identified and scrutinised by previous scholars. The question of normative implications of STS understanding of the dynamics of science and technology developmental processes has from the very start been a recurrent topic in the external as well as internal criticism of dominating perspectives of the field (Jasanoff 1996; Radder 1992).

The challenge of restoring normative perspectives in the field of STS is also a challenge of the overall goal of ELSA studies, it relates to the joint work of rethinking the two normative discussions, theoretically and methodologically. This challenge then, should not be understood as an STS specific challenge, but a challenge to be worked out in the broader context of nanotechnology and other emerging technologies of modern contemporary science. The STS history, however, may provide a point of entrance to a discussion of joint cultural challenges.

Revisiting basic assumptions – the epistemologically modelled ethics of the representational idiom

A recurrent topic regarding defects of dominating STS approaches concerns the critique of the fields methodological downplaying of normative questions. How are normative issues to be resolved and what is the role of the field's practitioners? This has recently become more pertinent as STS scholars have to an increasing extent been enrolled and empowered as they find themselves in position of being the relevant expertise to be consulted.

Developments within STS are often described in terms of "turns". The notion of "turns" suggest some centre of rotation for these turns - one distance oneself from something and move on further by means of yet another turn. If there is some characteristic feature of STS, Steve Woolgar (1991) suggested in his contribution to *Science as practice*, it is the field's capability to correct itself and move forwards through a series of "iterative reconceptualisations". This notion indicates an internal dynamics of the field where the practitioners of the field, based on recognition of the defects of their position, find themselves from time to time revisiting their basic assumptions.

Currently, we are in a situation where we need to revisit basic assumptions, and more specifically, the significance of understanding STS as a field opposing the epistemological tradition. Canonical STS works often have reference to the unfortunate barriers being created by classical epistemology. For instance, *Laboratory Life* was often misread, Latour and Woolgar observed, because it was read as a book about epistemology. STS literature seems however not to have paid enough attention to the philosophical literature criticising the epistemological tradition (Latour and Woolgar 1986). The approach of Charles Taylor is particularly important here because he provides an alternative to a classic philosophical distinction between theoretical and practical aspects of phenomena. His attempts at overcoming this distinction is not unique within philosophy, building on the insights from Hegel, phenomenology and hermeneutics, but he has demonstrated the relevance of this approach in light of social, cultural and scientific changes of the Twentieth Century. A Taylorean re-description of the basic assumptions in STS research provides suggestions for an understanding of what may constitute a normative centre of rotation of STS studies' series of turns. The goal of such a re-description is not to represent, or nail STS research down as a specific something, but to articulate another theoretical or methodological platform that in turn needs be tested in terms of what follows from studies committed to the methodology being prescribed.

Taylor's critique of the epistemological tradition is based in his normative diagnosis of how the representational account of knowledge have come to be an unfortunate barrier for normative approaches in general in Western societies. The epistemological tradition has become an integral part of ideals being embedded in the practices we live by in these cultures. Taylor (1984) claims in "Philosophy and Its History" that the epistemological tradition needs to be seen as part of the background that has staged the discussions of the point or worth of various practices. Classical epistemology has simply become an integral part of the way we have come to organise western societies.

Taylor searched for the historical contingent origins of the epistemological tradition in order to retrieve what truths it once articulated. The exclusivity of the epistemological model, in Taylor's words, exposes a "forgetting" of why the model once appeared as "an important polemic instrument in the establishing of new forms of scientific thought, and technological, political, ethical practices". In general, Western legitimising discourses tend to be "epistemologically model", in Taylor's words. The forgetting implies that the epistemological model does not appear *as* a normative model whose organisational principle may be questioned, but as the only conceivable option constituting a necessary foundation for a range of different practices.

In this reading, the potential of STS lies in its ability to establish an alternative to the epistemologically modelled approaches to ELSA research. It has, through a series of turns, rearticulated science through three successive "idioms" for thinking about science, technology and society.

The representational, the performative, and the co-production idioms

We may discuss engagement models with reference to three idioms for thinking about science, technology and society. Drawing on Andrew Pickering's *The Mangle of Practice* (1985), we may refer to the first two idioms as the "representational idiom" and the "performative idiom". The representational idiom in Pickering's words "casts science as, above all, an activity that seeks to represent nature, to produce knowledge that maps, mirrors, or corresponds to how the world really is". The performative idiom, in return, emphasises the material and technological mediators of scientific performance. In this idiom science is "regarded as a field of powers, capacities, and performances, situated in machinic captures of material agency". The performative idiom replaced the representational idiom but should in turn now be replaced by what Sheila Jasanoff (2004b) in an article title called "The Idiom of Co-Production". Co-production, in Jasanoff's words, "is a shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it".

The co-production idiom cast science in terms that bridge the epistemic and the ethico-political concerns in contrast to the ideals of sharp separation of the representational idiom. The performative idiom cast science in temporal terms in ways that undermined the technical/social distinction in ways that simultaneously came in conflict with methods and analytical strategies of traditional epistemic and ethical-political normative approaches. The co-production idiom now appears as a unifying approach we need in responding to the call for integrating ethics in science and technology developmental processes.

