Social Responsibility in Research Practice

Engaging applied scientists with the socio-ethical context of their work

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To the memory of my father.

'Three passions, simple but overwhelmingly strong, have governed my life: the longing for love, the search for knowledge, and unbearable pity for the suffering of mankind. ... I have wished to understand the hearts of men. I have wished to know why the stars shine. And I have tried to apprehend the Pythagorean power by which number holds sway above the flux. ... Love and knowledge, so far as they were possible, led upward toward the heavens. But always pity brought me back to earth. Echoes of cries of pain reverberate in my heart. Children in famine, victims tortured by oppressors, helpless old people a hated burden to their sons, and the whole world of loneliness, poverty, and pain make a mockery of what human life should be. I long to alleviate the evil, but I cannot, and I too suffer.'

Bertrand Russell. The Autobiography of Bertrand Russell, 1967-1969.

Contents

1 Introduction

How to 'revalue' value-neutrality in the applied sciences?[1] That is the main question of this thesis. It investigates different views on social responsibility in research, and argues that the 'neutrality view' – the view that researchers have no business with the social and ethical dimensions of their work – has become untenable, at least as far as applied sciences such as nano- and biotechnology are concerned. Instead, this thesis adopts a broader view, one in which the social responsibility of researchers includes the moral responsibility to critically reflect on the socio-ethical context of their work. This normative viewpoint itself is not uncommon: the argument that researchers *should* integrate broader ethical and societal considerations in their cogitations has been put forward by philosophers and sociologists of science as well as by 'concerned scientists' at various moments in history (Jonas: 1984; Roosevelt: 1936; Rose and Rose: 1969; Russell and Einstein: 1955; Verhoog: 1980). But how can such a broadened conception of social responsibility be realised in practice? That is the question this thesis aims to address. Three empirical interventions have, each in different ways, examined opportunities and constraints for encouraging a broadened vision of social responsibility at the level of research practice.

The purpose of this introduction is to provide the overall rationale for this undertaking. I will first consider why the neutrality view is problematic as a model for understanding the responsibilities of researchers in applied science. Then, I will introduce a broadened conception of the social responsibility of researchers, and discuss why this thesis is concerned with its realisation at the level of research practices. Finally, I will introduce the research questions that have guided the empirical interventions presented in subsequent chapters.

1.1. A critique of the neutrality view

In anticipation of a more detailed literature review and discussion in chapter two, this section introduces the neutrality view of the social responsibility of

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[1] This statement paraphrases Schurr (1977, 29): *'The crucial problem now is to revalue our valueless objective knowledge, technical problem solving and instrumental power.'*

researchers and argues why it is inappropriate in the case of applied science. The neutrality view denotes a particular way of understanding the responsibilities of the researcher and the research community. It is a normative guideline which basically suggests that researchers have no business with the broader social, ethical, or political context in which research operates: it is the exclusive responsibility of the researcher to produce reliable, objective knowledge about the world through a process of disinterested, curiosity-driven research. On this interpretation, research is to be governed by the Mertonian norms of CUDOS: communalism, universalism, disinterestedness, and organized scepticism (Merton: 1942). The only kinds of values that are allowed to play a role in research are *epistemic* values such as predictive accuracy, coherence, consistency, unifying power, and simplicity (Ruse: 1999) – broader ethical and social considerations are to be kept at bay. Hence, it is the researchers' moral duty to steer clear of the broader socio-ethical debates to which research may give rise. The task of researchers is to produce knowledge – what society decides to do with that knowledge is not up to them.

The neutrality view has served as the dominant frame of reference for understanding the responsibilities of the researcher for most of the twentieth century (Douglas: 2009), but it has not been without its criticisms. Philosophers of science have pointed out its philosophical inconsistencies, claiming that it confuses methodological principles with epistemological and ontological commitments (Verhoog: 1980). Engineering ethicists have argued that it unjustly 'neutralises' the moral responsibilities of researchers (Ziman: 1998; Van de Poel and Van Gorp: 2006). And science studies scholars have contested its tendency to exclude questions of a non-technical nature from research decision making (Feenberg: 1991; Wynne: 2006). Chapter two will examine the long and rich history of the debate on values in research in further detail, but the overall thrust of the argument against the neutrality view can be summarised as follows: research does not operate in a socio-ethical vacuum. Research endeavours necessarily embody value-commitments, and their outcomes are socially significant. The view that cultural values have no role to play in research whatsoever is therefore conceptually and practically inconsistent. Hence, it is the business of the researcher, at least on occasion, to reflect on the goals that drive research as well as the potential significance of its outcomes.

This holds especially true for the applied sciences, where research processes are by definition geared towards the application of scientific knowledge to solve practical problems. As Queraltó (2008) puts it, the curiosity-driven question *'what is it?'* is entwined with the question of purpose: *'what is it for?'* - the very definition of applied science thus negates the claim that researchers have no business with the consequences of their research. Contrary to what the term intuitively seems to suggest, applied science is not just a matter of finding practical applications for the findings of fundamental research; it is, in effect, quite a different ball-game altogether. Of course, 'basic' research questions may still play a role: researchers may be personally motivated by the particular intellectual challenge of a research question and carry out research without a direct concern for its applications. But in applied science, even the most fundamental research projects – what has somewhat paradoxically been termed 'use-inspired basic research' (Stokes: 1997) – are ultimately undertaken with a view to fostering innovation. The point here is that progress in applied research cannot be assessed with reference to its contribution to the progress of knowledge only. If knowledge is produced with the specific intention to introduce science-based technological innovations in society, then the question of the expected social functions of that knowledge, and the social values embodied in them, deserves attention as well.

The question is: how to integrate the consideration of such broader ethical and social considerations in research practice when value-neutrality is the norm? This question is pertinent for emerging areas of applied science such as nano- and biotechnology. While they have given rise to high expectations in recent years, the effective integration of socio-ethical considerations in research has proven to be a challenge. Nanotechnology, the study and manipulation of material at the nanometre scale (Royal Society and the Royal Academy of Engineering: 2004), has been hailed as the next major technological revolution, comparable to electrification or the steam engine, providing unparalleled technological and social progress in almost any field imaginable (Peterson: 2000; Roco and Bainbridge: 2003; Wennersten et al.: 2008). Likewise for biotechnology: the capacity to modify biological entities at the molecular level potentially unlocks a wide array of industrial, agricultural, medical and other applications. At the same time, advances in both nano- and biotechnology have given rise to strong normative uncertainty. Whether or not these technologies will prove as revolutionary as foreseen, their development poses ethical, legal and social questions that warrant attention: in nanotechnology, for example, little is as yet known about the effects of manufactured nanoparticles on human and environmental health (Maynard et al.: 2006; Poland et al.: 2008; Danovaro et al.: 2008); the development of new cosmetics with active nano-sized ingredients presents new regulatory challenges (Jacobs et al.: forthcoming); and the use of nanotechnological devices for human enhancement raises ethical issues (Bruce: 2007a), to name a few. As for biotechnology, deliberate modifications of the genetic structure of organisms have led to ethical concerns (European Group on Ethics: 1996), the development of new medical technologies such as genetic testing poses new questions on the nature of disease, privacy and confidentiality and the right to know (or not to know) our chances of contracting hereditary diseases (Burgess: 2001; Kinderlerer and Longley: 1998); and the potential risks related to the introduction of genetically modified organisms in the environment are as yet uncertain (Conner et al.: 2003).

This combination of high expectations and normative uncertainties has also given rise to public concern about nano- and biotechnology, leading to increased demand for public oversight and participation to ensure the accountability of science, government and industry. In summary, nano- and biotechnology develop in a social context in which, in the words of Funtowicz and Ravetz (1993, 735): *'facts are uncertain, values in dispute, stakes high, and decisions urgent'*. This volatile mix of political expectations, normative uncertainty and public concern has led social and natural scientists, ethicists and policy makers alike to call for the socio-ethical assessment of developments in nano- and biotechnology. The European Commission's Work Programme for Nanosciences, Nanotechnologies, Materials and New Production Technologies (NMP) for example aims to:

> ...investigate the impact of nanotechnology on society, human health and the environment, as well as look into the relevance of nanoscience and technology for the solution of societal problems as well as the societal acceptance of nanotechnology. This will include research on potential ethical, public health, occupational safety and environmental protection implications (European Commission: 2008, 8).

Hence, there seems to be a growing awareness that developments in emerging areas of applied science call for appropriate forms of socio-ethical appraisal. But how to effectively integrate such broader considerations in research developments?

1.2. Socio-ethical assessment and social responsibility

Consideration of the wider ethical and social implications of new research developments can occur at several stages of the R&D process. At the 'upstream' level of policy making, where funding decisions are taken and research priorities are determined, there are opportunities to consider the ethical implications of new developments by way of ethical advisory bodies (Paula: 2008); to integrate public values by public involvement and participation (Wilsdon and Willis: 2004); and to anticipate the possible social ramifications through various forms of technology assessment (Schot and Rip: 1997; Guston and Sarewitz: 2002). Further 'downstream', during the social uptake of research outcomes, opportunities include the assessment of public perceptions of new technologies (Durant et al.: 1998); user involvement in innovation processes (Moors: 2003); and environmental impact assessments such as life cycle analysis (Guinée et al.: 1993).

While such opportunities for assessment at the up- and downstream levels of R&D constitute important moments for the socio-ethical appraisal of new technological developments, I will argue that the integration of broader social and ethical considerations *during the research phase itself* forms an important component in the overall socio-ethical appraisal of newly emerging technologies. Arguing against value-neutrality in research, the aim is to broaden the types of considerations being invoked during research decision making. In other words, the general need for socio-ethical assessment at the 'midstream' of knowledge production (Fisher: 2007) translates into a moral responsibility for researchers to reflect on the wider socio-ethical contexts in which their research takes place. The neutrality view is inadequate as a model for understanding the social responsibility of researchers. An alternative view is called for, a broadened conception of the social responsibility of researchers that includes the responsibility to critically reflect on the socio-ethical context of research. This broadened perspective will be developed further in chapter two, where a normative framework for social responsibility in research is derived from the work of the Dutch philosopher of science Henk Verhoog (1980) which will serve as the normative background for the empirical interventions presented later on in this thesis.

This normative viewpoint on the moral responsibility of researchers to reflect on the wider socio-ethical context of their work falls within a well-established tradition. Philosophers of science and technology have argued that researchers have specific obligations towards society in different ways (Shrader-Frechette: 1994; Longino: 1996; Resnik: 1998; Weil: 2002). Ziman (1998, 1813) for instance has argued in a Science commentary that: '*ethical reflection should become* *a part of the 'ethos' of science*'; Mitcham (2003) has identified a 'co-responsibility' for a broadened notion of research integrity; and Van de Poel and Zwart (2010) have recently developed an approach for the moral assessment of R&D networks that leaves room for critical reflection about the moral judgments of the actors involved in R&D. But the question how such a broadened conception of social responsibility can be realised in practice remains a matter for debate. The contribution this thesis aims to make to the ongoing debate is to identify opportunities and constraints for realising such a broadened vision in research practice. The analytical point here is that the philosophical claim that researchers should engage in critical reflection implies a concern for research *practices*. This, then, is the central objective of this thesis:

> **The overall objective of this thesis is to examine opportunities and constraints for the practical realisation of a broadened conception of social responsibility that includes the moral responsibility of researchers to critically reflect on the socio-ethical context of their research.**

1.3. Requirements for broadening social responsibility

This concern for the realisation of a broadened conception of social responsibility research practice leads to two specific requirements. The first requirement is that the willingness of researchers to critically reflect on the socio-ethical context of their work cannot be forcefully implemented, but needs to be *encouraged*. This requirement derives from the combined challenge posed by the autonomy of the research community on the one hand, and the cultural dominance of the neutrality view on the other. Attempts to realise an alternative vision of social responsibility in research practice have to take into account that research communities are highly autonomous *by design*. In an important sense, the research stage of R&D cannot be 'micro-managed' – the creative process that lies at the heart of scientific invention demands a high measure of freedom. Researchers should to a large extent be able to 'go about their business.'[2] Consequently, the

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[2] In fact, direct calls for the societal *relevance* of research may for this reason be counterproductive. This viewpoint may seem to contradict the call for social responsibility in research, but there is an important distinction to be made here. A call for societal *relevance* implies the substantive norm that the *outcomes* of research be determined in advance; the call for social responsibility implies the procedural norm to critically reflect on socially relevant dimensions *if and when they arise*. This procedural criterion thus safeguards the open-ended character of the

research process has remained something of a 'black box': while research policies can broadly express research objectives and expectations, the translation of these objectives into outcomes ultimately lies in the hands of the research community. At the same time, the neutrality view is deeply entrenched in the research community. As Ziman writes:

> In pursuit of complete 'objectivity' – admittedly a major virtue – the norm rules that all research results should be conducted, presented, and discussed quite impersonally, as if produced by androids or angels. ... This 'no ethics' principle is not just an obsolete model that can be uninstalled by a keystroke. It is an integral part of a complex cultural form (Ziman, 1998, 1813).

As a result, any attempt to promote a broadened conception of responsibility faces a 'Catch-22' situation (Heller: 1961): because the neutrality view is culturally entrenched in the research community, calls for change depend on external stimuli; but the autonomy of the research community limits the capacity of such external stimuli to bring about change.[3] There is no easy way out of this Catch-22. External stimuli only have the desired effect when they are adopted internally; but the internal norm is that external stimuli should be kept at a safe distance. This places an important condition on attempts to address the neutrality view: the realisation of an alternative vision on social responsibility depends to a large extent on the autonomous decision of the research community to adopt such a vision. The relative autonomy of the research community thus implies that critical reflection on the socio-ethical context of research cannot be forcefully imposed, but has to be encouraged from 'within'.

The second requirement relates to the 'translation' of abstract normative principles into the concrete context of day-to-day research decisions. In order to integrate broader ethical and societal considerations in research decisions, the question is how such broader considerations can be brought to bear on research. This applies both to the question how to relate broad societal impacts of research to individual research decisions and to the abstract levels of analysis of ethics

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research endeavour. As Verhoog (1980) notes: *'The freedom of science is urgently needed, but no longer the freedom of an 'autonomous' science s.s. [sensu stricto], aiming at the expansion of scientific knowledge for its own sake... only.'*

3 This Catch-22 situation is reminiscent of the Collingridge dilemma in the social control of technology: on the one hand, the social impacts of a new technology cannot be easily predicted until the technology is developed; on the other hand, it is difficult to control or change the technology once it has been developed (Collingridge: 1980).

and the social sciences as academic disciplines. As Guston and Sarewitz (2002) indicate:

> Social science scholarship has identified complex linkages between society and science, but it has been less successful at actually enhancing those linkages in ways that can add to the value and capability of each sector (Guston and Sarewitz: 2002, 93).

Calls for more 'relevant and focused' approaches in ethics and the social sciences have recently emerged in engineering ethics, science studies and in the philosophy of science and technology - one could speak of an 'empirical turn' (Kroes and Meijers: 2000; Nordmann and Rip: 2009; Van de Poel and Verbeek: 2006; Webster: 2007). In a sense, the converse of the claim that researchers have a moral responsibility to reflect on the wider socio-ethical dimensions of research also holds: ethicists and social scientists have a responsibility to bring ethical and societal considerations to bear on research practices. This calls to mind a comment made by David Edge:

> Perhaps the next phase in the development of STS [Science and Technology Studies – DS] must be a more urgent concern for communication and translation: for making 'real' its true potential (Edge: 1995).

1.4. Methodology

The intervention-oriented nature of the research objective invites an action-research methodology. The research in this thesis thus combined conceptual analysis with case study research. Chapter two conceptually analyses the notion of social responsibility in research and defines a normative framework that serves as the background for the case studies: the social responsibility of researchers is specified as the capacity and willingness to critically reflect on, and integrate, the value-base socio-ethical premises that drive research, the epistemological and ontological commitments upon which research is founded, and the socio-ethical consequences of research. Three exploratory case studies subsequently identify opportunities and constraints of three different types of intervention for realising a broadened conception of social responsibility. The first case study considers the implementation of the Netherlands Code of Conduct for Scientific Practice at the Department of Biotechnology of Delft University of Technology. The second case study applies the method of 'Midstream Modulation' in two molecular biology research laboratories: the

Department of Biotechnology in Delft, and the Photosynthesis Laboratory at Arizona State University. The third and final case study concerns two advanced courses for nanotechnologists on public communication and applied ethics organised as part of the European Nanobio-RAISE project (section 1.5 introduces the case studies and their respective areas of intervention in further detail).

1.4.1. Engagement from 'within'

The specific institutional background of this research provided a relatively rare opportunity to investigate the question of social responsibility in close collaboration with researchers from the applied sciences. In 2005, the Working Group on Biotechnology and Society was established alongside existing research groups at the Department of Biotechnology at Delft University of Technology.[4] Researchers with backgrounds in communication science, law, philosophy, ethics and social science were brought together to perform research into public communication, the social and ethical dimensions of biotechnological research, the role of the researcher in society, and 'science and society'-education. Admittedly, the composition of the research group betrays a rather eclectic vision of the 'social researcher', combining philosophical, sociological and ethical insights. In fact, in addition to the working group's aim to bridge the divide between the natural and social research communities, one of the corollary aims has been to challenge some of the divides that exist within the social sciences and humanities itself. The PhD research project that has resulted in the delivery of this thesis also adopted such an integrative perspective. The Kluyver Centre for Genomics of Industrial Fermentation,[5] a public private partnership in which the Department

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[4] The biotechnological research in the Department of Biotechnology is carried out in eight research groups: Analytical Biotechnology, Biocatalysis and Organic Chemistry, Bioprocess Technology, Bioseparation Technology, Environmental Biotechnology, Enzymology, Industrial Microbiology and Complex Fluids Theory.

[5] The Kluyver Centre for Genomics of Industrial Fermentation brings together Delft University of Technology, Wageningen University and Research Centre, Leiden University, Nijmegen University, Utrecht University, TNO, Wageningen Centre for Food Sciences, Agrotechnology and Food Innovations and NIZO food research. The consortium performs pre-competitive research into yeast fermentation, fungal fermentation, lactic acid fermentation, biocatalysis and genomics tools including bioinformatics. A total of 51 million Euro was allocated for the period 2002 - 2007, with one third funding by the Netherlands Genomics Initiative and two-third by the participating organizations. The second term of the Centre has started in January 2008 and will continue until 2012 with roughly equal funding.

of Biotechnology is a key player, submitted a research proposal to 'empower scientists in their social responsibility' which was funded and supported by the Centre for Society and Genomics[6] in 2005. By combining normative and conceptual analysis of social responsibility with empirical, interventionist work, this research project aimed to bring insights from engineering ethics and science and technology studies to convergence.

The presence of an 'embedded' social research group in a natural science institute is relatively rare and provided an opportunity to carry out research in close contact with the researchers at the department. Admittedly, this position both enabled and constrained the research. While it facilitated close cooperation and provided access to different registers of justification, it also made a neutral stance towards the object of research and the maintenance of an outsider's view more difficult. Notwithstanding its limitations, this approach allowed for an approach of collaborative investigation: determining opportunities and constraints for critical reflection in research in collaboration with researchers at the Department.

1.5. Three areas of intervention

Three broad areas of intervention were identified as providing opportunities for encouraging reflection in research: codes of conduct, interdisciplinary collaboration, and education and training (see table 1). These areas are widely recognised to provide opportunities to engage the question of social responsibility in research practice (albeit in different ways). This section introduces the broad areas of intervention and the case studies.

[6] The Centre for Society and Genomics is the dedicated social research centre of the Netherlands Genomics Initiative. It aims to describe, analyse and improve the relationship between society and genomics research and improve the societal dialogue on genomics. Some fifty researchers at ten universities and institutes take part in CSG's research programme.

Table 1. The case studies and their areas of intervention.

Area of intervention	Case study
Codes of conduct	Implementing the Netherlands Code of Conduct for Scientific Practice
Interdisciplinary collaboration	Applying midstream modulation to encourage socio-ethical reflection in the laboratory
Education and training	Evaluating the Nanobio-RAISE Advanced Courses on Public Communication and Applied Ethics

1.5.1. Codes of conduct

Codes of conduct constitute a first area of intervention. They are widely used as instruments to describe, guide and evaluate what is perceived to be 'good' conduct of the members of professional communities (Royakkers et al.: 2004). In science and engineering, research organisations and institutes have established a range of codes to lay down the norms and values of the research community (Evers: 2001; UNESCO: 2008). Of the many functions that codes can have (Frankel: 1989), two particular aspects make them interesting with respect to the research objective of this thesis. First, codes express the established norms and values of the research community. They 'codify' the responsibilities of the researcher, expressing the expectations of the research community (and outsiders) towards the individual researcher. They provide moral guidelines, serving as a normative reference for the individual researcher. Second, they can invite reflection on the norms and values that govern the research community, possibly initiating discussion on the norms. Both the content of the code and its potential function make it an interesting area of practical intervention to identify opportunities and constraints for realising an alternative vision of social responsibility.

The Netherlands Code of Conduct for Scientific Practice was taken as the object of study because the Department of Biotechnology was considering the implementation of this code at the time of research. The Netherlands Code of Conduct was established by the Dutch Association of Universities in 2005 with the aim to hold scientific practitioners to a proper exercise of their duties. The Executive Board of Delft University of Technology adopted the code and encouraged its implementation in all departments of the university. Thus, while the code predominantly focused on the adherence of researchers to the internal norms of the research community (and was not explicitly concerned with the *social* responsibilities of researchers), it was considered an appropriate object of study because its practical implementation at the level of research practice was foreseen. With reference to the overall objective of this thesis, interviews with the researchers at the Department were held to identify opportunities and constraints of a code of conduct to encourage reflection on the methodological norms that govern research practices.

1.5.2. Interdisciplinary collaboration

Interdisciplinary collaborations between social and natural researchers constitute a second area of intervention, one which has received increasing attention in recent years as a tool to integrate broader ethical and societal considerations in research. The European Commission for instance envisages: *'the initiation of new forms of partnerships between researchers and others actors through 'co-operative research'* in its Science in Society Work Programme (European Commission: 2007, 10). In the United States, the 21st Century Nanotechnology Research and Development Act mandates the integration of nanotechnology R&D with research on societal, ethical and environmental concerns (Fisher and Mahajan: 2006). The Netherlands Organisation for Scientific Research has similarly established a research programme for 'Responsible Innovation' in 2008 that performs studies of the ethical and societal aspects of technological innovations in interaction and cooperation with the technical scientists involved (Netherlands Organisation for Scientific Research: 2008). In response to these emerging mandates, several studies have recently explored the potential of interdisciplinary collaborations between social and natural researchers for integrating wider ethical and societal considerations in research decisions (Doubleday: 2007; Fisher: 2007; Gorman et al.: 2004; Van der Burg: 2009; Van de Poel and Van Gorp: 2006; Zwart et al.: 2006). The results of these studies indicate that interdisciplinary collaborations may assist in broadening the kinds of considerations invoked in research decision making.

The second case study therefore examined the opportunities of interdisciplinary collaboration with respect to the particular objectives of this thesis. It applied the method of 'midstream modulation' developed by Erik Fisher during a three-year study at the Mechanical Engineering department's Thermal and Nanotechnology Laboratory at the University of Colorado, Boulder (Fisher: 2007; Schuurbiers: forthcoming). Fisher showed that specific interactions between nanotechnology researchers and an 'embedded humanist' can broaden the scope of considerations invoked in decision-making in the research laboratory and thereby induce changes in laboratory practices. Because midstream modulation situates interdisciplinary collaboration in the laboratory, focusing on the possibilities to broaden research decisions 'in real time', it was considered an appropriate intervention for the purposes of this thesis: to consider the opportunities and constraints for both encouraging critical reflection in research and bringing broad normative commitments to bear on research.

1.5.3. Education and training

The third and final area of intervention addressed in this thesis is the area of education and training. Opportunities to encourage social responsibility in research by broadening the knowledge, skills and attitudes of researchers have long been recognised (Rose and Rose: 1971; Verhoog: 1980; Rip: 1981; Evers: 2001; Osseweijer: 2006; European Group on Ethics: 2007; McGregor and Wetmore: 2009). Interestingly, the research literature identifies science and engineering education both as one of the causes for the persistence of the neutrality view, and as a possible solution. Beckwith and Huang (2005) ask:

> Why do scientists choose not to engage in those social debates that have important scientific components? When challenged to consider such activism, scientists often respond: 'My role is just to do my science. It is up to the politicians to decide how it is used.' This laissez-faire attitude is fostered by the education of scientists (Beckwith and Huang: 2005, 1479).

They conclude that changes in the education of researchers are needed to counter this 'laissez-faire attitude'. Kathinka Evers suggests what such better education is to look like in a report on the use of ethical standards in science:

> (we) want to include the study of ethics in the scientific education with the hope and purpose of increasing future scientists' ethical awareness and ability to think clearly about intricate – and often emotionally loaded – ethical problems (Evers: 2001, 6).

Such ideas have by now taken root in university education. The inclusion of ethics courses in science education has become widespread, particularly in engineering and applied science curricula. At Delft University of Technology, Master curricula have featured obligatory courses on the ethical aspects of technology and the engineering profession since 1995. In the United States, the Applied Science Accreditation Commission of the Accreditation Board for Engineering and Technology (2008, 2) includes the *'understanding of professional* *and ethical responsibility'* as an explicit accreditation criterion for Applied Science Bachelor and Master programmes. The possible broadening effects of education and training initiatives on the attitudes, skills and behaviour of researchers make it an interesting area of intervention with respect to the realisation of a broadened conception of social responsibility in research practice.

The third case study therefore considers opportunities for encouraging reflection on the broader socio-ethical dimensions of research through education. It analyses the effects of two five-day, residential advanced courses on 'Public Communication and Applied Ethics of Nanotechnology' organised in Oxford as part of the European project Nanobio-RAISE (Nanobiotechnology: Responsible Action on Issues in Society and Ethics). The courses aimed to increase knowledge and awareness of researchers in nanotechnology on the ethical, legal and social aspects of nanotechnology. They were therefore considered an appropriate object of study to identify opportunities and constraints for encouraging researchers to critically reflect on the wider context of their research.

1.6. Research questions

Applying the overall objective of this thesis to the case studies at hand, the following research questions have guided the empirical interventions:

1. **What are the effects of the specific interventions in the three case studies with respect to:**
    a. **encouraging researchers to critically reflect on the socio-ethical context of their work?**
    b. **bringing broad social and ethical considerations to bear on research decisions?**
2. **What opportunities and constraints for encouraging social responsibility in research can be identified in each of the areas of intervention?**
3. **How can these findings contribute to the practical realisation of a broadened conception of social responsibility in research?**

1.7. Chapter outline

Chapter 2 surveys the literature on social responsibility in research. It discusses critiques of the neutrality view and examines the role of broader socio-ethical dimensions with respect to the goals, processes and outcomes of research. Based on Verhoog's (1980) conceptual analysis of social responsibility, it presents a normative framework for the social responsibility of researchers, one that includes a moral responsibility to critically reflect on the value-based socio-ethical premises and consequences of research as well as its ontological, epistemological and methodological foundations. This framework functions as the normative background for the case studies presented in the following chapters.

Chapter 3 evaluates the implementation of the Netherlands Codes of Conduct for Scientific Practice through a series of interviews with researchers at the Department of Biotechnology of Delft University of Technology. The case study focused on specific questions concerning the implementation of the code: how is this code received by specific communities of researchers? What do they see as its role or function? What are their views and opinions about the content of the code and its implementation? While respondents agreed that discussion of the guiding principles of scientific conduct is called for, they did not consider this particular code as such to be a useful instrument. As a tool for the individual scientific practitioner, the code leaves a number of important questions unanswered in relation to visibility, enforcement, integration with daily practice and the distribution of responsibility. While recommendations for further implementation are provided on the basis of the interview results, this chapter concludes that a reconsideration of the norms and principles that govern research conduct might ultimately be more appropriate than the reiteration of those principles in codes of conduct.

Chapter 4 presents the results of two consecutive 'laboratory engagement studies' which applied the method of midstream modulation with the specific intention to encourage socio-ethical reflection in the laboratory. The first lab study was carried out in the autumn of 2008 at the Department of Biotechnology in Delft, and the second in the School of Life Sciences at Arizona State University, Tempe, USA in spring 2009. The studies provide a proof of principle that interdisciplinary collaborations between social and natural researchers in the laboratory may provide a fruitful basis for integrating ethical and social dimensions at early stages of R&D. Midstream modulation served to render the socio-ethical context of research visible in the laboratory and encouraged research participants to critically reflect on this broader context. In addition to providing an opportunity for such early normative assessment, the collaborations also identified a series of deeper challenges and current impediments within the curricular and institutional arrangements and the normative structure of science that hinder integration of broader social concerns in research decisions.

Chapter 5 evaluates two advanced courses organised in Oxford in 2007 as part of the European Nanobio-RAISE project which brought together an interdisciplinary group of experts with the aim to assess the societal and ethical dimensions of nanobiotechnologies. The courses presented several opportunities for engaging researchers in critical reflection on the wider societal concerns and expectations that surround their work by providing a broad overview of relevant socio-ethical aspects of nanotechnological research. This chapter argues that educational programmes aimed at multidisciplinary engagement could be a natural extension of ongoing collaborative research efforts in the lab towards 'better' ethics of emerging technologies (new forms of ethical deliberation in which ethical reflection is part and parcel of the R&D process itself). In addition to exploring how the elements that were conducive to multidisciplinary engagement in this course can be preserved in future courses, this paper suggests shifting the emphasis from public communication towards ethical deliberation. Further course work could thus build capacity among both nanoscientists and nanoethicists for doing 'better' nanoethics.

Chapter 6 finally considers the findings of the individual case studies in light of the overall objective of this thesis. It draws conclusions on the opportunities and constraints of the interventions to engage researchers in critical reflection on the broader socio-ethical context of their work, and examines how these findings can be used to realise a broadened conception of social responsibility in research practice. An approach towards addressing social responsibility in research practice is suggested that combines the strengths of each of the respective interventions, one in which codes of conduct articulate the normative commitments of the research community, interdisciplinary collaborations further specify the meaning of such broad normative commitments, and education builds the reflexive capacity needed for such commitments to take hold in research practice. Lastly, general conclusions will be drawn as to the cultural and institutional implications of efforts to revalue value-neutrality in the applied sciences.

2 Social Responsibility in Research

This chapter surveys the literature on social responsibility in research and presents a normative framework that serves as the background for the case studies presented in the following chapters. I will first provide a brief overview of the historical origins of the debate on social responsibility, followed by a discussion of the neutrality view and its critiques. The particular claims of the neutrality view will be visualised by way of a conceptual model of the R&D cycle. This analysis points out how arguments for value-neutrality have become contested with respect to each of the separate stages of the R&D cycle: cultural values turn out to play a role throughout the process. In response to these findings I will examine alternative views of social responsibility in research. Note that the purpose of this chapter is not necessarily to advance academic theorising on the concept of social responsibility, but rather to establish a framework that can serve as a normative background for the interventions in subsequent chapters. This framework will be based on the work of Henk Verhoog (1980) and others. In short, this view broadens the social responsibility of researchers to include a moral responsibility to critically reflect on the socio-ethical context of their work. This broadened conception of responsibility shifts the emphasis from passive adherence to existing norms towards an attitude and willingness to take morally relevant implications into account. But before going into that discussion, let us first turn to the origins of the debate.

2.1. Origins of the debate on social responsibility in research

The question of the social responsibility of the scientist may be as old as the idea of science itself. Rip (1981) provides an account from 1531 of the Italian mathematician Niccolo Tartaglia, who was concerned about the potential consequences of his mathematical theory of the trajectory of a cannonball. Applying his theory would allow for firing a cannon with greater precision, but the perfection of an art which is aimed at the destruction of his fellow men was, according to Tartaglia, 'disgraceful and barbaric'. Tartaglia thus faced an exemplary question of social responsibility: to what extent should considerations of the societal context of research be allowed to drive the development of research itself? Throughout history, there have been forces towards the separation of science from the worldly considerations that surround it, and forces towards their integration (Kass: 2004). In the 20th century the dispute has become a topic of central concern. Demands to integrate the societal dimensions of research have peaked at those times when scientific inventions threatened to destabilise existing social structures: think of the eugenics debate in the first decades of the 20th century, the development of the atom bomb during World War II, or the invention of recombinant DNA technology in 1974 for example. Although the specific themes characterising these debates have changed over time, they all express, in one way or another, a societal negotiation process on the obligations of scientists towards society, on what is to count as science's contribution to social progress, indeed, on what is to count as social progress at all. One of the central themes recurring in those big debates of the 20th century is the question of the cultural autonomy of the scientific community. Generally speaking, the cultural autonomy of a social subsystem is to a large extent conditional upon its endorsement by the wider social system of which it is a part (Hogenhuis: 1993). If for some reason uncertainty arises whether the goals of the subsystem are conducive to those of the wider society, its autonomy is challenged – society will demand increased social control or democratic oversight (think of the widespread calls for governmental control over the financial system which arose after the global credit crunch of 2007 for instance). As a result of growing uncertainty about the social merits of scientific invention, the autonomy of the research community has similarly been challenged at various times in the 20th century: should the relative autonomy of science as a social subsystem be constrained (Bernal: 1939)? Can we expect the subsystem to self-regulate or is external regulation necessary, and if so, how? Over time, a long list of stakeholders has joined the debate on the social responsibility of the researcher: natural scientists, politicians, activist social scientists, environmentalists, consumer interest groups, philosophers, sociologists and historians of science, theologians, and so forth.[7]

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7 Interestingly, the concept of social responsibility possibly implies both appraisal and admonition, depending on the interpretation of 'responsibility' (a point to which we will return at the end of this chapter). On the one hand, social responsibility is one of those terms, like 'integrity' or 'sustainability', that regularly figures in mission statements and company reports because it intuitively sounds like being in touch with our wider social and natural surroundings - who doesn't want to be socially responsible? On the other hand, social responsibility can also be used as a reproach: researchers have been held socially responsible for the negative consequences of their research. Social responsibility is a container term, or what Mark Bovens

Due to widely divergent views on the appropriate role of science and technology in society however, achieving closure on these issues has proven extremely difficult. The concept of social responsibility engages several questions of a different nature all at once. There is the normative question that Tartaglia faced: to what extent is the researcher *accountable* for the use that society makes of his discoveries? Should the researcher *take responsibility* for considering the possible consequences? And how does this relate to the *role responsibility* of a researcher, whose primary task it is, after all, to develop new knowledge? These questions are further complicated by the difficulty to establish to what extent the research outcomes factually contributed to the social consequences, and thereby to what extent the researcher can be said to be *causally* responsible for the observed effect (see also page 42 for an analysis of different interpretations of responsibility).

To structure the different types of claims being negotiated under the umbrella of social responsibility, the following sections will present and discuss the neutrality view, and the claims raised against it, by way of a conceptual model of the R&D cycle. Note that this portrayal of the neutrality view is an ideal-type. It represents, for purposes of clarification, the extreme end of the spectrum of possible views on social responsibility, combining ontological and epistemological assumptions which may not be held in this particular form by any particular individual (although its constituent elements can in fact be recognised as part of the traditional research ethos). The purpose of this survey of claims for and against the neutrality view is not to take a definitive stand on each of these individual claims. Rather, the sheer variety of objections raised against the neutrality view is a motive in itself to at least consider different ways of understanding the social responsibilities of the researcher. As Rip (1981) points out, it is impossible (in principle) to define *the* social responsibility of the researcher. The conceptual framework introduced at the end of this chapter therefore does not attempt to define substantive norms, but invokes a procedural norm: the moral responsibility to critically reflect on the wider socio-ethical context of research. The empirical interventions presented in the subsequent chapters of this thesis have aimed to honour this complexity: the researcher's predicament

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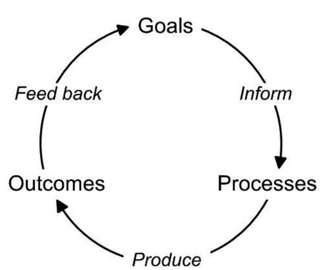
has called a 'Sunday concept', an idea that doesn't serve as a point of departure for one's actions: *'but which in Sunday rhetoric sounds all the better … because everyday life throughout the week is not burdened by it'* (Bovens, 1998).

with respect to acting on her social responsibility is to be understood in light of often diametrically opposed expectations from different stakeholders.