The notion of "integration" of ethics does itself bear the marks of the representational idiom that understands science as a pure epistemic activity – that now is in need of integrating ethics. The co-production idiom needs to be articulated in terms that display the true integrated nature of ethical and political activities (but still recognise the need for analytical distinctions between two different normative concerns).

Bruno Latour argued the need for innovative descriptive terms that crossed over the technical and the social in order to capture the nature of the sosio-technical "thing" that were to be accounted for. The call for integrating ethics in the process of producing this thing draw attention for the need for theory-method approaches that may take into account the nature of embedded normative realities. For this purpose we need normative cross over terms that may crossover the issues we frame as respectively epistemic and ethico-political.

Normative crossover terms

The call for perspectives and concepts that "cross-over" the issues we recognise as respectively epistemic and ethical-political follow from the widely used notion of socio-technological system. In particular Bruno Latour's, or more broadly the actor-network, approach gives weight to this notion. Latour borrows the crossover notion from genetics, having chromosomal crossover in mind. Crossover terms in Latour's analogy are meant to capture the exchange, mixing and mutual blending of the social and the natural. The "thing" under consideration in this perspective, is not the isolated technological artefact, but rather the dynamic actor-network that mediates the actions being done. Given this perspective, we need to explore how normative evaluations of the actor-networks in question are being shaped.

Actor-network approaches require the development of a descriptive language that makes it possible to articulate and trace the shaping and maintenance of the distributed and aggregated purposes of the actions being mediated through the technological system. This descriptive approach, however, may easily result in a neglect of normative issues. A notion of ethos, we propose, may serve such a normative cross-over purpose within a co-production idiom.

The co-production idiom, then, will be understood as expressing pretentions to represent an alternative normative posture with respect to the ideals expressed in the representational idiom. In engaging in the production of sosio-technical "things" we need to take into account the nature of embedded normative realities. Ethos may with reference to the actor-network theory vocabulary serve as a short cut reference to traces of human evaluation embedded in an actor-network. Human agents, as analysed by Taylor, cannot escape evaluating their own actions, although the evaluation may be weak or strong, that is, even crucial decisions we live by may be more or less well explicit deliberated or more or less well argued. The notion of ethos of a technological system draws attention to immanent evaluative traces of human action, and may provide useful guidelines for the work of instigating morally accountable developmental processes.

This suggested notion of ethos has methodological implications for students of science. With respect to the research based on Latour's seminal work, the notion of ethos implies an ontological extension of what is to be accounted for. This creates a methodological challenge to the analyst who aims for an account of how the actor-network is established as a desirable and well-constructed actor-network. Such an account should seek to capture the process of formation of immanent normative evaluations that are shaped as the actor-network is constructed. The actor-network is not necessarily well constructed even though it displays a high degree of robustness and stability, because the corresponding ethos is neither necessarily well-constructed in the process nor fully in plain view to the practitioners themselves.

Recognising that the valuable insights of STS does not provide sufficient reflection of the challenges of the an integrated approach, we draw on the work of Taylor, in suggesting that we try to make sense to notions like the ethos of technological system or the ethos of an actor network. Reference to ethos may provide a short-cut reference to traces of human evaluation embedded in an actor-network. Human agents, as analysed by Taylor (1985a), cannot escape evaluating their own actions. Admittedly, the evaluation may be weak or strong, meaning that even crucial decisions we live by may be more or less well explicit deliberated or more or less well argued. But Taylor (1989) argues that strong evaluations that give meaning and direction to our lives "involve discriminations of right or wrong, better or worse, higher or lower, which are not rendered valid by our own desires, inclinations, or choices, but rather stand independent of these and offer standards by which they can be judged.”

By articulating these strong evaluations involved in a certain practice, institution or socio-technological system, we will determine its ethos. This is not merely a descriptive work, as a sociological or anthropological study of value systems. It will also involve an act of double reflexivity in the sense that it will evaluate the strong evaluations embedded in the system. The notion of ethos of a technological system then draws attention to immanent evaluative traces of human action.

Ethos and transitional ethical evaluations

To instigate better moral processes of deliberation of a research project, we need guiding perspectives that understand normative evaluations as part and parcel of the technological system under discussion. The notion of ethos seeks to capture how evaluations of values play a role in mediating, maintaining as well as destabilising a technological system, without compromising crucial insights of the actor-network approach.

By ethos we understand the character or the defining values of a certain person, institution or practice, drawing on the Aristotelian analyses in the Nicomachean Ethics as well as in the Rhetoric and the Poetics. Unlike Merton’s definition of the ethos of science as a permanent and fixed set of ideals or standards (Merton 1996), we assume that the values of institutions and practices of this kind are dynamic and processual; established and altered through more or less reflexive interactions between those who take part in the activity in different ways.

A significant insight articulated by the notion of technological systems is that the borders of practices such as scientific and technological developments are porous and vague. The creation of a certain technology is also a creation of a new social reality, and the society in which these techniques and apparatuses are developed and employed, become, in a certain sense, part of the technology itself (Winston 2000). The implication is that it is impossible to define the ethos of the technology without reflecting on this reciprocity: the society partakes in determining the purposes of the activity as the technological development more or less alters crucial societal practices. This co-constructionist view echoes Aristotle’s organic view of society, where the character of the individual is shaped socially, while the same individuals make the society.