2.2. The R&D cycle

The R&D cycle can be conceived of as an iterative process in which research *processes* (a series of experimental and argumentative investigations undertaken to confirm or refute initial hypotheses in light of empirical data) are performed in light of certain predefined research *goals* (in the form of research mandates, objectives or questions), eventually leading to research *outcomes* (scientific knowledge as embodied or codified in publications, patents, products and the like). Research outcomes may occasion new research goals, leading to a next iteration of the knowledge production cycle (see figure 1). The overall R&D process can be interpreted as an agglomeration of nested cycles, ranging from broad-level research programmes down to the level of individual research projects.

Figure 1. The Research and Development (R&D) Cycle.



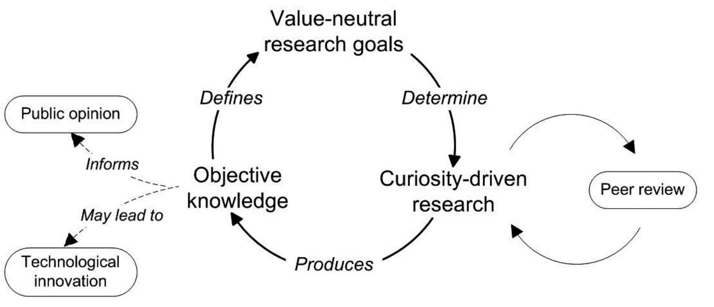
2.3. Re-examining the neutrality view

This schematic representation of the R&D cycle can be used to visualise the neutrality view of the social responsibility of the researcher. As indicated in the introduction, the neutrality view basically asserts that the primary responsibility of the researcher consists in producing reliable, objective knowledge about the world through a process of disinterested, curiosity-driven research. It is the responsibility of the research community to ensure the continuity of this process by maintaining a research ethos that fosters epistemic values, the kinds of values that are presumed to promote the 'truth-like character of science' (McMullin:

1983) such as predictive accuracy, internal coherence, external consistency, unifying power, fertility, and simplicity (Ruse: 1999), and keeps cultural values (such as religious, political, ethical or personal values and beliefs) at bay. Hence, it is the researchers' *duty* to steer clear of the broader socio-ethical context in which research operates. In terms of the conceptual model of the R&D cycle, knowledge production is represented as an autonomous process that is largely independent of the wider social subsystem that surrounds it, a closed loop in which value-neutral research goals drive a process of disinterested, curiosity-driven research that eventually leads to the accumulation of objective knowledge about the world. The research findings in turn determine the new research goals that occasion the next iteration in the knowledge production cycle. Quality assurance, furthermore, is also an internal affair of the research community: peer review processes ultimately determine the acceptance of new research findings (see figure 2). Although the research outcomes – objective scientific knowledge – may eventually diffuse into society by knowledge dissemination or technological innovation (see the left hand-side of figure 2), such processes of social uptake are beyond the realm of the researcher's responsibility. To be sure, this representation of the neutrality view is as neutral as it gets. As will become clear from the discussion below, there are more sophisticated versions that grant a measure of cultural values in the research goals (such as social justice) or recognize the cultural value of research outcomes (such as the right to information) while maintaining the value-neutrality of the research process.[8] But let us stick with this base-line representation for the moment, because it defines quite clearly the dominant frame of reference for understanding the responsibilities of researchers.

[8] In fact, even some of the strongest neutralists recognize a responsibility to communicate the outcomes of research to the wider society, although they do not necessarily see it as *their own* responsibility.

Figure 2. The Neutrality View.



The neutrality view is supported by strong political and philosophical rationales. Politically speaking, a research community that is neutral with respect to the wider ethical and social debates occurring in the society that surrounds it, in a sense safeguards the sphere of knowledge production from undue external influences. When the Royal Society, the oldest association of scientists, was officially founded in 1660, its members determined that:

> The business and designe of the Royall Society is, to improve the knowledge of Naturall things and all usefull Arts, Manufactures, Mechanick practices, Engynes & inventions by Experiments. Not meddling with Divinity Metaphysics, Moralls, Politicks, Grammar, Rhetorick or logick [sic].[9]

In other words, political, philosophical and ethical issues were not considered to be the Society's business. As Paula (2008) notes, the newly established power of scientists was considered a possible threat to the powerful institutions of the time: the Church and the State. The statutes of the Royal Society thus carved out a self-contained area for the disinterested pursuit of knowledge, making sure to distinguish it from the pursuit of power (Hogenhuis: 1993).

In addition to the political convenience of value-neutrality, the positivist and logical empiricist philosophies of science of the 20th century provided philosophical foundations for the demarcation of scientific research, as the objective production of facts, from the value-based discussions that surround it. Logical

[9] Authorship of this text is usually attributed to Robert Hooke, but there is some uncertainty whether he was in fact the author. See Hunter (1995: 173).

empiricism separated knowledge, as a purely descriptive enterprise, from ethics, as a purely normative enterprise (Hempel: 1965; Reichenbach: 1951) – the proper role of science was to discover objective truths about the world, to be separated as far as possible from normative discussions. Douglas (2009) points out that the value-free ideal, the notion that ethical and social considerations have no role to play in scientific research, has become the dominant frame of reference in the philosophy of science from the 1960 onwards. It has also left its mark on the ways that researchers and policy makers interpret the role of values in science: neutrality with respect to cultural values has become the norm within research communities. The general picture is this: the task of the researcher is to acquire objective, reliable data about the world, independent of one's personal beliefs or convictions. Only when the facts are out on the table can society make up its mind to decide what to do with it.

The neutrality view would probably not be problematic if it were true that the production of scientific knowledge is wholly unrelated to the goings of the wider society, apart perhaps from serving as hobby material for interested outsiders. But its critics have judged otherwise. They have argued that one cannot ignore the impacts of science on society, nor maintain that the research community is neutral with respect to the purpose of science in society, or for that matter assert that cultural values have no role to play in the research process itself. In light of the social function of current-day science in society, these critics argue, the neutrality view is in urgent need of revision. The following sections will survey the kinds of objections raised against the neutrality view, passing through each of the stage of the R&D cycle – goals, processes and outcomes – one by one. Even though there is room for debate on the weight of each of the individual objections, the aggregate of concerns suggests that the neutrality view merits reconsideration.

2.4. Research outcomes: social impacts

The final stage in the R&D cycle will be discussed first: the societal impact of research outcomes. While the neutrality view asserts that the ways society decides to make use of research findings is not the researcher's business, a range of historical examples have cast doubt on this assertion. Consider the development of the atomic bomb for example, which may have been the single most important event in the debate on social responsibility. The devastating consequences of the knowledge that arose out of advances in atomic physics irrevocably showed the potential of social disruption through scientific invention. Researchers quite suddenly realised that the social consequences of research could not justifiably be said not to be their business, what with scientific knowledge being centrally implicated in the development of this awesome weapon. It has led many a researcher to conclude that science had forever lost its innocence (Beckwith and Huang: 2005; Russell: 1960; Stemerding: 1976; Van Melsen: 1969;). As Badash (2005) notes:

> The explosions over Hiroshima and Nagasaki not only made society more aware of the importance of science, they made scientists more aware of their responsibility to society (Badash: 2005, 138).

Although the development of the atomic bomb arguably forms the centrepiece for the discussion on social responsibility in science, it was not the first time that the use of scientific knowledge for purposes of war gave rise to debates on social responsibility, nor was it the last (Evers: 2001). The use of chemical agents during the First World War (Lengwiler: 2008; Rip and Boeker: 1975) unleashed a debate on the social responsibility of the researchers involved in their development. Such debates have reappeared each time science and technology were militarized such as during the Vietnam war when napalm, antipersonnel gases and defoliating agents were used (Neilands: 1971), and more recently in relation to activities undertaken to counter (or expedite) acts of bioterrorism (Guillemin: 2005). The central claim behind these debates can be summarised as follows: the fact that researchers causally contributed to the possibility of new forms of warfare implies that they are socially accountable for the consequences of their actions. One may wonder whether such a claim is entirely justified: the causal chain from scientific invention to military application is complex and involves a multitude of actors. This invokes the problem of 'many hands': if research is largely a distributed process in which many individuals have contributed to the end product, then responsibility cannot be meaningfully attributed to any specific individual, even if the outcome is deemed morally problematic by the actors involved (Cohen and Grace: 1994). Still, the use of knowledge for military purposes seems to complicate the claim that the responsibility of researchers is limited to the development of knowledge only.

Concerns about the responsibility of researchers for the results of their work have not been restricted to military applications of science and technology alone. Scientific advances in chemistry, biology, physics and medicine have repeatedly given rise to debates on the social responsibility of the research community. The eugenics debate for example, which first appeared in the early decades of the 20th century but was recently revived in the wake of developments in genetics, centres on the moral acceptability of extrapolating scientific insights to justify (questionable) social programmes for the improvement of the human population (Allen: 1975). Similarly, the invention of recombinant DNA technology in 1974 marked the beginning of a long and hefty debate about the use of genomic techniques to improve biological systems, a debate which continues to date. These examples point out that the consequences of research cannot so easily be said not to be the business of the researcher. But what then, *is* the business of the researcher?

That question is further complicated by the growing influence of science and technology on daily life. The moral and social challenges brought forward by science-based technological innovations have led to a widespread feeling of concern whether the fruits of science are conducive to the goals of society. Robert Merton had already described this concern in 1938:

> Concern with the primary goal, the furtherance of knowledge, is coupled with a disregard of the consequences that lie outside the area of immediate interest, but these social results react so as to interfere with the original pursuits. ... Precisely because scientific research is not conducted in a social vacuum, its effects ramify into other spheres of value and interest. Insofar as these effects are deemed socially undesirable, science is charged with responsibility. The goods of science are no longer considered an unqualified blessing (Merton: 1938, 284).

This ambivalence about the role of science and technology in society deepened in the later decades of the 20th century, due to the increasing effectiveness of the applied sciences to transform new scientific knowledge into applications, enabling a range of science-based technological innovations that have transformed our way of life over the course of the century. On the one hand, technological innovation has contributed significantly to human well-being and economic prosperity (at least in the Western world). On the other hand, in most cases their contribution seems to have come at a cost. New technological developments often pose complex moral dilemmas: the revolution in information and communication technologies enabled instant global communication and trade, but also presents issues of privacy and control. Medical technologies such as genetic testing offer significant promise for the prevention and treatment of diseases but also invite questions on the fair use of genetic data, confidentiality and the right to information. The emergence of sophisticated monitoring technologies such as Radio Frequency Identification (RFID) improves logistics but challenges consumer privacy and security. What makes these issues even more complicated is that the social consequences of technological innovation are often difficult to predict: products that were originally introduced as miracle materials like plastics, asbestos and DDT turned out to have drastic ecological and health effects. Toxicological studies of carbon nanotubes (Poland et al.: 2008), the miracle material of the present, have given rise to concern that nanotechnology could offer similar unexpected surprises.

In summary, a clear view of the social responsibility of the researcher is blocked by the entanglement of knowledge production and application as well as the omnipresence of science-based innovations in daily life, making it impossible to establish causal links between research outcomes and the eventual social uptake of technological innovations. Public attitudes towards science and technology in the 21st century are characterised by deep ambivalence, combining high expectations with strong uncertainty. From nuclear power to genetically modified crops, biofuels, mobile phone masts, stem cell research and cloning, the list of public controversies over new technological developments continues to grow, giving rise to calls for public oversight and social control over technological development. Nowotny, Scott and Gibbons make the point very clearly:

> Science has spoken, with growing urgency and conviction, to society for more than half a millennium. Not only has it determined technical processes, economic systems and social structures, it has also shaped our everyday experience of the world, our conscious thoughts and even our unconscious feelings. ... In the past half century society has begun to speak back to science, with equal urgency and conviction. ... Science has had to come to terms with the consequences of its own success, both potentialities and limitations (Nowotny et al.: 2001, 1).

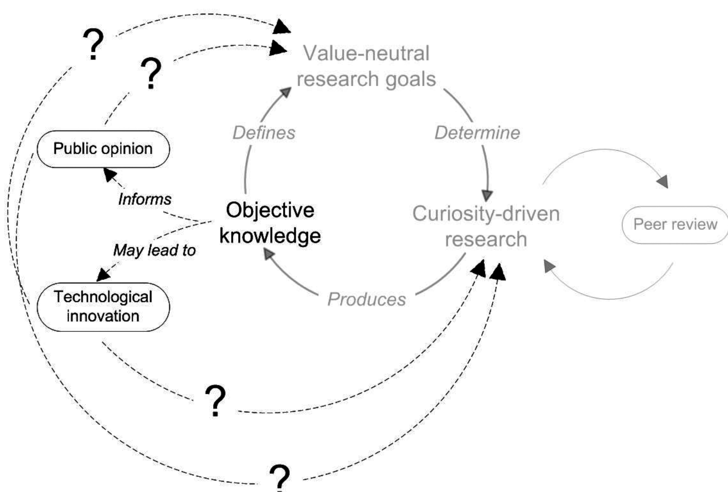
2.4.1. Taking social impacts into account

In summary, the social significance of research outcomes demonstrates that science and technology do not appear in a vacuum: their societal impact has given rise to repeated calls for social appraisal. This also has implications for the question of the responsibility of researchers for the consequences of their work. The fact that the production of scientific knowledge has an impact that extends beyond the research community and into society complicates the claim that researchers have no business with the use society makes of its discoveries. Particularly the entwinement of science-based technological innovations in modern societies seems to call for mechanisms by which to relate the impacts of technology back into the research cycle. Stemerding (1976) suggests that:

> Given our increasing ability to manipulate our surroundings through technical-scientific developments, the question arises to what extent we wish to do so. … In other words, the denial of the socio-political questions put forward by scientific developments … makes the delimitation of responsibility of scientists for the development of their science only untenable.

In terms of the conceptual model of the R&D cycle, the need for science to 'come to terms with the consequences of its own success' calls for feedback mechanisms that relate the outcomes of research to the goals and processes by which the outcomes have been produced (see figure 3):

Figure 3. Taking the social impacts of research into account.



Precisely what such feedback loops are to look like is still a matter for debate. The design and implementation of such accommodating mechanisms have traditionally occurred under the header of 'Technology Assessment', which, according to Schot and Rip (1997) can be characterised by an overall philosophy:

> …to reduce the human costs of trial and error learning in society's handling of new technologies, and to do so by anticipating potential impacts and feeding these insights back into decision making, and into actors' strategies.

Technology assessment initiatives originally sought to feed back assessments of research outcomes into research funding decisions (*cf.* Fisher et al.: 2006). Due to the realisation that social processes enable and constrain technological development trajectories throughout, technology assessment over time evolved into more interactive and constructive forms (Barben et al.: 2008; Grin and Van der Graaf: 1996; Guston and Sarewitz: 2002; Schot and Rip: 1997). While staying true to the overall philosophy, these different forms of technology assessment aim to influence R&D processes themselves as well as their outcomes by incremental modulation of research processes (Fisher and Nahajan: 2006; Rip: 2007).

Questions of implementation aside, the purpose of this section was to point out that the social significance of research outcomes suggests the need to 'open up' the R&D cycle, incorporating feedback mechanisms that relate the consequences of research to R&D goals and processes. Note that these feedback mechanisms in themselves do not necessarily undermine the neutrality view of the social responsibility of the researcher. While the neutralist may acknowledge that the outcomes of research on occasion call for their appraisal in terms of their cultural significance, she may still maintain value-neutrality with respect to the goals and processes of research. On this interpretation, scientific knowledge is seen as a double-edged sword which can be used for good or for bad, depending on how society chooses to use that knowledge – but the knowledge *itself*, and the ways it has been produced, may still be objective and value-free. To investigate this claim, the following sections will look more deeply into the remaining stages of the R&D cycle, beginning with a consideration of the goals that drive research.

2.5. Research goals: social relevance

Moving up one step in our analysis of the R&D cycle, this section will consider different views on the role of cultural values in determining the goals that drive research. The neutrality view suggests that the determination of research goals is, or should be, an internal, autonomous process: it is the research findings themselves that should lead to the new research goals that drive the next iteration of the cycle. These research goals are themselves to be neutral with respect to cultural values, driven purely by a thirst for new knowledge – the internal pursuit of knowledge is to proceed unfettered. Thus, in the neutrality view, it is the *intrinsic* value of knowledge that drives research.

Whether or not knowledge has a value in and of itself, it is unlikely that this intrinsic value accounts for the hundreds of billions of dollars currently being spent on R&D worldwide (OECD: 2009). Such research investments are probably driven by expectations of *instrumental* value: the possibility to make practical use of the knowledge being developed. Indeed, the growth of knowledge production systems in the 20th century is predicated on their expected contribution to technological innovation. Policy texts invariably link R&D expenditure to social progress.[10] The European Commission's 'Europe 2020' strategy for instance states that:

> A greater capacity for research and development as well as innovation across all sectors of the economy, combined with increased resource efficiency will improve competitiveness and foster job creation. ... Investing in research and development as well as innovation, in education and in resource efficient technologies will benefit traditional sectors, rural areas as well as high skill, service economies. It will reinforce economic, social and territorial cohesion (European Commission: 2010, 9).

Research thus operates as part of a wider 'telic' enterprise: progress in research is believed to result in social progress. This is reflected in the commitment to social relevance that is generally found in research proposals. Socially relevant research programmes are more likely to receive funding.

Gibbons et al. (1994) identify the changes that have occurred in the justifications for research as a result of a transformation from 'Mode 1' to 'Mode 2' knowledge production. There are other analyses as well, such as 'academic' towards 'post-academic' (Ziman: 2000), or 'normal' and 'post-normal' science Funtowicz and Ravetz: 1993). While there are essential differences between the different analyses (*cf.* Hessels and Van Lente (2008)), they all emphasise a noticeable shift from traditional, small-scale, knowledge-oriented, academic, disciplinary modes of knowledge production towards the large-scale, application-oriented, privately funded, multidisciplinary approaches that characterise current-day research. This new mode of knowledge production seems to demand new forms of justification for knowledge production: the fact that research funding decisions are made with expectations for social benefit, and that researchers justify their research with reference to social benefit undermines the neutrality view with respect to the goals of research. Critics of the neutrality view have argued that the methodological norm of value-neutrality is illegitimately transferred to the social context. By ignoring the social values that account for

10 Edgerton (2007), among others, has argued that the relation between scientific invention and economic growth may not be as clear-cut as suggested.

research funding, progress in research is equated with social progress. According to Stirling, this results in:

> ...an unreflexive normative teleology in which the manifest unfolding of scientific and technological trajectories is itself taken as the principal evidence of their intrinsic social merit (Stirling: 2006, 233).

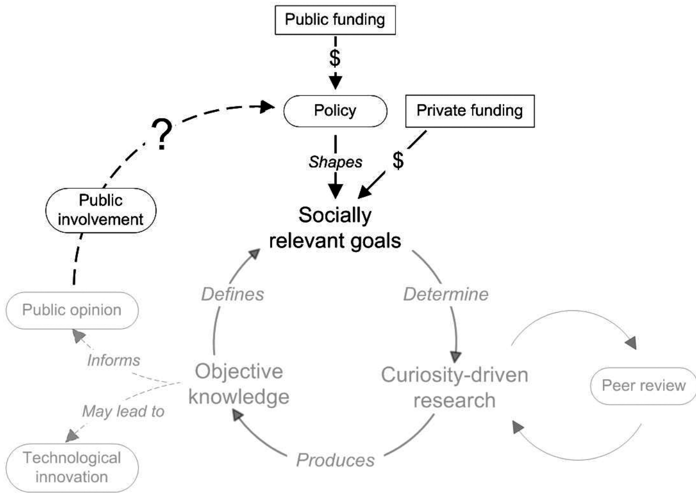
The normative commitment to value-neutrality with respect to the social values embodied in research goals in their view 'neutralises' the discussion of those value commitments. Some social science scholars have reversed the order of the argument: instead of developing science and expecting social progress, they have argued for a notion of social progress and ask how science can be used to contribute 'improve the lot of humankind' (Cross and Price: 2006). Their commitments have led them to suggest a reversal of the drivers behind knowledge production: from 'knowledge push' to 'society pull', to be achieved through increased public participation in setting the goals for knowledge production. One example that gained popularity in recent years is the notion of 'upstream public engagement'. As Wilsdon and Willis (2004) note in See-Through Science:

> Downstream, the flow of innovation has absorbed numerous engagement processes. Yet few of these have any real connection to the upstream questions that motivate public concern: *Why this technology? Why not another? Who needs it? Who is controlling it? Who benefits from it? Can they be trusted? What will it mean for me and my family? Will it improve the environment? What will it mean for people in the developing world?* The challenge -and opportunity - for upstream public engagement is to force some of these questions back onto the negotiating table, and to do so at a point when they are still able to influence the trajectories of scientific and technological development (Wilsdon and Willis: 2004, 28).

2.5.1. Taking social values into account

Summarising the argument thus far, social values do play a role in the determination of research goals. Research performs specific social functions, depending on the conditions on which funding is attributed. The application-oriented nature of applied research makes it difficult to maintain the neutrality view with respect to the research goals. This may be represented in the conceptual model of the R&D cycle by integrating the explicit consideration of the wider policy context that determines which research goals are to be pursued (see figure 4).

Figure 4. Taking social values in research goals into account.



Which values to invoke is a political question, and the answers given depend on political worldviews. I do not intend to propose one answer to that question here. The point is rather that whatever political stance one takes, the instrumental rationales for research funding complicates value-neutrality with respect to the goals set for research. The following section will examine objections raised against the neutrality view at the level of the research process itself.

2.6. Research processes: cultural values in research

The moderate neutralist may grant that the social significance of research outcomes implies a responsibility, at least on occasion, to reflect on the social consequences of research; she may also grant that the wider policy context in which research operates demands consideration of the social values that research supports. But surely, once the research questions are on the table, the proper approach to doing research is to subject one's hypothesis to the most rigorous scientific testing, and let the facts speak for themselves whatever one's personal views? Isn't the exclusion of worldly considerations, be they political, philosophical or religious, what sets the scientific endeavour apart from all other forms of reasoning? Isn't the beauty of research that any researcher, who would scrupulously apply the principles of scientific method, would draw the same conclusions from experiments on a set of data, whether they be a middle-aged, white American born-again Christian, a French feminist atheist or a Vietnamese Buddhist monk? Unfortunately for the neutralist, social research has claimed otherwise. In what Verhoog (1980) has called the 'age of questioning' which started during the late 1960s, the research community and the methods it adopts have been scrutinised by science and engineering ethicists, philosophers, historians and sociologists of science among others. Systematic studies of 'science in the making' (Latour: 1987) have cast doubt on the absence of cultural values during research process themselves. These studies can be roughly divided into two classes: the types of study that investigate the practical adherence of researchers to the cultural norm of value-neutrality in research (which can be said to belong to the fields of engineering ethics and science policy studies); and those that examine the theoretical validity of claims to neutrality (belonging to the realm of science and technology studies). Especially in the second area, the neutrality view has been contested.

With respect to the question of adherence, engineering ethicists have studied research misconduct, types of deviant behaviour with respect to the methodological norms of the research community. Their work has resulted in a view of the research community that struggles to uphold Merton's (1938) scientific ethos of CUDOS: communalism, universality, disinterestedness and organised scepticism. There are notorious cases such as the story of the Korean researcher Hwang Woo-Suk who was sentenced to two years conditional imprisonment in October 2009 for embezzlement of research funds and illegal purchase of human egg cells after a brief claim to fame by (unrightfully, it turned out later) publishing the cloning the first human embryos in Science in 2004. Another case is Jan-Hendrik Schön who was accused of fraudulent reporting shortly after publishing a series of spectacular breakthroughs in physics (Mitcham: 2003; Consoli: 2008). But beyond such well-known individual cases, recent studies on image manipulation in research manuscripts (Gilbert: 2009), plagiarism in digital publications (De Jong: 2009), and nepotism in peer review (Wennerås and Wold: 1997) suggest that fraud and plagiarism may be more widespread than expected. These and other cases have cast doubt on the aptitude of the research community to assure the integrity of the research system, leading to calls for increased oversight and control. Similar calls for strengthening the integrity of researchers can be heard in the area of science policy studies. Scrutiny of the use of scientific knowledge and the role of researchers in political decision-making suggests that the use of 'objective' scientific facts often serves political purposes (Guston: 2000; Wynne: 2006; Yearley and Collins: 1992). The recent commotion over reported errors in the International Panel on Climate Change underline this point. The extent to which scientific advice can be value neutral in the political domain, and the conditions for researchers to be 'honest brokers' (Pielke: 2007) is a matter for continued debate.

While the reported lack of adherence to the norm of value-neutrality obviously presents problems of enforcement, it does not necessarily endanger the validity of the norm itself. In a way, it is no more than logical to expect that some members of the research community will find it difficult to resist the temptation of concluding what their funding agencies of superiors expect them to conclude, especially when the stakes are sufficiently high, as studies of the undue influence of pharmaceutical companies in medical research (Krimsky: 2004), and of the role of tobacco companies in medical studies of the health effects of smoking (Meade: 1996) point out. These cases may fly in the face of the image of researchers as trusted experts who uphold the rigorous standards of the scientific community against political and commercial interests, but they do not necessarily endanger the view that there *is* such a thing as objective, value-neutral research. Rather, they strengthen that view: while some researchers may be found to deviate from accepted scientific norms, it is precisely this deviant behaviour that presupposes the existence of non-deviant behaviour – that not all researchers are as disinterested as they should be, can be interpreted as evidence that it is possible to *be* disinterested, and this is what 'good' science is (which explains efforts of research institutes and associations for upholding the normative standards of science, *cf.* Schuurbiers: 2008).

Critiques of the neutrality view from the area of science and technology studies however constitute a deeper claim. They focus on the validity of the claim for value-neutrality itself. Various sociological analyses of knowledge production have 'deconstructed' the view of science and technology as the disinterested discovery of objective scientific facts (Bijker and Law: 2002; MacKenzie and Wajcman: 1985; Knorr-Cetina: 1999; Knorr-Cetina and Mulkay: 1983). These studies radicalise the scientific relativism that can be inferred from Kuhn's (1962) philosophy of science. Although it is debatable whether Kuhn himself would agree with this interpretation of his views, his contention that scientific truths are always truths *within a paradigm* throws doubt on the presence of objective criteria by which to decide between competing scientific theories. If an observer has access to the world only through subjective forms of knowledge – the beliefs and convictions that make up the paradigm – if, in a sense, the paradigm *creates* reality, there can be no objective, outside measure to judge among paradigms.

Latour and Woolgar's *Laboratory Life* (1979) has become an influential exponent of such relativism with respect to the objectivity of research. It provides an ethnographic account of research activity in a neuroendocrinology laboratory that portrays the production of facts as an intrinsically social process; the production of facts proceeds by way of a complex series of social negotiations. The work of Latour and Woolgar inspired a range of laboratory ethnographies which ultimately gave rise to a wide array of critical analyses. The general idea that the production of facts is an intrinsically social process can be classified as a social constructivist view of research. On this interpretation, science is not the objective process in which disinterested researchers uncover the objective facts about the world. The 'facts' should be interpreted as 'artefacts': social constructs, 'truths' within very specific temporal and cultural limits at best, not the kind of objective truths valid anywhere, anytime. The social constructivist sees science as governed by '*diverse forms of contingencies rather than objective truth seeking*' (Stirling, 2008, 13), and therefore stresses the *'the plural and conditional natures of science and technology'* (ibid, 40). Social constructivist views clash with the views of 'scientific realists' who maintain that the scientific method serves to provide facts about an objectively knowable world (see figure 5). The complexity of their dispute lies in the fact that it is simultaneously about ontology (about the things that exist in the world), epistemology (how we come to know that world), and methodology (the working principles of knowledge production). Given the opposition between these views, and particularly the consequences of holding such a view led, to some extent understandably, to the bitter disputes in the 1990s that have become known as the 'science wars'.[11]

[11] The science wars culminated in the so-called Sokal affaire in which a bogus article of physicist Alan Sokal made it to an edition of *Social Text* in 1996 which, ironically, was devoted precisely to understanding the science wars (Flyvbjerg: 2001).

Figure 5. Taking cultural values in research processes into account.

Figure 5a. Scientific realism.

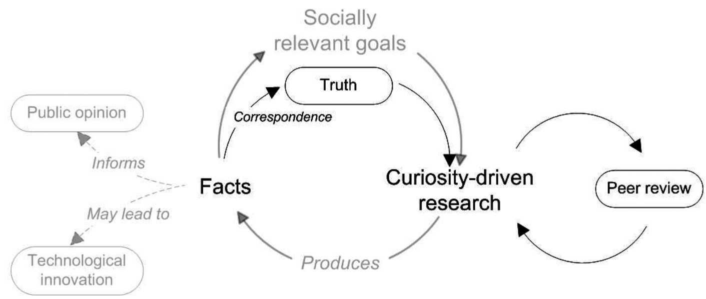
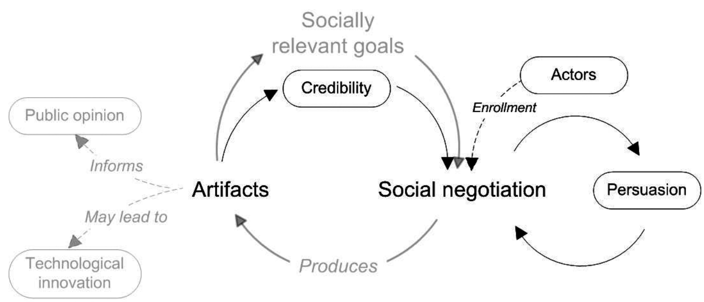


Figure 5b. Social constructivism.



2.6.1. Taking values into account in research

The relevance of this dispute to our discussion of the neutrality view is that social constructivism, by defining knowledge as an intrinsically social construct, contradicts the very possibility of value-neutrality in research: the distinction between facts and values itself has evaporated. The implication of the social constructivist view is that scientific research has no special claim to the discovery of truths about the world, because what is to be determined as truth is itself the consequence of social conventions. Indeed, social science scholars have opposed the dominant role of scientific knowledge (as opposed to other forms of expertise) in technological decision-making (Wynne: 1995; Wynne: 1996); others have claimed that the overall pervasiveness of technologies demands a process of social shaping (Pinch and Bijker: 1984). Commenting on the perceived need to 'improve' the social acceptability of technology as a reaction to negative public perceptions of agricultural biotechnology, Marris et al. remark:

> It is perhaps not so much the misguided public which needs to be reformed, but the institutional practice and technological objects which this public is reacting against (Marris et al.: 2001, *14*).

Admittedly, there are difficulties involved in dispensing with the fact-value distinction. In its most literal sense, social constructivism is self-defeating: if it is impossible to distinguish claims to truth by some form of correspondence with the world 'out there', then neither can the claims of the social constructivist be awarded any special status. It seems that the very nature of truth claims essentially presupposes some external standard of verification. Without it, human reasoning quite literally becomes 'all talk'. Also, strong relativism leads to problems with authority: if there is no measure of 'truth' to determine whether one opinion carries more intrinsic weight than another, this ultimately undermines claims to expertise and hence authority. Even the most adamant supporters of social constructivism, those scholars that have contributed to the erosion of trust in scientific authority, have recently become concerned to see how the democratisation movements of the last decades have eroded public trust in authority, especially scientific authority, and are now calling for 'repair work'. Bijker, Bal and Hendriks (2009) attempt to 'repair' objectivity by distinguishing between 'front-stage' and 'back-stage' objectivity: even if scientific truths are ultimately social constructions (implying that there is no 'real', back-stage objectivity to be found in science if one only looks deeply enough into the construction of scientific 'facts'), there seems to be a need to safeguard the front-stage objectivity in terms of the 'hardness' and 'durability' of research findings (its 'front-stage' objectivity).

The point of this survey is not to speculate on the validity of the claims of scientific realists versus those of the social constructivists. Dogmatic interpretations of the claims made on both sides of the spectrum lead to inconsistencies - the 'truth' (for want of a better word) probably lies somewhere in the middle. But the value of the social constructivist analyses lies in their deconstruction of naïve correspondence theories of truth, in their power to visualise the social dimensions of the production of scientific facts. Research cannot simply be assumed to be entirely devoid of value judgments: even at the very heart of the scientific enterprise, the neutrality view merits reconsideration. The following section will consider what this might imply for the notion of social responsibility in research.

2.7. An alternative view of social responsibility

We have come full circle in our analysis of the R&D cycle. Passing through each of its consecutive stages one by one, different types of claims raised against the neutrality view have been analysed. The social significance of research outcomes cast doubt on the assertion that researchers have no business with the use society makes of its discoveries. The promises and expectations that guide research funding decisions implied that researchers cannot ignore the value commitments embodied in research goals. And finally, cultural values were seen to play a role even at the level of research processes themselves. Even if some of the objections outlined above seem to carry more weight than others, it has become difficult to dismiss the value-ladenness of the overall R&D process. As John Ziman notes:

> Post-academic science has features that make nonsense of the traditional barriers between science and ethics. … Even the 'purest', 'most basic' research is thus endowed with potential human consequences, so that researchers are bound to ask themselves whether all the goals of the activity in which they are engaged are consistent with their other personal values. … One of the virtues of the new mode of knowledge production is that it cannot brush its ethical problems under the carpet. Science can no longer be 'in denial' of matters that many of us have long tried to bring to the fore (Ziman, 1998: 1814).

Over the last decade or so, some consensus seems to be emerging that the 'social contract' between science and society is in need of revision (Rip: 2007; Gibbons: 1999). In a speech to the Austrian Academy of Sciences in Vienna on 20 January 2006, European Commissioner for Science and Research Janez Poto□nik stated that:

> Science should not live in an ivory tower. Ivory towers are now an architectural rarity. It is the responsibility of all of us to ensure that scientific endeavour is more and more embedded in the wider society.

This quote indicates a willingness to broaden the kinds of considerations invoked in research decision-making, to reconsider the neutrality view of the social responsibility of the researcher. The question is: what should an alternative vision of social responsibility look like, if it is to do justice to the insights outlined above? The aim of the admittedly rather long introduction to the broad dynamics of the debate on social responsibility was to show that any attempt to address the question of social responsibility in research, while timely, faces a complex situation. Opening up to the socio-ethical context of research invites several dilemmas that the neutrality view had kept at a distance. In the neutrality view, research had a clear purpose: to produce objective, reliable knowledge. But when broader social values are taken into account, the question what goals research is to pursue becomes a *political* question (precisely what the Royal Society was afraid of). Similarly, if the consequences of research are to be taken into account this introduces a range of extra-scientific considerations of which it is unclear how to deal with them. And finally, if research processes are not objective, the question arises how the integrity of research is to be assured. The reconsideration of the neutrality view thus invites a range of complicated questions: what is the purpose of research, if not to produce knowledge? Who should be involved in determining research priorities, if not researchers? And how can research outcomes be integrated in the evaluation of research process? Conceptually opening up the R&D cycle to the broader socio-ethical context visualises the 'co-evolution' of science and society, the complex relations between the internal and external dynamics of the research cycle. Research decisions turn out to be affected by different kinds of knowledge (scientific, political), considerations (epistemic, moral, political cultural) and stakeholders. The current renegotiation of science's new social contract with society thus centres on the question how to assure the integrity of research while accommodating the complex interactions between R&D and its socio-ethical context.