On this view the ethos of a person or a practice is influenced by, and influences, the politics of society, an approach we find useful for understanding the complexities of the normative aspects of nanotechnology development.

The notion of ethos carries three important elements:

1. A reference to ethos may provide a short-cut reference to traces of human evaluation embedded in a socio-technical system. The ethos is an intrinsic part of a network that must be accounted for.
2. Given a temporal perspective, imposing a moral asymmetry between humans and non-humans does not need to imply sharp boundaries between scientific and political activities.
3. The notion of ethos may function as a "cross-over" term, that is, it may counteract the tendency to discuss moral issues in isolation from technical and scientific issues as the term carries an epistemic as well as an ethical component.

Ethos –the Greek conception

Ethos is a term that goes back to the Greek conceptions of the moral character of man. The word can mean custom, habit, disposition, temper, as well as moral character (Liddell and Scott 1990). Thus the word points beyond the character of the singular person. It indicates the intersubjective aspects of our value judgement and it includes non-moral personality traits in this moral notion. It is also worth noticing that the term is concerned with patterns of action rather than singular acts. Thus it is reasonable to say that also groups of people engaging in a set of activities with a common goal have an ethos as a group, related to their joint activity. This ethos will be different from the ethos each has as a human agent. Likewise, it is also meaningful to speak of the ethos of certain practices, as long as we reasonably assume that practices consist in activities that have shared goals.

As a point of entrance to the notion of the ethos of an actor-network, one may say that the term refers to the moral character that a practice, like a specific nanotechnology project, has qua human practice - without which there would not be a technological system. For example, when a fish health researcher attempt to use nanoparticles as vaccine vectors in order to improve the health of farmed salmon, judgements of worth of the technology development needs to be seen as part and parcel of how the programme is performed and maintained. The ethos of the nanovaccine research and development, capturing what it is as something good and desirable, may however be fragmented, more or less consistent and well articulated. By engaging in articulation work, ELSA researcher's intervention may have a crucial effect on the course of events. They may for instance facilitate engagement or provide substantial analysis that, if effective, serves as a social intervention that could be seen as a way of improving or testing the social robustness of a specific nano initiative.

The ELSA researchers may spark a debate – and the quality or authenticity of such debates can be assessed in terms of the outcome: Do they open up new perspectives for the involved parties? Do they lead to changes in the way the technology project is conducted or understood? A vivid debate would possibly not appear if there was nothing there to be sparked, something that was crucial and important for the persons being engaged in the debate – simply waiting for the appropriate possibilities or opportunities to be sparked. The meaning of a product is not totally in the hands of the designers, but also in the way the technology is appropriated and taken into use. The point or purpose – or more broadly, the ethos of a nanotechnological project - is not in the hands of the scientist and engineers, it is rather something they have to deal with in the process of development. One of the important rationale for integrating scholars of the social sciences in ELSA programs should be measured in terms what difference the ELSA presence make in terms of altered practices and altered ways of thinking and speaking about the practices.

Ethos –as temporally shaped

Ethos is something that is temporally shaped. Ethos, as used as a technical term in rhetoric, is a term that urges the analyst to scrutinise how the speaker's ethos (qua trustworthy speaker) is temporally constructed, maintained or deconstructed through the speech act. The notion of the ethos of a nanotechnology project should urge the analyst to scrutinise how the technological system was brought together in order to establish a stable technological system people are willing to rely on, put their trust in and live with.

In this case the notion of ethos draws attention to a discussion of the desirability of the research project in terms of whether or how the research project possibly could pave the way for radical changes in the world; changes that for instance would impose a set of novel choices or responsibilities on the end user of the technology.

The ethos of a nanotechnology project must, however, not be narrowly construed. It does not only concern the actual practice of the research and its applications. The ethos refers in addition to the practice it eventually is to be embedded in – like a nano-silver refrigerator is embedded in household practices. Evaluating the ethos of nanotechnology project implies evaluation of the practices in which the technology will partake. How will this technology alter the practice, will it alter the practice, and if so, in which ways? It is also important to ask about the ethos of the practice itself, for example regarding a project concerning fish vaccines. We should be particularly concerned with the aspects that the vaccine project is intended to alter. We should ask to what extent the fish farming practices should be judged as good practices, in particular when we consider the systems for fish health and welfare.

Drawing attention to processes draws attention to the role non-humans, technologies and the emergence of novel diagnostic techniques play in the process of the shaping the ethos. This is why the notion of the ethos of the socio-technical system may be more workable than the notion of the ethos of a practice. The ethos of a particular household practice is difficult to fully articulate because of the changes brought about by the kitchen becoming a modern nano-kitchen. Controversies on nano-silvered refrigerators or washing machines can be seen as controversies that contribute to the articulation of the ethos of these socio-technical systems rather than the isolated household practices in themselves. In the same way, the discussion concerning the values embedded in fish health strategies as expressed in the aims of the nano-vaccine project will contribute to the articulation of the ethos of the socio-technical systems of fish farming.

Given the notion of ethos of socio-technical systems, one may better come to grips with how moral *problems* appear, disappear and are temporally shaped during the process of research. The temporal perspective allows us to say in a meaningful way that material agencies are morally relevant agencies (without for instance imposing a symmetric descriptive language of humans and non-humans). We often find ourselves reconsidering our previous moral judgments adjusting to the formation of novel connections of socio-technical systems in ways that may throw us into moral confusion.

Ethos –as temporally and contextually shaped

The ethos of fish health in fish farming is temporally shaped – both as a reliable and desirable technological system, but not only by humans. The focus on transitional evaluations draws attention to the role non-humans play in the process of the shaping the ethos. In fish health, the vaccine solves some problems while creating new ones, neither intended nor expected by the researchers. In the interactions within the socio-technical network new problems and challenges arise as others are solved. The focus on the temporality of the process allows us to say in a meaningful way that material agencies are morally relevant agencies (without imposing a symmetric descriptive language of humans and non-humans). The very existence of a technology taken in use may in instances change the personal storyline of individuals as well as open up new issues, like questions of who should possibly make decisions of whether or not someone should be able to get access to knowledge.

The notion of ethos brings to the forefront the joint ethical-epistemic character of scientific activities. This may become visible if we pay closer attention to the fact that the notion of ethos may also be seen as having epistemic roots. The notion of ethos has figured as a key notion in rhetorical analysis of the construction of convincing argumentation. The legitimacy of the authority of the speaker critically depends on the audience's judgement of the speaker's moral character. When one refers to the "ethos of science", this insight may be understood as transferred to the context where the legitimacy of the authority of science is discussed. The authority of a scientist's word does not depend on his personal character as long as he appears as a spokesperson for science. In this setting, it is the ethos of science that makes the scientist's word trustworthy, where the ethos of science has come to refer to science's characteristic trait as truth seeking. In the co-production idiom, however, the ethos of science cannot entirely be articulated in epistemic terms.

Ethos, when used as a technical analytical term in rhetoric, is a temporal term that urges the analyst to scrutinise how the speaker's ethos is constructed, maintained or deconstructed through the speech act (Andersen 1995:35). The notion of the ethos of socio-technical network should likewise be connected to the analysis of how the ethos is constructed, maintained or deconstructed through the construction process

Three ELSA perspectives

We have argued that ELSA research in general can inform, and actually has informed and shaped, the ethos of technologies. Further, we have pointed out that this research is interdisciplinary and involves a plurality of approaches to the issues at stake. This means that the way ELSA research influences technology practices are many and different. There are at least three main groups of researchers or perspectives operating in the interdisciplinary ELSA research field. We have made this distinction on the basis of the project catalogue of the former ELSA programme of the Research Council of Norway, as well as other research programmes. We can say that the main differences between the groups are due to the differences in their basic training and education. This background to a large extent determines the subject matter of their research, their methodology and their analyses. As the interdisciplinary field develops, the differences between these groups are gradually reduced, but the three main ways of approaching the subject matter will remain, although some combine elements in their projects. The three approaches are related to the three main groups of researchers within the field: Ethicists, social researchers and scientists/technologists/practitioners.

Their approaches are dominated respectively by:

1. Normative analysis; typically developed through conceptual analysis by ethicists and epistemologist with training in philosophy or theology.
2. Studies of stakeholder opinion or studies of how scientific and social activities mutually interact typically undertaken by scholars trained in STS and/or fields like sociology, anthropology and history
3. Scientific analysis of technical issues like risk research, typically developed by researchers with a science and technology background.

The first group was arguably the dominant one in the early days of ELSA studies. In some cases these researchers are doing purely theoretical work in the tradition of analytic philosophy, but generally they focus on the normative consequences of technology developments or discuss ethical issues as they arise in concrete cases. This use of a theoretical reference frame for reflection over general technology development and concrete dilemmas is the paradigmatic model of applied ethics. It is also philosophy's version of a methodological approach well-known from social sciences and other branches of the humanities. Unlike these, this kind of applied ethics is valuable not only as a way to understand the empirical issues at stake. It is also a mean for theoretical reflection, in that it serves as an interpretation of the theory in a new setting. Gadamer (1990) points out that there is a close relation between understanding, interpretation and application, in that we understand a theory by interpreting it in an application in the present circumstances. This is also a further reason to say with Toulmin (1982) that medicine saved the life of ethics. In the attempts to solve real issues, different moral theories were brought into play, and were reinterpreted through these applications. In this way the theories were given new life by the reflection on them in light of these applications, while discussing how to solve the problems.

The second group did to a large extent continue the kind of research they already engaged in within other fields, using methodology from social sciences in order to understand how the technology was perceived by the users or by those affected by the development and production of the technical applications. Their aim was purely descriptive, as we have pointed out above, but the information they gathered was considered to be crucial for understanding reasons for scepticism in cases where large groups of people were negative to some application of modern biotechnology and not others. The most important example was perhaps the European public scepticism towards the use of biotechnology in food production. Understanding the reasons for such attitudes and the accompanying mistrust towards some forms of technology contributed to altering communication strategies and regulation on some of these issues. One important change was an increasing awareness of the significance of public engagement in technology regulation. In this way, the social science research served an important role as an instigator of normative changes in science politics and regulation. Simultaneously, the social sciences studied the way science and technology was conducted, enhancing our understanding of these activities as crucial and paradigmatic forms of modern life. One could say that these studies led to theoretical reflections analogous to the ones seen in applied ethics, and this continuous reflexive work has resulted in altered ways of doing these kinds of study. It is important to note that despite the descriptive nature of social sciences, they served a very important normative role. It can be argued that this normative role has not been clearly acknowledged within the field, although there has been growing awareness of this role in later years.