This broadened vision of the role of research in society also implies a broadened conception of the responsibility of researchers: in addition to their internal responsibilities towards the research community, to assure the integrity of research, researchers are now confronted with a moral responsibility to critically reflect on the wider socio-ethical context surrounding their work. But how to specify this broadened conception of the social responsibility of the researcher? What exactly is the researcher responsible for? Several philosophers of science have analysed these questions. Shrader-Frechette (1994) has argued that researchers have special responsibilities to promote human welfare as a result of the 'implicit contract' between researchers and society which grants special status and power to researchers (Weil: 2002). Resnik (1998) argues that researchers have a responsibility to serve society because the people who produce knowledge should be responsible for its consequences. While these arguments support the general claim that the researcher has a responsibility towards society, they do not prescribe how to act in concrete decisions. The specific nature of social responsibility does not allow for such substantive norms. As Rip (1981) has argued, *the* social responsibility of *the* researcher cannot be defined. The following section will therefore present a conceptual framework, based on the work of Verhoog (1980), that introduces a *procedural* norm for critical reflection as part of the broadened conception of social responsibility and specifies the different dimensions. The social responsibility of the researcher includes a moral responsibility to critically reflect on the wider socio-ethical context of their work. This wider socio-ethical context includes the value-based socio-ethical premises of research, the epistemological and ontological assumptions and methodological norms that govern research practices, and the socio-ethical consequences of research.

2.7.1. Conceptual framework: critical reflection

The normative framework for social responsibility in research developed in this thesis is based on the work of the Dutch philosopher of science Henk Verhoog. In his thesis 'Science and the social responsibility of natural scientists' (1980), Verhoog provides a conceptual basis for a philosophy of science that integrates the hitherto separated philosophical studies of science as scientific rationality (science *sensu stricto*, or science s.s.) and the ethics of science. Following Merton, Verhoog interprets science as a social phenomenon that can be studied from a normative point of view, allowing for a normative analysis of the cultural dominance of the neutrality view in scientific cultures. In opposition to the dominant neutrality view, which in his view contains logical inconsistencies, he proposes a critical-interactionist view of the social responsibility of the researcher *'in which no separation is made between the scientist qua scientist, only being responsible for doing science s.s., and the scientist as citizen'* (180). He criticises the potentially ideological nature of the neutrality view in those cases where the methodological principles of science s.s. are confused with ontological or epistemological commitments, for instance where a one-sided account of science is extrapolated to explain the actual role of science in society, or when the meaning of concepts such as neutrality or value-freedom are transferred from a methodological context to a socio-ethical context. Value-neutrality may be a normative principle for doing good science (in the strict sense), and may be invoked when arguing for the validation of scientific results towards one's peers, but it cannot be maintained when applied to the broader social context in which research is situated. According to Verhoog:

> ...science is more than a specific method or a particular kind of knowledge. Science is also, and first of all, I would say, a human activity taking place in a social context. Rather than saying that values cannot be derived from facts it is more to the point to reverse the sequence of the arguments and assert that the value-based socio-ethical premises have priority above the methodological principles which lead to the discovery of facts. Values determine which 'facts' are to be sought for and how they are used. ... So-called 'facts', while still being facts in a methodological sense, always arise within an ongoing 'telic enterprise', ultimately directed at goals which can only be classified as ethical goals (Verhoog: 1980: 166).

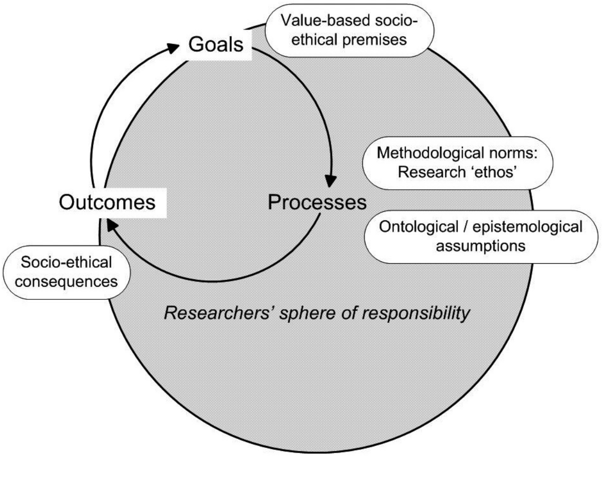
Verhoog's viewpoint thus constitutes a normative perspective that conceives of knowledge production not as an entirely autonomous system but essentially as part of a larger human endeavour. The 'telic enterprise' that he refers to is the ultimate purpose of science in society. He argues for the restoration of two particular visions of that enterprise that have been lost: the Aristotelian and Baconian ideals of science. The Aristotelian ideal conceives of the social function of science as contributing to realization of the *'humanistic cultural ideal of a self-conscious, harmoniously developed individual.'* (p.183) Restoring this ideal would imply that the *humanistic* value of science be formulated explicitly. The second ideal is the 'Baconian' ideal, in which science serves the survival, health, and material well-being of humanity. Both these visions include human well-being or 'the good life' (eudaimonia) as a central value. This means that knowledge production cannot be separated from the value commitments it helps to support.

The 'reintegration' of objective, scientific knowledge, which is produced through abstraction from the subjective features of daily life, in these wider human telic patterns is part of this broadened conception of the social responsibility of the scientist. Since knowledge production necessarily embodies commitments to cultural values, Verhoog stresses that the responsibility of the researcher towards society, the *social* responsibility of the researcher, requires *critical* reflection upon the epistemological and methodological assumptions upon which science is founded, broadening scientific rationality to include reflection on the socio-ethical context of research.

Verhoog's views do leave open certain questions. First, a much debated question is what such 'critical reflection' precisely entails. What does it mean to reflect 'critically' on one's research? And what will be the effect of asking researchers to reflect on their research in different ways? Does it lead to different, more 'socially responsible' outcomes? Second, is it enough to maintain the procedural norm of critical reflection without specifying the more substantive norms to which research should aspire? At some point, the overall purpose of critical reflection needs to be further substantiated. For Verhoog, this is the restoration of the Baconian and Aristotelian ideals of science. But for the purposes of this thesis, the question which substantive norms are to guide research developments will be forestalled. The primary aim of the empirical interventions in the subsequent chapters is to examine the initial question of how critical reflection can be integrated in research decisions. The social responsibility of the researcher will therefore be specified in terms of the following procedural norm: researchers have a moral responsibility to critically reflect on the wider socio-ethical context of their work in addition to the responsibility to adhere to the internal norms of the research community. The researcher's 'sphere of responsibility' is thus broadened to include critical reflection upon the wider socio-ethical context in which research operates. This can be represented in terms of the goals, processes and outcomes of the R&D cycle (see figure 6) as a responsibility to critically reflect on:

1. the 'value-based socio-ethical premises', the underlying values and the 'wider human telic patterns' that determine which facts are to be sought for and how they are used;
2. the methodological norms of scientific culture and its underlying epistemological and methodological assumptions;
3. the socio-ethical consequences of research.

Figure 6. A broadened conception of responsibility.



2.7.2. Different interpretations of responsibility

Note that this broadened vision opens up the *field* or the *sphere* of responsibility of the researcher widely: it encompasses a responsibility for the premises and consequences of research in addition to a concern for research processes. This suggests a conception of responsibility that differs from the predominant interpretation of responsibility as accountability. Before going into questions of practical implementation, an explanation of the kind of responsibility envisaged may be helpful. Mark Bovens (1998), following Hart, offers a categorisation of different possible interpretations of responsibility:

1. Responsibility as *cause*. The phrase 'to be responsible for' can simply mean having caused: the wind can be responsible for weather movement.
2. Responsibility as *accountability*: political, moral, or legal answerability for the results of a given form of behaviour or event. Investment banks have been held responsible for the credit crunch of 2007.
3. Responsibility as *capacity*: 'soundness of mind'.
4. Responsibility as *task*: the extent to which one makes decisions about and acts on important issues (authority); the burdens and tasks that flow from authority (duty), for instance the way in which an Operations Manager is responsible for the operations of a company.
5. Responsibility as *virtue*. Being responsible here implies being dedicated, caring for, having a sense of responsibility, taking one's tasks and duties seriously, acting only after due deliberation, and considering oneself answerable to others for the consequences of one's actions. Responsibility as virtue is, above all, an attitude: it relates to the preparedness to base the decision on whether or not to follow a rule on a critical examination of that rule in light of the meanings and intentions behind the rule (Hogenhuis: 1993).

Using these distinctions, the overall argument on the social responsibility of researchers can be summarised as follows: researchers are responsible for (in the sense of having the task) the advancement of scientific knowledge. In virtue of their contribution to the advancement of knowledge they are to an extent responsible (in the causal sense) for the socio-ethical consequences of their research, which implies they are responsible (in the sense of accountable) for their actions in proportion to the impact of their work on society, and therefore have the responsibility (in the sense of attitude/virtue) to critically reflect on the socio-ethical context of their work.

This broadened conception of the social responsibility of the researcher thus integrates both retrospective and prospective dimensions of responsibility. Whereas the interpretation of responsibility as accountability dominates present-day responsibility discourse, it is this latter, prospective sense of responsibility, as an intended *character*-trait of the researcher, that plays a central role in the normative framework outlined above. As Mitcham (2003) indicates, the social responsibility of the researcher is not restricted to passive adherence only, but also include active agency:

> Responsibility for some fundamental concern (e.g. scientific integrity) involves not only the adherence to whatever social role model has emerged historically to embody this concern, but also the occasional creative adaptation of those models to changing historical and social circumstances, in light of the general concern itself. This is role responsibility not as passive acceptance but as active agency, recognizing the extent to which we create roles at the same time that we are created by them. As such we are obliged to take responsibility not just for living out some role but for critically reflecting on the concerns the role itself embodies and the way it embodies them. Although we must to some degree rely on social roles to act in the world, we are at another level in charge of those roles (Mitcham: 2003, 280).

The social responsibility of the researcher thus implies supererogation, a willingness to take morally and socially relevant implications of research into account, over and beyond one's formal duties (Bovens: 1998; Swierstra and Jelsma: 2006; Feinberg: 1974). The emphasis on responsibility as virtue thus places a sense of responsibility *from within* the research community, rather than imposing norms from outside, as is the case with responsibility as accountability. On this interpretation, the researcher has an individual, prospective responsibility for critical reflection on the goals, methods, and outcomes of research. The responsibility of researchers is not delimited to the development of their science only, but also includes the development of society (Verhoog's Baconian ideal). Ideally, the notion of 'responsible conduct of research' is to be broadened to include the consideration of the ethical, legal and social aspects of research. Doing research *is*, in a sense, doing ethics. It may make sense to openly question and reflect on social values at early stages of research: in whose name is this knowledge being developed? Can possible societal impacts of this knowledge be foreseen? There may be questions of equity and justice involved: what effects will this new insight, product or device have on the health, well-being and private life of individuals? Does it exclude certain user groups? Will it reduce global inequality, or increase it? Will it lead to a reduction in the use of natural resources, or increase it? When responsibility is interpreted as accountability, such considerations cannot be included. But from a viewpoint of responsibility as virtue, they *do* form part of the social responsibility of the researcher.

Considering the practical realisation of a broadened conception of social responsibility, the institutional contexts in which researchers operate deserve attention as well. As Swierstra and Jelsma (2006) have pointed out, full moral responsibility can hardly ever be attributed to individual researchers. They warn against the danger of committing 'moralism', assigning responsibilities to individuals that they cannot possibly meet. First, there is the problem of 'many hands' (see page 24 above). Second, pressure from superiors can constrain the autonomous decisions of individuals as Milgram's (1963) obedience experiments have pointed out. According to Swierstra and Jelsma:

> There is also the connected danger of naively expecting engineers to assume their responsibility actively. ... An actively responsible person has an acute sense of his or her duties, performs them well, and shows vision. But how strong is the motivation of an anonymous cog, without real power or foresight, to behave responsibly in this active sense? Not very strong, one would expect. ... the lack of incentive for moral behaviour in engineering is not a property of modern technology-in-the-making as such. It is, to a large degree, the consequence of the specific way this technology-in-the-making is organized (Swierstra and Jelsma: 2006, 314).

The conclusion is that reflection on the responsibility of researchers should include reflection on the institutional context. While the case studies have largely focused on encouraging critical reflection of researchers, chapter six will reflect on relevant aspects of institutional design.

2.7.3. Realising an alternative vision in research practice

In conclusion, this survey of the claims made for and against the neutrality view of the social responsibility of researchers led to the conclusion that a reconsideration of responsibility is in order. Verhoog's critical interactionist view serves as the basis for a broadened conception of the social responsibility of the researcher. This view includes in the social responsibility of the researcher a responsibility to critically reflect on the socio-ethical context of research in addition to the internal responsibility for the advancement of science s.s. As such, it incorporates elements of prospective responsibility. According to Verhoog, the individual scientist or the scientific community cannot defer their responsibility to philosophers, although philosophers have an essential role to play:

> Philosophy should be reintroduced into science, but now in a conscious manner through critical reflection upon the relation between the methodological assumptions of science and its ethical implications (Verhoog: 1980, 183).

While Verhoog notes that the practical consequences of his alternative view of the social responsibility of the research must be worked out, he defers this task to 'applied ethics.' The following chapters have aimed to pick up where he left off: what are the opportunities and constraints for realising an alternative vision on social responsibility in research practice? The empirical interventions in the case studies extend the philosopher's role, acknowledging that the performance of critical reflection is ultimately the task of the individual researcher and the research community broadly, but at the same time taking into account that this will require communication and translation: how to encourage researchers to critically reflect on the socio-ethical context of their work?

The practical difficulty is how to integrate broader societal and normative dimensions in research without throwing the baby of scientific progress away with the social bathwater. While there is an emerging consensus that the social contract between science and society is in need of revision, its precise terms and conditions are still up for negotiation. The practical realisation of a broadened view of social responsibility in research faces a double bind: the methodological norm of value-neutrality safeguards the methodological 'objectivity' of research - but the 'broadened' vision of social responsibility demands reconsideration of that norm. The fundamental question then, is how to set the parameters in such a way that the quality of research is assured while broader considerations can be integrated with processes of research? The following chapters will explore opportunities and constraints for encouraging critical reflection on the socio-ethical context of research. Let us therefore pause the philosophy here, and move on to the practices. Invoking a well-known quote from Karl Marx (1845):

> Die Philosophen haben die Welt nur verschieden interpretiert; es kommt aber darauf an, sie zu verändern.[12]

[12] The philosophers have interpreted the world in various ways; the point however, is to change it.

3 Implementing the Netherlands Code of Conduct for Scientific Practice – A Case Study[13]

3.1. Introduction

Scientific and engineering codes of conduct have received a considerable amount of attention over the last decades: several hundreds of codes, pledges and oaths can be found on the web. The UNESCO Global Ethics Observatory (UNESCO: 2008) has registered 151 codes of conduct related to science and technology worldwide, and this is probably just a fraction of the total number of codes produced in recent years.

Whereas scientific associations often have high expectations of such codes in regard to raising awareness of the principles that the profession endorses (Lentzos: 2006), the mere establishment of codes of conduct may not always lead to the expected outcomes (Rappert: 2007). Codes of conduct do not necessarily support their stated intentions, and may, when they appear superficial or strategic, even work against them (Evers: 2001). Whether codes of conduct achieve their aims is dependent on the aims and intentions with which they are produced, the way they are received and taken up by the members of the professional community, continuing efforts to discuss and reflect on them, and the involvement of relevant stakeholders outside the professional community. The implementation phase is thus at least as important as their establishment. This phase, however, often receives little attention. How is the code taken up by the scientific community that it addresses? What are scientists to make of a code of scientific practice once it has landed on their desks? And how can it be integrated with ongoing practices? The aim of this paper is to address these kinds of questions for one particular code of conduct in one particular place.

[13] This chapter was originally published in Science and Engineering Ethics (2009) 15: 213-231 and was co-authored with P. Osseweijer and J. Kinderlerer.

The Netherlands Code of Conduct for Scientific Practice (VSNU: 2005) will be used as a case study. This code of conduct, which was established in 2005, distinguishes itself from other codes in the Netherlands by addressing scientific practice in general. Furthermore, it is to be implemented in universities throughout the Netherlands and was therefore considered an appropriate object of study. The Department of Biotechnology of Delft University of Technology (TU Delft) was chosen as the locus for evaluation. The research in this department focuses on living micro-organisms, the cell and its components. It employs 22 permanent scientific staff, 12 laboratory technicians and 85 temporary researchers (PhD's, post docs, etc.). Research areas include analytical biotechnology, bioseparation technology, biocatalysis and organic chemistry, enzymology, bioprocess technology, industrial microbiology and environmental biotechnology. The department was considering implementation of the code of conduct at the start of this study. Whilst good scientific conduct in the case of research on either animals or humans is ethically sensitive for obvious reasons, research on micro-organisms is much less publicly controversial. Researchers' willingness to discuss the norms of scientific conduct can therefore be expected not to arise from a perceived need to appease public concerns which means the results may apply in other fields of research as well. Based on a series of interviews held with researchers at the department, this paper will evaluate how the code is received by those that it is supposed to govern. The empirical results are followed by reflection on a number of underlying concerns, by which recommendations for guiding effective implementation of this code and scientific codes of conduct in general will be identified.

3.2. Codes of conduct

Codes of conduct establish guidelines that indicate what organisations or institutions perceive as 'good' conduct of their members or employees, or which norms and values should guide that conduct (Royakkers et al.: 2004). Types, functions and remit of codes vary widely. Frankel (1989) describes several functions that codes may have: as an enabling document, a source of public evaluation, a deterrent to unethical behaviour or a support system with the aim to socialize the profession, to enhance public trust, or to adjudicate. Codes usually fulfil several of these functions simultaneously. Derivatives of these functions can be found within codes of conduct for science and engineering: to prevent scientific misconduct, fraud or plagiarism; to hold scientific practitioners to a proper exercise of their duties; to restore or maintain public trust in science and engineering; or to encourage scientists and engineers to engage with their responsibilities towards society.