ELSA research is interdisciplinary, and in some instances discussing cases or general development requires detailed technical knowledge and understanding of natural phenomena or of particular technologies. This is only possible with a proper professional training within the field, and the third group of ELSA researchers has this kind of training. Once more we can point to the development of medical ethics as paradigmatic of ELSA research, as there have always been physicians actively participating in this kind of research. Medical ethics is historically speaking a proper subdiscipline of medicine and the Hippocratic oath, which has been part of the professional identity of physicians, is primarily an ethics statement. The ethical issues that were traditionally included within medical practice were sharpened and altered due to the rapid technology development in medicine. In addition, new issues appeared, that arguably raised genuinely new problems, where it was unclear what was at stake (Jonas 1996). Analysis of these issues and discussions how to deal with them, often required detailed knowledge of the technology involved, and professionals beyond those of philosophers and physicians could give valuable contributions to the debate.

Also within other technology areas, such as agricultural biotechnology and the emerging fields of nanotechnology, scientists and technologists participated in ELSA research, often going beyond established fields of risk assessments into more encompassing ethical-political issues on how to deal with scientific controversy and uncertainties. Their strengths were to a large extent related to their understanding of the technical and scientific issues involved and grasp of concrete cases, their familiarity with laboratory work, as well as their credibility when communicating with fellow scientists.

Thus both their approach and their credibility, i.e. their *ethos*, differed from that of the two other groups.

These three approaches must be regarded as indispensable and complementary aspects of the ELSA field. We should be aware that even if their basic training, perspective and methodology are very different, there is increasing cooperation and exchange of theories and methods between the different groups. Although surveys and qualitative methods such as focus groups and consensus conferences, as well as other public engagement exercises can be considered as derived from social science methodology, researchers with philosophy or science backgrounds use these methods. Likewise, there is an increasing overlap in theoretical literature. Deliberative democracy theories are parts of political philosophy as well as social sciences, and all three groups may refer to post-normal science or related frameworks, when discussing risk and uncertainty or public engagement.

We will argue that the ethos of the practices we have called nanotechnology is connected to the ideas of the good or the values expressed explicitly or implicitly in the practices in this field. It is reasonable that ELSA research is the primary tool for engaging these values by expressing and analysing them, and that the different approaches may bring out different aspects of this ethos. This does not mean that all methods are equally adequate for this task, but that none can be excluded at the outset. Different approaches may enlighten different aspects of the value system involved in nanotechnology. Articulating values is always more than a purely descriptive project, as the theoretical frameworks we employ in studying human action invariably contain some notion of the good (Taylor 1985b). So describing the values involved in nanotechnological practices from different theoretical perspectives, means evaluating the good of these practices from different viewpoints. In order to engage the ethos of the practice in an adequate way, reflection on the implicit value structure in the theoretical framework for analysis must be an integrated part of the analysis of the practices. As the different approaches not only bring to light different aspects of nanotechnology practices, but do this based on different sets of implicit value judgements, we hold that an adequate approach to ELSA studies should strive to keep alive this pluralism in professional training, theoretical frameworks, methodologies and perspectives.

This is not to say that every theory, method or perspective is equally adequate or provides good analyses in all cases. It is important that scientific quality requirements are ensured through peer review processes and that we keep alive the critical discussions. Clearly, in a fairly novel and interdisciplinary research field, scientific standards are not fully established. It is plausible that lack of clear quality standards leads to disagreements concerning what is considered good research, and therefore it is important to ensure an inclusive approach combined with an ongoing open debate on standards for ELSA research. In this way, one can assume that the field in the long run will establish methods for ensuring high quality research. But only by supporting perspective pluralism in the phase of consolidation can we ensure that we do not exclude important contributions prematurely.

References

Andersen, Ø. 1995 *I retorikkens hage*. Oslo: Universitetsforlaget.

Arrow, K. J. 1950. A Difficulty in the Concept of Social Welfare. *The Journal of Political Economy*, (58)4 328-346.

Beck, U. 1992. *Risk Society: Towards a New Modernity*. London: Sage.

Burgess, M.M. and Tansey, J. 2005. *Complexity of public interest in ethical analysis of genomics: Ethical reflections on salmon genomics/aquaculture*. Electronic Working Paper Series. W. Maurice Young Centre for Applied Ethics, University of British Columbia: http://www.ethics.ubc.ca/workingpapers/deg/deg008.pdf [Accessed 22.11.2010]

Coghlan, A. 2003. UK public strongly rejects GM food. *New Scientist*, 24. September 2003: http://www.newscientist.com/article/dn4191-uk-public-strongly-rejects-gm-foods.html [Accessed: 23.11.2010]

Craye, M. Governance of nanotechnologies: Learning from past experiences with risk and innovative technologies. Unpublished manuscript.

Collingridge, D. 1980. *The Social Control of Technology*. New York: St. Martin's Press.

Covello, V.T. and Merkhofer M. V. 1993. *Risk assessment methods, approaches for assessing health and environmental risks.* New York: Plenum Press.

Delgado, A., Kjølberg, K. and Wickson, F. 2010. Public engagement coming of age: From theory to practice in sts encounters with nanotechnology. *Public Understanding of Science*, published online 11 May 2010

de Melo-Martin, I. and Meghani, Z. 2008. Beyond risk. A more realistic risk-benefit analysis of agricultural biotechnologies. *EMBO reports*, 9, 302-306.

Demeritt, D. 2000 The New Social Contract for Science: Accountability, Relevance, and Value in US and UK Science and Research Policy. *Antipode*, 32, 308-329.

Doubleday, R. 2007. Risk, public engagement and reflexivity: Alternative framings of the public dimensions of nanotechnology, *Health, Risk and Society*, 9, 211-227.

EC Sanco 2004. Nanotechnologies: A Preliminary Risk Analysis on the Basis of a Workshop Organized in Brussels on 1-2 March 2004 by the Health and Consumer Protection Directorate General of the European Commission, European Commission Community Health and Consumer Protection.

Edge, D. 1995. Reinventing the Wheel. In Jasanoff, S., Markle, G. E., Petersen, J. C. and Pinch, T. (eds.) *Handbook of Science and Technology Studies.* London: Sage

Felt, U. and Wynne, B. 2007. *Taking European Knowledge Society Seriously*. Report on the Expert Group on Science and Governance to the Science, Economy and Society Directorate. Directorate – General for Research. European Commission.

Fisher, E., Mahajan, R. and Mitcham, C. 2006. Midstream modulation of technology: Governance from within. *Bulletin of Science, Technology & Society*, 26, 485-496.

Fujimura, J. H. 1996. *Crafting Science. A Sociohistory of the Quest for the Genetics of Cance*r. Cambridge: MIT Press.

Funtowicz, S and Ravetz, J.R. 1993. Science for the post-normal age. *Futures*, 25, 739-755.

Galison, P. 1987. *How Experiments End*. Chicago: University of Chicago Press.

Gadamer, H.-G. 1990. *Wahrheit und Methode*. Tübingen: J.C.G. Mohr, p. 312-346.

Gallopin, G. C., Funtowicz, S., O'Connor, M. and Ravetz, J. 2001. Science for the Twenty-First Century: From Social Contract to the Scientific Core. *International Social Science Journal*, (53) 219-229.

Gaskell et al. 2006. *Europeans and Biotechnology in 2005: Patterns and Trends. Eurobarometer 64.3*, p. 59: http://ec.europa.eu/research/press/2006/pdf/pr1906_eb_64_3_final_report-may2006_en.pdf [Accessed 17.11.2010]

Genome Biology. 2003. Whither NHGRI? News, Genome Biology [17 April 2003]

Gibbons, M. 1999. Science's New Social Contract With Society. *Nature*, 402, 81-84.

Gibbons, M., Limoges C., Nowotny, H., Schwartzman, S., Scott, P., and Trow, M. 1994. *The New production of knowledge : the dynamics of science and research in contemporary societies*. London: Sage

Giddons, A. 1990. *The Consequences of Modernity.* Standford: Standford University Press

Guston, D. 2010. The Anticipatory Governance of Emerging Technologies. *Journal of the Korean Vacuum Society*, 19, 432-441.

Guston, D. H. and Keniston, K. 1994 Updating the Social Contract for Science. *Technology Review*, 97, 60-69.

Guston, D. and Sarewitz. D. 2002. Real-time technology assessment. *Technology in Society*, 24 93–109.

Jasanoff, S. 1996. Beyond Epistemology: Relativism and Engagement in the Politics of Science. *Social Studies of Science*, (26) 393-418.

Jasanoff, S. 2004a. Ordering Knowledge, Ordering Society. In Jasanoff, S. (ed.) *States of Knowledge: The Co-production of Science and the Social Order*. London: Routledge.

Jasanoff, S. 2004b. The Idiom of Co-Production. In Jasanoff, S. (ed.) *States of Knowledge: The Co-production of Science and the Social Order*. London: Routledge.

Jasanoff, S. 2005. *Designs on Nature. Science and Democracy in Europe and the United States.* Princeton University Press, Princeton (NJ).

Jensen, K. K., Gamborg, C., Hauge Madsen, K., Krayer von Krauss, M., Folker, A. P., Sandøe, P. 2003. Making the EU ”Risk Window” Transparent: The normative foundations of the environmental risk assessment. *Environmental Biosafety Research*, 2, 161-171.

Joly, P.-B. and Kaufmann, A. 2008. Lost in Translation? The Need for ’Upstream Engagement’ with Nanotechnology on Trial. *Science as Culture*, (17), 3, 226.

Jonas, H. 1993. *Das Prinzip Verantwortung*. Frankfurt a.M.: Suhrkamp, p. 15 ff.

Knorr-Cetina, K. 1999. *Epistemic Cultures: How the Sciences Make Knowledge.* Cambridge: MIT Press.

Latour, B. 1983. Give Me a Laboratory and I will Raise the World. In Knorr-Cetina, K. D. and Mulkay, M. (eds.) *Science Observed: Perspectives on the Social Study of Science*. London: Sage Publications. 258-275.

Latour, B. 1993. *We Have Never Been Modern.* New York: Harvester Wheatsheaf.