The importance attached to scientific codes of conduct can be related to several instances of scientific misconduct in recent years, the most notorious cases probably being those of the South Korean biotechnologist Hwang Woo-Suk and German physicist Jan Hendrik Schön, both of whom were accused of fabricating data and fraudulent reporting. These and other cases, which have received wide media attention, have been said to erode public trust in science. If scientists themselves disregard the principles of scientific research, then what does that imply for the credibility of their results? Holding scientists to the proper exercise of their duties thus becomes an issue.

There are several ways to distinguish types of codes (Rappert: 2007; Frankel: 1989; Hogenhuis: 1993). Rappert's classification scheme will be used here. He distinguishes between codes of ethics: *"aspirational codes that aim to set standards and alert individuals to certain issues"*, codes of conduct: *"educational or advisory codes that aim to provide guidelines for action"*, and codes of practice: *"enforceable codes that prescribe or proscribe certain behaviour"*. The Netherlands Code of Conduct studied here is a scientific society code of conduct in Rappert's scheme: an advisory code with the aim to hold scientific practitioners to a proper exercise of their duties, and ultimately to maintain public trust in science. Before going into the results of the interviews, we will briefly describe the code we have taken as our case, how it came into existence, what it purportedly aims to achieve and what stage its implementation has reached.

3.3. The Netherlands Code of Conduct as a case study

This code of conduct was established in response to a lecture by Paul van der Heijden, former Rector Magnificus of the University of Amsterdam (Van der Heijden: 2004). He suggested that universities should try to convince society at large of the worth of their efforts by making the principles of scientific conduct explicit in a commonly accepted, generic code of conduct for universities. The Dutch Association of Universities (VSNU) subsequently established the Netherlands Code of Conduct for Scientific Practice which came into force as from 1 January 2005.

The code consists of a preamble, five basic principles including best practices, and a number of dilemmas regarding each of the principles intended to encourage discussion of the code and its limitations (see Table 1).

As originally suggested by Van der Heijden, the principles in the code reflect Robert Merton's four commandments of science commonly known as CUDOS (Communism, Universalism, Disinterestedness and Organised Scepticism) (Merton: 1942). The code is advisory in nature: the principles are not intended as supplementary judicial rules, and the code does not contain sanction rules or a complaints procedure. It does, however, contain some disciplinary references, providing: *"if necessary, ground for admonishment"*, for which the code refers to the regulations established by the universities and the National Committee for Scientific Integrity Regulations (KNAW/VSNU: 2001). The VSNU furthermore stipulate that *"all universities and their scientific staff will make the necessary effort to familiarise themselves with the content of this code without delay"*.

3.4. Adoption of the code at Delft University of Technology

The Executive Board of TU Delft have responded to the VSNU code by explicitly and formally declaring it to be applicable to TU Delft in its Regulations concerning academic integrity (Delft University of Technology: 2005). After its formal adoption, the Platform on Ethics and Technology[14] drafted an implementation plan in 2005 aiming for implementation of the code in all departments of the university. For unknown reasons, however, this process was delayed: the code is still to be implemented in the departments. Implementation has up to now consisted of a debate session on academic integrity, discussion of the code in three different research departments of the university, and a workshop on ethics and technology for PhD students. As a baseline for further implementation activities, a series of interviews was held with researchers at the Department of Biotechnology addressing the following questions: how is this code received by specific communities of researchers? What do they see as its role or function?

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14 The Platform for Ethics and Technology focuses on addressing ethical issues in the engineering profession in an early stage. The platform wants to develop practices to address these questions in a systematic manner. To achieve these goals, the platform organizes activities such as workshops and debates about the ethical aspects of the engineering profession at the university, with a special focus on analysis and evaluation of real-life case-studies. http://www.platformet.tudelft.nl/about.html.

What are their views and opinions about the content of the code and its implementation?

Table 2. Principles, definitions and best practices in the code.

Scrupulousness	Principle	Scientific activities are performed scrupulously, unaffected by mounting pressure to achieve.
	Definition	1: Having moral integrity; acting in strict regard for what is right or proper; 2: Punctiliously exact.
	Best practices	Precision and nuance in conducting scientific research. Accurate source referencing. Acknowledgement of authorship. Good mentorship.
Reliability	Principle	Science's reputation of reliability is confirmed and enhanced through the conduct of every scientific practitioner. A scientific practitioner is reliable in the performance of his research and in the reporting, and equally in the transfer of knowledge through teaching and publication.
	Definition	1: The quality or state of being reliable. 2: The extent to which an experiment, test, or measuring procedure yields the same results on repated trials.
	Best practices	Justification of the selective omission of research results. Respect for intellectual property. Distinction between transferred knowledge and personal opinion.
Verifiability	Principle	Presented information is verifiable. Whenever research results are publicized, it is made clear what the data and the conclusions are based on, where they were derived from and how they can be verified.
	Definition	Capable of being verified. [Verify: to establish the truth, accuracy or reality of]
	Best practices	Accurate documentation of research data and setup. Quality of data collection. Storage of raw research data.
Impartiality	Principle	In his scientific activities, the scientific practitioner heeds no other interest than the scientific interest. In this respect, he is always prepared to account for his actions.
	Definition	Not partial or biased: treating or affecting all equally
	Best practices	Giving room to other intellectual stances Impartial assessment of manuscripts Providing an overview of sideline activities
Independence	Principle	Scientific practitioners operate in a context of academic liberty and independence. Insofar as restrictions of that liberty are inevitable, these are clearly stated.
	Definition	The quality or state of being independent. [Independent: not subject to control by others; not requiring or relying on something else]
	Best practices	Executing commissioned research without interference by the commissioning Freedom to publish results. Identification by name of external financiers.

3.5. Method

A representative sample of interviewees was selected based on the principle of maximum variation. Fourteen respondents were interviewed (four professors, two associate professors, three assistant professors and five PhD students) with roughly equal representation from the various research groups in the Department. Because of the lack of ambiguity in responses, it was not considered necessary to conduct further interviews. Respondents were asked to read the code in advance. Familiarity with this code and other relevant codes, regulations and institutions was assessed. The principles and dilemmas mentioned in the code were discussed in detail and compared with respondents' own views on proper scientific conduct. The interviewees were invited to give their opinion on the need for and relevance of the code whether they thought it was or could be effective in holding scientific practitioners to a proper exercise of their duties, and whether the code encourages ethical reflection. They were asked to name ethical and social aspects of their research and to describe their views on moral responsibility and scientific integrity. Finally, they were invited to propose activities for further implementation. The interviews were recorded and transcriptions were analysed (the quotes below were translated into English by the author, with consent from respondents). The interview results are provided below.

3.6. Results

3.6.1. Familiarity with codes of conduct

Two out of 14 respondents had heard about the VSNU code of conduct before the interview. None of them said they use or explicitly refer to it in their work. There was low awareness of other relevant codes as well: half of the respondents had not heard of any of the codes or initiatives mentioned. Best known were the Code of Conduct for engineers from the Dutch association for engineers and engineering students (KIVI/NIRIA), and the Code of Conduct for Biotechnologists from the Netherlands Biotechnology Foundation. Four out of fourteen said they had heard about the Platform on Ethics and Technology. One respondent was familiar with the Regulations concerning academic integrity at TU Delft, none had heard from TU Delft's Committee on Academic Integrity (see Figures 7 and 8).

Figure 7. Awareness of codes and committees - per code.

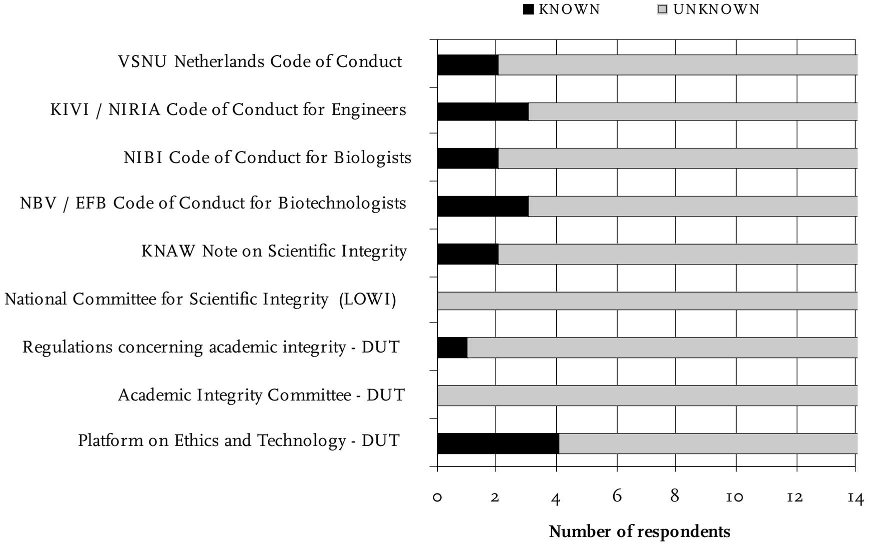
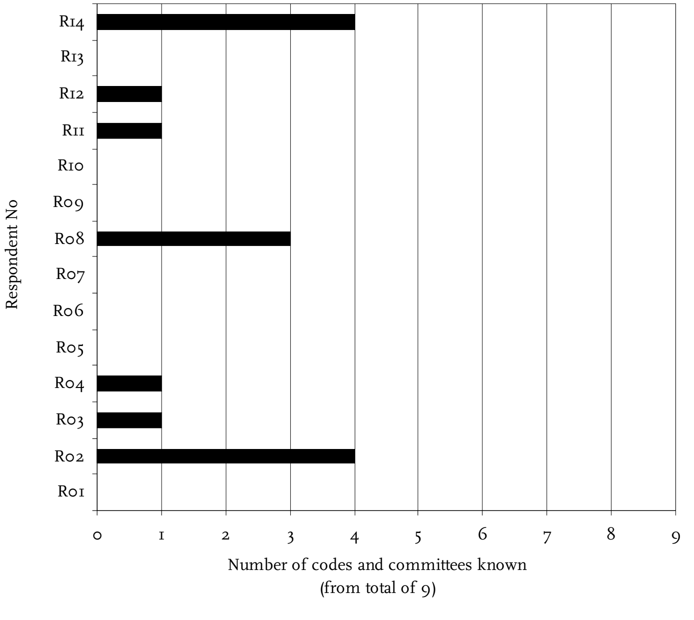


Figure 8. Awareness of codes and committees - per respondent.



3.6.2. Content of the code

General views and opinions

Eight respondents thought that a code of conduct could in principle be a useful instrument to enhance awareness of what good scientific teaching and research entails:

> There are many points in there, and, in that sense, when we're honest as a profession, in fact, broadly, science in general, there are, well, quite a few problems in various institutes, right? (R02)

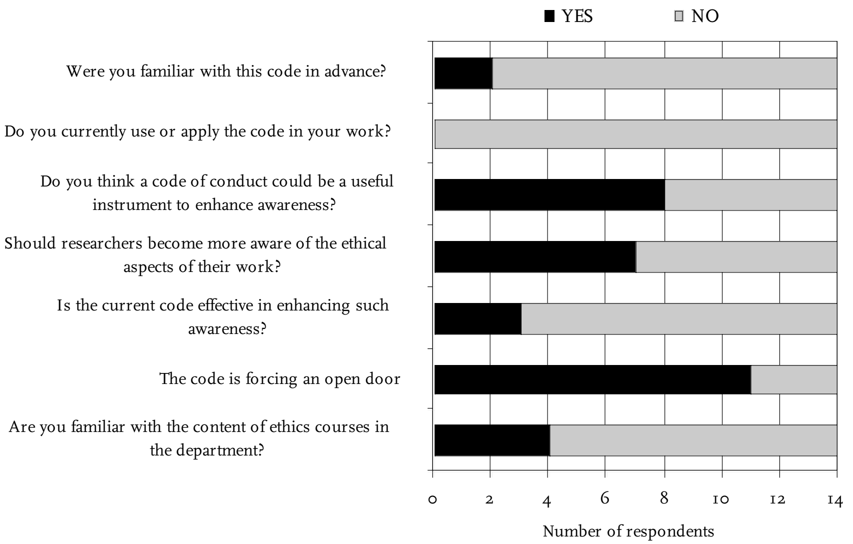
Seven interviewees said that researchers should become more aware of the ethical aspects of their work. They did, however, not see how the code of conduct as such would enhance awareness. Six respondents were very sceptical about the use and function of this code:

> I don't know what this code will add to the diarrhoea of codes that is already there. ... It almost seems as if everybody wants to have their own code ... instead of looking whether there already is an existing code that we might hook on to (R08)

Even though most interviewees were less sceptical, eleven of them commented spontaneously that the code was 'forcing an open door' (Fig. 4):

> I think it's all a matter of forcing an open door ... This is just another, a group of people that liked establishing a code so they'd have something to do, at least that's how I see it. (R12)

Figure 9. Respondents' opinions on the relevance of the code of conduct.

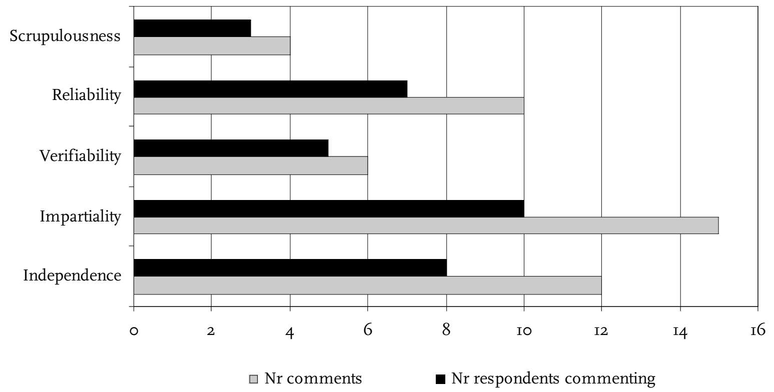


The principles and dilemmas

Respondents were all asked for their opinion on the principles and dilemmas within the code. The principles did not seem to surprise anyone; they were seen to reflect the norms and values within science rather well. Interviewees did recognize potential dilemmas if these principles are to be applied in practice. It is interesting to note that although all respondents stressed that their colleagues generally follow the principles of scientific conduct and do not need to become more aware of them, they all gave several examples of dilemmas encountered either personally or indirectly when asked about their personal experience.

As can be seen from Fig. 5, each of the dilemmas elicited responses, scrupulousness and verifiability being the least contested. Some respondents commented on personal working styles and relations between senior researchers and their research students in relation to scrupulousness, or the source of research data in relation to verifiability.

Figure 10. Respondents' comments on the principles and dilemmas.



Significantly more comments were related to the principle of reliability. They concerned the acquisition, interpretation and presentation of research data, results and conclusions:

> I think that as a researcher, of course you always try to publish the good and nice results, and results that are less good, well, you keep them back, or you try to work around them in a nice way. (R05)

Most of the comments (15 in total) were on the principle of impartiality. They were related to biased assessments in peer review processes and biased presentation of research data and conclusions:

> Let's say you're doing research that is paid for by a company, and then you can do decent publications, and then you can't, in the media for example, then you're not going to say anything improper about the company, because then... that's not very smart. But okay, then you can still do pure science, that is another matter. (R03)

There were 12 comments on the principle of independence, concerning contract research and balancing scientific interests with the commissioning party's interests:

> Well I'm sorry, but if a company offers us three hundred thousand to do research... of course we'll choose things that are academically interesting and we're not going to do purely commercial research... but if we would choose something purely fundamental ... then the company will say like: hello what good is this to us ... or something that is more directed towards application and which they could actually use, well then it's rather clear which way that will go, because we consult together very often [within the research group] ... of course we talk about this a lot ..., but that's quickly a very easy decision. (R13)

Five respondents also commented spontaneously that the principles of impartiality and independence were untenable in the current day research climate, due to major changes in the financing of research:

> Impartiality, and independence, you see that so often in this work ... because I co-operate closely with [name of company], ... certain research results are not good for the innovation, you have to publish those as a scientist, but I often discuss this with [name of company] ... because they'd rather not have it ... Things appear and risks that you actually wouldn't want to bring out into the open, and how should researchers deal with those, etcetera. This happens more and more often, with these big, privately financed projects and those sorts of things. That has to be thought through. (R09)

3.6.3. Implementation: applying the principles in practice

The responses above show that although researchers perceive the principles within the code to be almost self-evident, the application of those principles in practice may lead to morally complex situations. The principle of reliability may seem clear enough at first reading, but when exactly does the omission of a data point become morally reprehensible? Similarly, the example provided with the principle of impartiality shows the difficulty of maintaining that principle in the context of private funding. These are just a few of the examples provided that point to the potential moral complexities involved in the application of the principles. Enhancing awareness of how the principles relate to practice thus seems appropriate. On the other hand, most respondents did not see how the code as such would achieve that aim. Why do they consider the code to be ineffective? Interviewees provided several answers with remarkable agreement. Their comments were related to visibility, enforcement, the separation of general ethical principles from daily practice, and responsibility. Each of these issues will be discussed in turn.

The code has largely remained invisible

The most obvious reason for not having an effect was that the code is still unknown to the majority of researchers. As can be seen from Figure 2, most respondents were not aware of the existence of the code, nor of the institutions involved. This could be due to a lack of interest from the side of the scientific community, but it was also connected with a lack of communication from the side of the institutions:

> ... two things, so that's, well, just never needed it... but also, invisible, these institutions, to put it that way... So it works in both directions, so call it disinterestedness, or no need, or don't have the time for it, but the institutions are themselves invisible as well. (R02)

Due to the voluntary nature of this code, enforcement was seen to be problematic

Specifically because of the fact that this is an advisory code without the possibility of enforcement through disciplinary measures, some people doubted whether it would hold scientists to a proper exercise of their duties:

> ... you can't do anything with it, because when there is someone who doesn't behave that way ... there are no sanctions to beat him around the head with or anything. To do that you've got other codes and guidelines, and... Then I'm thinking to myself, yeah, okay. What a pity. (R12)

Several respondents indicated that adherence to the code is not so much determined by knowledge of the principles, but rather in the willingness to apply them:

> I think scientists who don't ehm, apply the code, know very well that they don't apply it, and maybe even do it on purpose, because they, well eh, to boost their career or I don't know what. (R13)

If scientific practitioners cannot be held accountable on the basis of this code, it may be ineffective in holding them to the proper exercise of their duties. What to do in case of an observed breach of the code? What disciplinary measures can or will be taken?

It is unclear how the principles of a generic code relate to daily practices

The previous point could become obsolete once the code has become generally accepted, and when it is clear what the principles mean in actual practice. Most interviewees, however, did not see how the principles were meant to guide conduct in practice. They considered the code too general to apply:

> Such a code aims to be all-encompassing, by which it remains relatively vague, and it misses the specific points that people work with. They are a part of it, they fall within that big cloud of what the code deals with, but it doesn't give an answer to how I should act in this specific situation. (R14)

The wish to establish a code of conduct that applies to all scientific practitioners allied with a university in the Netherlands seems to have come at a cost. These five principles have to apply to a range of fields of research, from the history of ancient Greek pottery to chemical engineering, and from theoretical physics to the social studies of science. But practitioners in different fields of research have agreed to different norms and values, due to differences in the nature of the research topics, approaches, methods, and results. Principles of conduct differ across universities, especially between academic and technical sciences. In biotechnology, where there is often close cooperation between scientists, engineers and industry, the principles of impartiality and independence are much harder to maintain than in less application-oriented fields like philosophy. Such differences occur even in closely related fields: reproducibility might be a key aspect of the principle of reliability in organic chemistry, but it is much less so in enzymology, because of the inherent instability of enzymes. In order to find the common ground between disparate fields of research, the specificities of particular fields of research have remained outside the scope of the code. At that point, the relation between the code and working practices may become very abstract and difficult to grasp for individual practitioners.

Moral principles cannot be separated from working practices

A related but different point was put forward in relation to the way moral principles in the code were presented as the sole criteria for good scientific practice. Several respondents were dissatisfied with the way the moral principles have been uncoupled from actual working practices:

> I think this describes quite sharply, like I said, the issues… But it's out of context. … Science is an odd business, right, it's in fact all about… being acknowledged, being recognized… But why then do we still have those stubborn guys, that, let's say, are just issuing orders from their little ivory tower? Why? Because they do deliver scientifically, as regards to content, scientifically superb quality…that's crucial, so, scientific quality is first…So that's what I would like to see clearly in here… Because in effect you want to prevent … that social aspect to be torn from its context, right? (R02)

Concerns about individual responsibility

A final, major concern with the code had to do with the specific nature and conception of responsibility within the code. The code was perceived to put the burden of responsibility entirely on the individual researcher. This focus on individual responsibility irritated some respondents; it was seen as a lack of trust in scientists:

> … the researcher can feel like eh, not reliable then. Because if somebody checks him, he thinks like … it is a kind of interfering with my freedom, and somebody doesn't believe that I'm doing good work. (R06)

> What the effect will be, once they start applying it? I think we'll all feel eh… at least, I would feel very much accused… (R12)

Responsibility was rather seen as something that is distributed:

> It's a distribution of all kinds of responsibilities… this code was also very much written for one person, how he should act, but it leaves out how responsibility is distributed, just like in peer review where you've got the researcher himself, the co-authors involved, the colleagues he works with, the institute, and then even the editor and the reviewers. (R14)

Several respondents also referred to the 'system' in which researchers have to operate as a potential cause of misconduct:

> Well, you have a conflict sometimes, that is that, universities like to hold accountable, on numbers of publications for example, on all kinds of parameters… And if that pressure grows too strong, then the urge to publish the same thing twice… or to, well, salami-slicing-tactics in publications, grows considerably. (R08)

3.7. Discussion

In summary, although the code has been established in response to a perceived need to discuss and reflect on the principles that govern scientific practices, respondents identified several issues that make the code ineffective in achieving its aim as a guideline for the individual scientist: most scientists are not aware of its existence, there is no means of enforcement, it is too general to apply in practice, the moral dimensions of research decisions should not be separated from the practical context, and the division of responsibility is perceived as unfair and unrealistic.

3.7.1. Suggestions for implementation

What recommendations for further implementation of this particular code of conduct can be derived from these observations? The following suggestions will be discussed in greater detail below: the code first of all needs to become more visible and discussions on the principles need to be stimulated; the code of conduct should be integrated with existing codes of practice; and the specific conception and attribution of responsibility should be reconsidered.

Increasing visibility, stimulating discussion

The first step in the implementation process should be that researchers become more familiar with the code. Respondents were asked what they would do if they were given the assignment to address ethical and social aspects in the department themselves (see Table 3).

They said the code itself needs to become more visible, for instance by making copies of the code available for all students and staff, or by attaching the code to the employment contract.

> When everybody takes the time to read it ... you'll initiate a discussion, and even though the discussion will be about what nonsense have you read this... why are they bothering us with this now... Then they'll still have colleagues around them, who can say like yeah, but I think point 3.6 is rather interesting, so to say... And once you get that discussion going, then it will come alive with people... (R09)

Apart from visibility, respondents also agreed that the code should become more tangible if it is to enhance awareness of what good scientific research entails. The suggestion mentioned most often (seven times in total) was to initiate discussion sessions on real-life cases of ethical dilemmas and, importantly, ways to address them:

> ... if one simply provides a few examples, like this is what happened there, and this is what happened here... That might speak more to the imagination, that is relevant... that has to do with the university specifically. (R10)

There may be a social desirability bias in these answers: who would deny that ethics is important? Looking at the actual involvement of scientists with the ethical aspects of research, few of the respondents were familiar with the content of the ethics courses in their department, or had been directly involved in ethics-related activities (see Figure 4). But this lack of familiarity might also have to do with ethics being perceived as external to scientific practices. Once the ethical aspects of relevance to scientific practice are discussed, there does seem to be a genuine desire to engage in discussion. The challenge is therefore to remain close to the lived morality of researchers. Several research groups in the department are currently constructing 'bottom–up' solutions for addressing issues of impartiality and independence in an increasingly privately funded research context. It is those kinds of discussions, those kinds of questions that should be the focus of ethical deliberation. How to make judgments when the principles prescribe conflicting courses of action? The principles need to be discussed openly, and especially where they are vague of contradictory.

Table 3. Suggestions for implementation by respondents (n = 14).

		N° times suggested
Stimulate a discussion	Discussion session on real-life cases of ethical dilemmas	7
	Plenary session with specific points as introduction	1
	Discussing the reasons, motivations, intentions behind the code	1
	Discuss the shift from government funding to private funding	1
	Discuss in board meeting and in the lab	1
	Convince professors of the need for such a code	1
	Offer lectures or a workshop on ethics	1
Increase visibility	Make copies of the code available for everybody	5
	Attach the code to the employment contract	3
	Make visible on the university homepage	1
Integrate with existing rules	Integrate in annual assessment cycle	2
	Integrate with lab rules	1
Use in education	Courses with relevant, specific cases	2
	Use in education of bachelors, masters and PhD	1
Further measures	Appoint confidential advisors at the university	1
	Integrate in the annual social report	1
	Conduct ethical parallel reseacrh	1
	Create a personal oath	1

Integrating the code of conduct with existing rules of practice

Detailed discussion of concrete cases may assist in clarifying how the principles apply to daily practice. But this does not mean researchers will be held to a proper exercise of their duty. Due to the voluntary nature of the code, enforcement remains an issue:

> If people really don't want to, and say like, yeah, I'm following all this, but in fact aren't doing a lot of these things, then you'll need some very concrete indications to say like, hang on, it says so there, and you're doing it very differently... And it's the question to what extent one can enforce it. (R11)

If the aim of the code is to guide individual researchers in their behaviour, then rules for conduct need to become a part of the day-to-day working codes of practice. Scientists are already following existing codes of practice: lab rules, GM regulations, safety regulations and so forth. Contrary to the current status of the code, these are seen to be central do to research properly. They are required to make experiments work, or even to be able to do experiments in the first place. But the code of conduct is considered peripheral, and not perceived as related to their work. If the ethical principles can be embedded into the ordinary working methods, there is a greater chance of getting the issues addressed within the group. The code of conduct would then be more than a pie in the sky, a statement of the values universities hold high without reference to daily research practices. Several respondents also proposed to integrate the code with existing rules and regulations, such as the lab rules with which everybody is familiar.

Rethinking responsibility

The dilemmas provided above underline the need to enhance awareness of the principles of good scientific research and the responsibilities of individual scientists. But when the responsibilities of individual scientists are isolated from the 'system' in which researchers have to operate, potential underlying causes of scientific misconduct remain hidden. Swierstra and Jelsma (2006) have shown that assigning full responsibility to individual researchers is unrealistic. It is often hard to point to a single researcher in the event of unwanted outcomes. Science is first of all a collective endeavour, and this should be reflected in the notion of responsibility. As Mark Frankel (1989) writes:

> ... promoting ethical conduct does not, and should not, have to be solely the responsibility of the individual ... The professional group, as a more visible, more stable, and more enduring entity, has a collective moral responsibility that is nondistributive; that is, a responsibility borne by the profession as a whole independent of the ethical posture of its individual members. (Frankel: 1989, 110)

There are potential conflicts between the principles and the research context in which scientists have to operate: increasing pressures to achieve, the shift in financing structures, 'subjective' elements within the peer review process and conflicting expectations from different parties may all give rise to morally problematic behaviour. To prevent individual researchers from becoming the scapegoat for morally problematic situations that are beyond their powers of influence, the distribution of responsibilities therefore, deserves attention in the implementation process as well.

There was some concern with respondents that the true cause for this code was not to encourage researchers to reflect on their responsibilities, but rather to evade responsibility in the higher echelons:

> Yeah, where is this coming from so all of a sudden? Scientific research is nothing new, it's not the latest fashion or anything, but now all of a sudden, well, certainly in the field I'm working in, which has been in existence for about thirty, forty years... and suddenly there is this code. How did that originate, what initiated that? (R05)

At the moment, it is difficult to say what the true intentions behind this code are. Why have the VSNU and the Board of TU Delft wanted to implement the Code? What does the Board expect to achieve? How does the board see its own responsibility in these matters? There is very little information available on the motivation for establishing the code and commitment to implement it. But if researchers cannot be convinced of the fact that the code is meant to encourage responsibility, distancing might occur. The code then becomes a strategic instrument to delegate responsibility instead of taking it, leading to a situation where the management of the university points to the individual's personal responsibility, and the individual scientists point to their relative lack of freedom. Apart from the individual responsibility of researchers to follow the principles of scientific conduct, there is a collective responsibility to resolve possible pressures in the 'system' that may invite scientific misconduct such as linking possibilities of promotion to the number of publications, holding researchers accountable for their own budget or the increasing competition among researchers.

Scientists can and should be held responsible for their actions, but it has to be acknowledged that their responsibility is distributed and role-dependent. More robust ways of addressing the complex relationship between individual responsibility and institutional or collective responsibility can be found in the engineering ethics literature (Mitcham: 2003; Miller and Makela: 2005; Consoli: 2008).

3.7.2. Reconsidering the principles of research conduct

Although most respondents confirm that researchers in the department should become more aware of the ethical aspects of scientific practice, they do not consider the code as such a useful tool to reach that objective. The principles first need to become better integrated in daily practice. The main interview results corroborate findings in the business and research ethics literature (Coughlan: 2005; Lere and Gaumnitz: 2003; Raiborn and Payne: 1990; Nitsch et al.: 2005), and may inform further implementation activities of the Platform on Ethics and Technology. Despite the fact that most of these results apply to the Department of Biotechnology specifically, two general observations apply to the implementation of codes of conduct across the board: the difficulty of maintaining Merton's principles as a guide for good scientific conduct in a changing research context, and the complexities of explicitly addressing ethical issues in research cultures.

Echoes of Merton's CUDOS can be heard in many contemporary scientific society codes of conduct, either literally, as is the case with the VSNU code of conduct, or in spirit, when the code focuses on the neutrality, objectivity and critical attitude of the individual researcher. But research practices in several areas of research have changed quite drastically in relation to the time when Merton devised those principles. First of all, most modern-day science has become 'Big Science', performing large-scale research programmes that require considerable investments. Second, science and technology have become increasingly application-oriented. Especially in such new disciplines as genetics, biotechnology and nanotechnology, the development of new knowledge is intimately connected to the application of that knowledge in new tools, materials, products and devices. Third, government funding has decreased in recent years, while private funding has increased, leading to a more important role for industry in setting research policies and a further focus on knowledge production in a context of application. One respondent remarked:

> I think it also has to do with the fact that the whole financial infrastructure of universities has changed in recent years. ... I know many professors who said like private funding is dirty, you shouldn't touch that, ... you'll become a puppet of companies. Well nowadays ... I think those who say that will be stoned to death immediately, so to speak. So that has changed completely. ... You want to continue your research anyway, and that means eh, when the tide turns, one needs to replace the beacons. (R11)

This shift in practices goes by many names like Mode 2 science, post-normal science, or post-academic science (for a review, see Hessels and Van Lente (2008)). The point here is that neither scientific nor engineering codes of conduct quite cover the new types of research practices that have begun to emerge in the aforementioned areas of research. As the interview results imply, the principles of impartiality and independence for instance can hardly be maintained in privately funded, application-oriented settings. This also puts respondents' concerns about individual responsibility in perspective: reconsideration of the principles of scientific conduct is a collective endeavour per se. These issues cannot be solved by individual researchers alone.

The second observation relates to the ways ethical issues are dealt with in research cultures. Respondents did not always see how the ethical aspects of research relate to their own work:

> Scrupulousness, reliability, independence,.........Ehm, oh dear,......Well, the point is, we, I, I am so far away from this, or, well, far away,......Ehm... I can... I lead my own investigation... and I am fully autonomous in that, so I have very little to do with other people. ... The work I do, eh, has very little to do with society. (R05)

Researchers in the department generally do not discuss the ethical aspects of research explicitly. When asked how moral dilemmas are addressed within the group if and when they occur, one respondent commented:

> In general... those things aren't on the table that explicitly. ... Like with many other things that's not a separate topic in daily conversations with colleagues. Yeah, it just happens in between... implicitly. (R01)

The perceived need to establish codes of conduct could be interpreted as a response to these two observations: the need to rethink the responsibilities of scientists and the principles of scientific conduct within research cultures that are not accustomed to the explicit discussion of moral principles. If that sounds like a reasonable suggestion, then initiatives that facilitate the discussion and reconsideration of the principles might in fact be more appropriate than the reiteration of those principles in codes of conduct.

3.8. Conclusion

The veritable explosion of scientific codes of conduct indicates the importance attached to reflection on the role of scientific expertise, and given the impact of scientific research on society, addressing the moral responsibilities of scientists seems to be warranted. Coding can be a useful exercise to open up discussion on the principles that govern scientific conduct. The Netherlands Code of Conduct for Scientific Practice was established to hold scientific practitioners in the Netherlands to a proper exercise of their duties. The interview results, however, point out that effective implementation of the code of conduct still offers many challenges: as a tool for the individual scientific practitioner, the code leaves a number of important questions unanswered. The code should become more visible and better discussed and integrated with research practices. Furthermore, if it is to be more than an instrument used for delegating responsibility in order to go back to 'business as usual', the conception of responsibility in the code needs to be reconsidered. As to the implementation of codes of conduct in general, attention needs to be paid to recent changes in the research context: the principles of good scientific conduct themselves may need to be revisited and the capacity to address moral issues within research cultures should be addressed. In conclusion, there is more at stake than merely holding scientific practitioners to a proper exercise of their duties; implementation of scientific society codes of conduct also concerns the further motives and value commitments that gave rise to their establishment in the first place.

4 In and Beyond the Lab – Applying Midstream Modulation to Encourage Socio-Ethical Reflection in the Laboratory[15]

4.1. Introduction

Science policies in the US, Europe and elsewhere have in recent years called for 'responsible innovation' in science and technology, implying that social and ethical considerations be integrated with R&D processes (21st Century Nanotechnology Research and Development Act: 2003; European Commission: 2004; European Group on Ethics: 2007; Netherlands Organisation for Scientific Research: 2008). Political concern for the societal impact of science and technology may in itself be nothing new (*cf.* Roosevelt: 1936), but what distinguishes recent policies from more traditional ones is a widespread interest in socio-technical integration at the 'midstream' (Fisher et al.: 2006): integrating societal dimensions at the earliest possible stages of R&D by means of 'co-operative' or 'interdisciplinary' research. The European Commission for instance aims to: *'encourage actors in their own disciplines and fields to participate in developing Science in Society perspectives from the very beginning of the conception of their activities'* (European Commission: 2007, 6).

While these mandates clearly mark a political interest in interdisciplinary research efforts to integrate social and ethical concerns at early stages of R&D, the appropriate means by which such integration is to occur is still open to experimentation. The recently developed framework of midstream modulation (MM) opens one potential avenue for interdisciplinary collaboration in the research laboratory.[16] This paper presents two 'laboratory engagement studies'

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[15] A slightly modified version of this chapter has been accepted for publication in Science & Engineering Ethics.

[16] To be sure, various interdisciplinary approaches aimed at broadening considerations in research decision making have recently emerged such as trading zones (Gorman *et al.*: 2004), ethical parallel research (Zwart *et al.*: 2006), biographical narratives (Consoli: 2008), co-evolutionary scenarios (Robinson: 2009), and initiatives aimed at increasing the 'moral

(Fisher: 2007) which aimed to apply MM specifically to address the question of social responsibility in research practices, by encouraging researchers to critically reflect on the broader socio-ethical context of their work. The studies sought to explore to what extent MM could be used to render the broader context of research visible in the laboratory, and whether research participants considered critical reflection on this broader context to be relevant.