Latour, B. and Woolgar, S. 1986. *Laboratory Life: The Construction of Scientific Facts.* (2. ed) Princeton, NJ : Princeton University Press.

Levidow, L. and Carr, S. 2007. GM crops on trial: technological development as a real-world experiment. *Futures*, 39 , 408-31.

Levitt, M. 2005. UK Biobank: a model for public engagement? *Genomics Soc Policy*, 1, 78–81.

Liddell & Scott 1990. *Greek-English Lexicon*. Oxford: Oxford University Press.

Lubchenco, J. 1997. Entering the Century of the Environment: A New Social Contract for Science. *Science,* 279, 491-497.

Luhmann, N. 1968. *Vertrauen: Ein Mechanismus der Reduktion sozialer Komplexität*, Stuttgart: Enke (English translation: *Trust and Power*, Chichester: Wiley, 1979.)

Macnaghten, P., Kearns, M.B.,and Wynne, B. 2005 Nanotechnology, governance and public deliberation: what role for the social sciences? *Science Communication*, 27, 268–291.

Maclean, S. A. M. 1994. Mapping the human genome –Friend or foe? Social Science & Medicine, 39, 1221-1227.

Mayer, S. and Stirling. A. 2004. GM crops: good or bad?. *EMBO reports,* 5, 1021-1024.

Mayo, D. G. and Hollander, R. D. 1991. *Acceptable evidence: Science and values in risk management.* Oxford: Oxford University Press.

Merton, R. 1996 [1942]. The Normative Structure of Science. In Nowotny, H. and Taschwer, K. (eds). *The sociology of the Sciences* Volume 1

Meslin, E, M., Thomson, E.J., Boyer, J. T. 1997. Bioethics inside the beltway. The Ethical, Legal, and Social Implications Research Program at the National Human Genome Research institute. *Kennedy Institute of Ethics Journal,* 7, 291-298.

Myskja, B. 2007. Lay expertise: Why involve the public in biobank governance. In *Genomics, Society and Policy*, 3, 1, 1-16.

Nanoforum 2004. *Benefits, risks, ethical, legal and social aspects of nanotechnology*. European Nanotechnology Gateway, Available at: http://www.nanoforum.org/ [Accessed 17.02.11 2011].

NFR 2002. Work programme *Etikk, samfunn og bioteknologi / Ethical, legal and social aspects of biotechnology (ELSA - Norway)*. Oslo: NFR.

NFR 2008. Work Programme 2008-2014. *Ethical, Ethical, Legal and Social Aspects of Biotechnology, Nanotechnology and Neurotechnology – ELSA Oslo: NFR.*Available at: http://www.forskningsradet.no/servlet/Satellite?c=Page&pagename=elsa%2FHovedsidemal&cid=1224698247035http://www.forskningsradet.no/servlet/Satellite?c=Page&pagename=elsa%2FHovedsidemal&cid=1224698247035 [Accessed 17.02.11]

Nordmann, A. (Rapporteur) 2004. Converging Technologies - Shaping the Future of European Societies. European Commission, Brussels. Avaliable at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.133.2322&rep=rep1&type=pdf [Accessed 17.02.11]

Nowotny, H., Scott, P., and Gibbons, M. 2001. *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty.* Cambridge: Polity Press.

Nye, D. 2006. *Technology Matters Questions to Live With*. Cambridge: MIT press

Pickering, A. 1984. *Constructing Quarks: A Sociological History of Particle Physics.* Chicago: Chicago University Press.

Pickering, A. 1995. *The Mangle of Practice. Time, Agency and Science.* Chicago: Chicago University Press.

Rabinow;P. and Benett, G. 2008 Human Practices: Interfacing Three Modes of Collaboration, In Bedau, M. and Parke, E. (eds). *The Prospect of Protocells: Social and Ethical Implications of Recreating Life*. Cambridge: MIT Press.

Rabinow;P. and Benett, G. 2009. Ethical ramifications 2009, *Systems and Synthetic Biology,* 3, 99–108.

Rheinberger, H-J. 1997 *Toward a History of Epistemic Things. Synthesizing Proteins in the Test Tube.* Stanford: Stanford University Press.

Radder, H. 1992. Normative Reflexions on Constructivist Approaches to Science and Technology. *Social Studies of Science*, 22, 141-173.

Reason, P. and Bradbury, H. (Ed.) 2001. *The SAGE Handbook of Action Research. Participative Inquiry and Practice. 1st Edition.* London: Sage.

Renn, O. 1998. Three decades of risk research: accomplishments and new challenges. *Journal of Risk Research,* 1, 44-71.

Rowe, G.and Frewer, L.J. 2000. Public participation methods: a framework for evaluation. *Science, Technology & Human Values*, 25, 3-29.

Royal Society and Royal Academy of Engineering, London: Royal Society 2004. *Nanoscience and nanotechnologies: opportunities and uncertainties*. London, Royal Academy of Engineering, 29 July 2004. Available at: http://www.nanotec.org.uk/finalReport.htm [Accessed 17.02.11]

Schrage, M. 1992. Increasing Medical Dilemmas Mean Job Security for Budding Bioethicists', *San Jose Mercury News* (13 Oct 1992)

Schot, J. and Rip, A. 2007. The past and future of constructive technology assessment. *Technological Forecasting and Social Change,* (54) 2-3, 251-268.

Schrader-Frechette, K.S. 1991. *Risk and Rationality: Philosophical foundations for populist reforms*. Berkely: University of California Press

Shew, A. and Bird, D. 2004. Probing the history of scanning tunneling microscopy. In Baird, A. and Nordmann A. (eds). *Discovering the nanoscale*, Amsterdam: IOS Press. 145-156.

Shew, A. 2008. Nanotech's History : An Interesting, Interdisciplinary, Ideological Split. *Bulletin of Science Technology & Society*, 28, 390 -399.

Slovic, P. 2001. *The perception of risk*. London: Earthscan publishers.

Stephansen, S. M. 2006. Har teke etikk på alvor. *Forskning*, 3. Avaliable at: http://forskningsradet.ravn.no/bibliotek/forskning/200603/200603020.html [Accessed 16.02.2011]

Stirling, A. 2008. Opening up or closing down? Power, participation and pluralism in social appraisal of technology. *Science, Technology and Human Values*, 33 (2), 262-294.

Tait. J. 2009. Upstream engagement and the governance of science. The shadow of the genetically modified crops experience in Europe. *EMBO reports*, Special issue (10), 18-22.

Taylor, C. 1984. Philosophy and Its History. In Rorty, R., Schneewind, J. B. and Skinner, Q. (eds.) *Philosophy in History*. Cambridge: Cambridge University Press.

Taylor, C. 1985a. What is Human Agency*? In Human Agency and Language. Philosophical Papers I*. Cambridge: Cambridge University Press.

Taylor, C. 1985b. *Philosophy and Human Values*. Cambridge: Cambridge University Press, 58-90.

Taylor, C. 1989. *The Sources of the Self. The Making of the Modern Identity*. Cambridge: Cambridge University Press

Toulmin, S. 1982. How medicine saved the life of ethics. *Perspectives in Biology and Medicine*, 25, 736–750.

Toumey, C. 2006. Science as Democracy. *Nature Nanotechnology*, 1, 6-7.

van Est, R. and van Keulen, I. 2004. "Small technology - Big Consequences": Building up the Dutch debate on nanotechnology from the bottom**.** *Theorie und Praxis*, 13, 72-79.

van Est, R. and Brom,F.1997. Technology assessment as an analytic and democratic practice**.** *Encyclopedia of Applied Ethics*: Academic Press von Schomberg, R. 2007. *From the ethics of technology towards an ethics of knowledge policy & knowledge assessment.* A working document from the European Commission Services. Available at: http://ec.europa.eu/research/sciencesociety/pdf/ethicsofknowledgepolicy_en.pdf [Accessed 16.02.11]

von Schomberg, R. 2009. Organising Collective Responsibility: On Precaution, Code of Conduct and Understanding Public Debate Keynote lecture at the first annual meeting of the *Society for the Study of Nanoscience and Emerging Technologies*, Seattle, 11 Sept. Avaliable at: http://www.nanotechproject.org/process/assets/files/8305/keynotesnet.pdf [Accessed 17.02.11]

Walls, J., Rogers-Hayden,T., Mohr. A. and O'Riordan, T. 2005. 'Seeking citizens' views on GM crops: Experiences from the United Kingdom, Australia and New Zealand', *Environment,* 7, 23–36.

Wickson, F., Delgado, A. and Kjølberg, K. L. 2010. Who or what is "the public"? *Nature Nanotechnology*, 5, 757-758.

Williams, R. 2006. Compressed foresight and narrative bias: pitfalls in assessing high technology futures. *Science as Culture,* 15, 327–348

Winner, L. 1993. A New Social Contract for Science. *Technology Review* (96) 65.

Winner, L. 2004. Testimony to the Committee on Science of the U.S.S House of Representatives on The Societal Implications of Nanotechnology. Wednesday, April 9, 2003. Available at: http://www.rpi.edu/~winner/testimony.htm [Accessed 17.02.11]

Winston, M. 2000. Children of Invention Introduction to Winston, M. and Edelbach, R. (red.) *Society, Ethics and Technology*. Wadsworth.

Wolfe, A. 2000. Federal Policy Making for Biotehcnology, Executive Branch, ELSI. In Murray, T. H. And Maxwell, J. M. (eds) *Encyclopedia of ethical, legal, and policy issues in biotechnology*. Wiley: New York: Wiley-Interscience cop

Woolgar, S. 1991. The Turn to Technology in Social Studies of Science. *Science, Technology, and Human Values,* 16, 20-50.

Wynne, B. 1992. Uncertainty and environmental learning: Reconceiving science and policy in the preventive paradigm, *Global Environmental Change*, 2, 111-127.

Wynne, B. 2001. Creating public alienation: Expert cultures of risk and ethics of GMOs. *Science as Culture*, 10, 445-481.

Wynne, B. 2006. Public engagement as a means of restoring public trust in science: Hitting the notes, but missing the music? *Community Genetics*, 9 (3), 211-220

Ziman, J. 1998. Why must scientists become more ethically sensitive than they used to be? *Science*, 282, 1813-1814.

Ziman, J. 2002. *Real Science: what it is and what it means.* Cambridge: Cambridge University Press.