4.2. Engaging researchers with the socio-ethical context of their work

The laboratory studies were performed as part of a research project on social responsibility in research. This research project argues against the 'neutrality view' of social responsibility - the notion that the social responsibility of researchers is exhausted by the disinterested pursuit of scientific knowledge - and instead proposes a normative framework in which the social responsibility of researchers includes the responsibility to critically reflect on the socio-ethical context of their work in addition to the responsibility to adhere to the cultural norms of the scientific community (Rip: 1981; Verhoog: 1980).

This normative framework reflects recent observations in ethical and normative scholarship broadly (*cf.* Douglas: 2009), and the engineering ethics (EE) literature in particular. Several engineering ethicists have argued for the early assessment of moral issues in technological design by direct involvement of scientists and engineers. According to Ziman (1998, 1813), *'the transformation of science into a new type of social institution'* requires that scientists become *'more ethically sensitive than they used to be'* - the ethical dimensions of research should become part of the 'ethos' of science. Van de Poel and Van Gorp (2006, 335) have similarly argued that 'designing engineers have a moral duty to reflect on the ethically relevant choices they make during the design process.' In addition to such general appeals to strengthening ethical reflection in research, various scholars have suggested new multidisciplinary engagements in light of the radical ethical challenges posed by new and emerging science and technology (Khushf: 2006; Moor: 2005; Herkert: 2009, unpublished manuscript; Schuurbiers et al.: 2009b).

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imagination' of researchers (Van der Burg: 2009). A full comparison between these promising new approaches, albeit potentially valuable, is beyond the scope of this paper.

The engineering ethics literature has thus established both a moral imperative for socio-ethical reflection in research and a general vision towards integrated forms of ethical reflection. But how to implement this vision? EE faces the predicament that theoretically established claims that engineers should (thus have a moral responsibility to) reflect on the normative dimensions of their work, do not in themselves enforce or encourage such reflection. Indeed, policy calls for ethical reflection, including demands from funding agencies and other measures like codes of conduct, have been shown in several cases to have a tangential effect on research practices: researchers perceive the broader socio-ethical context of research as peripheral to their work at best (Guston: 2000; Rappert: 2007; Rip: 2007; Schuurbiers et al.: 2009a). The question of implementation is thus particularly important if broad normative commitments to ethical reflection are to take hold in research practices. The lab studies presented here therefore sought to apply the methods and techniques of MM to the challenge identified in EE, on the assumption that MM may offer possibilities to define a context-sensitive form of ethics, using ethnographic methods to open up the 'black box of science and technology' to normative inquiry (Van de Poel and Verbeek: 2006).

4.3. Midstream Modulation

MM is a framework for guiding intervention-oriented activities in the laboratory that aims to elucidate and enhance the 'responsive capacity' of laboratories to the broader societal dimensions of their work (Fisher et al.: 2006). Originally developed by Erik Fisher during a three-year laboratory engagement study in a nanoscale engineering lab, MM is currently being applied in a range of laboratories around the world (Fisher and Guston: 2008).[17] MM extends more traditional laboratory ethnographies by augmenting participant observation methods with distinct engagement tools that allow for feedback, discussion and exploration of research decisions in light of their societal and ethical dimensions. An 'embedded' social or human scientist interacts with laboratory practitioners by closely following and documenting their research, attending laboratory meetings,

[17] The studies formed part of the NSF-funded Socio-Technical Integration Research (STIR) project, a coordinated set of twenty laboratory engagement studies to assess and compare the varying pressures on – and capacities for – laboratories to integrate broader societal considerations into their work. See: http://cns.asu.edu/stir/. Website accessed 23 December 2009.

holding regular interviews and collaboratively articulating decisions as they occur through the use of a protocol that maps key components of research evolution and helps feed back ethnographic observation and analysis into the laboratory context itself in real time (Fisher: 2007). Regular use of the protocol allows for collaborative exploration of the various factors that influence research decisions, with the ultimate aim of shaping technological trajectories by rethinking the very research processes that help to characterize them (Fisher et al.: 2006).

Since the general possibility and utility of MM was tested in an earlier pilot study (Fisher and Mahajan: 2006), the studies presented in this paper aimed to explore in further detail if and how MM could be applied specifically as a framework to implement the procedural norm identified above with respect to social responsibility: the moral duty to critically reflect on the broader socio-ethical context of research. This objective can be seen as responding to a standing invitation for bringing together the normative approaches within EE with the descriptive richness of science and technology studies (Zuiderent-Jerak and Jensen: 2007; Radder: 1998; Van de Poel and Verbeek: 2006). The specific research questions addressed in these two studies were, first: how can broader social and ethical dimensions of research be rendered visible in the laboratory? And second: do researchers perceive critical reflection on the broader socio-ethical context of their work to be *relevant*?

4.4. First- and second-order reflective learning

To assess the research findings in light of these two questions, I will use the distinction between first- and second-order reflective learning as identified by Van de Poel and Zwart (2009), who base their views on the works of Sclove (1995), Wynne (1995), Schot and Rip (1997) and Grin and Van der Graaf (1996). First-order reflective learning is defined as an iterative process in which a professional finds solutions to problems by acquiring experimental feedback to several lines of inquiry. This process *'takes place within the boundaries of a value system and background theories'* (Van de Poel and Zwart: 2009, 7). First-order reflective learning thus concerns: *'…improvement of the technology and the improved achievement of one's own interests in the network.'* Second-order reflective learning, on the other hand, *'requires a person to reflect on his or her background theories and value system'* (ibid.). In second-order learning, value systems become the object of learning while in first-order learning these are taken for granted.

Applying this distinction to the two dimensions of responsibility identified with respect to the social responsibility of researchers (towards the research community and towards society), it can be used as a framework for analysis of the research findings. The reflection that occurs in first-order reflective learning is reflection 'within' the research system. Van de Poel and Zwart note: *'In first-order reflective learning, moral issues are dealt with within the bounds of the background theories and are approached from within the value system of the actor'* (ibid.) In terms of responsibility, such forms of reflection involve compliance to one's internal responsibilities towards the research community such as the responsible conduct of research and environmental health and safety (EHS). Second-order reflective learning involves reflection 'on' the research system, including the value-based socio-ethical premises that drive research, the methodological norms of the research culture, and the epistemological and ontological assumptions upon which science is founded (Verhoog: 1980): the background theories and values of the research system itself become the object of learning.

Based on the findings of two laboratory engagement studies, I will argue below that the value of MM with respect to the challenge for EE (i.e. encouraging normative assessment at early stages of research) lies in the possibility of initiating second-order reflective learning. In addition to several instances of first-order learning that occurred as a result of the interactions, MM served to encourage researchers to critically reflect on the socio-ethical context of their work. Regular discussions of the broader socio-ethical dimensions of research 'permeated' the types of considerations that the research participants invoked when discussing research progress. Importantly however, first-order learning seems to be a prerequisite for the possibility of second-order learning: research participants' willingness to engage in critical reflection on the broader socio-ethical context of research was seen to be dependent on their perception that the collaboration also improved the achievement of their own (research) interests. Before going into that discussion, I will first present the research setup and findings.

4.5. Two laboratory engagement studies in Delft and Tempe

I carried out two consecutive laboratory engagement studies, the first in the Department of Biotechnology at Delft University of Technology, The Netherlands in Fall 2008 and the second in the School of Life Sciences at Arizona State University, Tempe, USA in Spring 2009. A total of eight laboratory researchers participated in the studies, with four of whom I had regular interactions of up to twelve hours a week during a period of twelve weeks. The other four participants acted as 'controls', doing only the pre- and post-interviews at the beginning and end of the study (see table 4). The participants were all PhD students in molecular biology. The researchers at the Department of Biotechnology in Delft focused on the use of micro-organisms for industrial production of chemicals from renewable resources and as diagnostic systems. The researchers in the Photosynthesis Group in Tempe applied genomic and molecular biological techniques to elucidate physiological processes in cyanobacteria with a view to bioenergy generation.

Table 4. Research participants.

University	Research group	Participant	Interaction
Delft University of Technology	Industrial Microbiology	R1D	High
Delft University of Technology	Industrial Microbiology	C1D	No
Delft University of Technology	Environmental Biotechnology	R2D	High
Delft University of Technology	Environmental Biotechnology	C2D	No
Arizona State University	Photosystem II	R1A	High
Arizona State University	Photosystem II	C1A	No
Arizona State University	Microbial Engineering	R2A	High
Arizona State University	Microbial Engineering	C2A	No

4.5.1. Data collection

Following the MM pilot study (Fisher and Mahajan: 2006), interactions with research participants consisted of pre- and post interviews, participant observation, regular application of the decision protocol and collaborative drafting of visual representations of the research process. The pre- and post-interviews enquired into the research objectives, project partners and funding mechanisms, decision-making structures, implicit and explicit references to societal goals in the project description and changes in participants' awareness of and attitude towards ethical and societal dimensions of the research. The pre-interviews marked the beginning of a period of participant observation in which I followed the 'high interaction' participants, spending ample time in the lab and participating in regular lab meetings whenever possible.

During the research phase, we regularly applied the decision protocol (Fisher and Mahajan: 2006; Fisher: 2007; Schuurbiers and Fisher: 2009). Reconstructing decisions by way of the protocol allows for reflection on how the interplay of various decision components leads to decision outcomes, constituting a collaborative process in which both observed and reported information is reflected back to the practitioner over time. The embedded humanist thus becomes 'part of the convergence of goals, strategies, and socio-material configurations' (Fisher and Mahajan: forthcoming). Given the normative background that motivated the particular lab studies presented here, the studies attempted, in addition to bringing out latent considerations, to examine how EE issues as such could be brought to bear on the research process with a view to 'deliberately' expand the opportunities, considerations or alternatives.

We also drafted schematic overviews of the research progress to link the interrelated series of decision processes mapped over the twelve-week period (see figure 11 below as an example). Like with the decision protocols, I would create initial drafts of these overviews based on earlier conversations and discuss them during regular meetings to get feedback from the research participants, then adapt them on the basis of the feedback provided, discuss the new draft at the next meeting, and so forth. These overviews, and the regular discussion of them, served to confirm my understanding of the unfolding progress of the research project (and to build 'interactional expertise' (Collins and Evans: 2002) in the process), and to identify in relation to what specific experimental steps discussion of broader considerations or new alternatives, as discussed in the decision protocol meetings, had taken place.

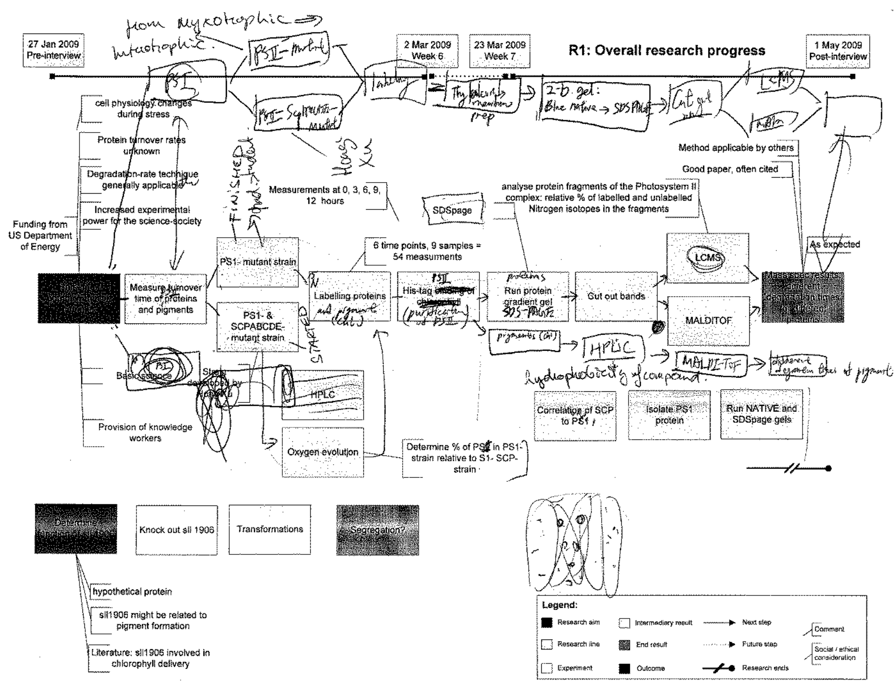

Figure 11. Drafting a research overview. Feedback from the research participant on my initial draft led to a following draft, ultimately leading to a shared understanding of the research processes and the considerations invoked.

4.5.2. Objects of reflection: topics discussed during the lab studies

In response to the first research question identified above, I will indicate how the iterative process of observation and feedback by means of the protocol and research overviews served to render broader normative questions visible while being directly related to the research at hand. Observation and feedback predominantly focused on the research opportunities and outcomes (mostly knockout or overexpression of protein production pathways followed by phenotypic characterization) and the molecular biological techniques employed to achieve those goals: plasmid insertion, the polymerase chain reaction (PCR), separation gels, high performance liquid chromatography (HPLC), and so forth. Still, reconstructing even the most 'technical' decisions by way of the decision protocol quite naturally brought out what Herkert (2005, 373) has called 'microethics', normative issues concerning: *'individuals and internal relations of the* *engineering profession'*. Enquiring for the considerations related to the decision not to repeat a gel run for instance could bring out financial and time considerations as well as considerations of a more overtly normative nature: the kinds of expectations that a supervisor might have, how strictly researchers in the group adhere to the norm of verifiability, and whether anonymous reviewers would accept the research data if submitted to a journal. Asking why research participants took protective measures against harmful effects of carcinogens brought out personal health and safety and environmental considerations, but could also invite a research participant to comment on how colleagues ought to behave, or lead into a discussion about the appropriateness of safety regulations.

In addition to the kinds of microethical discussions - lab practices, responsible conduct of research and EHS - emanating directly from the work done in the laboratory, the feedback processes also occasioned discussion of macro-ethical issues, normative issues that apply *'to the collective social responsibility of the profession and to societal decisions about technology'* (Herkert: 2005, 373). Enquiring for the impact of a confidentiality agreement on the freedom to publish research results could lead us to examine intellectual property, confidentiality and the influence of private investors on research. A question on the relation between expectations raised in a research proposal and the actual work done could serve to explore the role of promises and expectations in research, science-policy interfaces and hype-disillusionment cycles in research. Ultimately, repeated questions like 'how do you know that the results you have just obtained are actually a result of your transformations?' led to abstract discussions on philosophical topics like reductionism and the problem of underdeterminacy of scientific data.

Table 5 categorizes the range of topics discussed and provides indicative questions that initiated such discussions, showing how implicit value judgments were rendered explicit by asking 'broader' questions. Most, but not all of these topics were addressed in each of the interactions, given that their discussion was dependent on the nature and stage of the research projects as well as the particular experiments performed at the time of study.

Table 5. Ethically relevant topics discussed during the lab studies.

Micro-ethics	R1D	R2D	R1A	R2A	Exemplary question
Lab Practices					
Methods and techniques	x	x	x	x	Will you repeat the gel run?
Research hierarchy	x	x	x	x	Do you or your supervisor determine the next step?
Lab culture	x	x	x	x	Would you ask a co-worker for help?
Environmental Health and Safety					
Worker health	x	x	x	x	Why are you wearing plastic gloves now?
Health and safety regulations	x	x	x	x	Why is the -80 freezer locked?
Environmental impact	x	x	x	x	Would the cells survive if you throw them into the lake?
Responsible Conduct of Research					
Scientific integrity	x	x	x	x	Would you use these results without referring to the author?
Impartiality and independence	x	x		x	Would you follow this route, even though it is not in the interest of your investor?
Reliability and verifiability	x		x	x	Do you think you will include these outliers in your graph?
Macro-ethics					
Ethical, Legal and Social Aspects					
Intellectual property and patenting	x	x		x	Are you allowed to present these data before it is patented?
Ethics of genetic engineering	x	x		x	Why do you see a difference between inserting a human gene or a mouse gene?
Dual use of synthetic biology	x	x			What if everyone can order and assemble genes as they please?
Social Responsibility of Researchers					
Social relevance of research	x	x	x	x	Does your research benefit society? Should it?
Ethics of promising - hype in proposal writing	x	x	x	x	Why would you raise expectations in a proposal that may well not be fulfilled?
Philosophy and Sociology of Science					
Reductionism	x	x		x	Why wouldn't the synthetic gene work as well? A gene is a gene, right?
Underdeterminacy	x		x	x	How do you know the effect you observe is in fact a result of your transformations?
Scientific realism versus social constructivism	x	x		x	Would you say scientific facts describe the world as it is?

These findings suggest that researchers frequently deal with normative and social issues but without necessarily labeling them as such, as the notion of *de facto* modulation (Fisher and Mahajan: 2006) also posits. Researchers are not accustomed to viewing their decisions from a normative perspective or discuss the normative aspects of decisions explicitly: the moral principles of the research community operate 'below the surface' (Schuurbiers et al.: 2009a). During the studies, such broader issues were made explicit and brought into focus by routinely asking different kinds of questions than those usually encountered in the midst of laboratory research: questions about laboratory culture, about researchers' personal concerns, about the long term implications of research, economies of scale, innovation systems, and so forth. In response to the first question outlined above, the methods and techniques of MM can thus be used to render ethical and societal dimensions of research visible to practitioners within the context of laboratory.

Having analyzed the kinds of discussion brought about by applying the methods and techniques of MM, the following section will focus on the kinds of learning that occurred as a result of the interactions in search of an answer to the second question: whether research participants perceived critical reflection on the broader socio-ethical context of their work to be relevant. I will first present examples of reflection 'within' the system (relating to technological improvement and the improved achievement of the researchers' interests in the network), followed by examples of reflection 'on' the system (encompassing the background theories and value systems of the network in which researchers operate).

4.5.3. First-order reflective learning: reflection 'within' the system

The iterative observation and feedback processes occasioned instances of first-order reflective learning in several ways. The regular occurrence of what I would call 'efficiency' discussions, probing for possible overlooked considerations or alternatives of a technical nature, on several occasions led to improvement of the technology or the improved achievement of the research participant's interests in the network. For instance, after observing R1A repeatedly preparing small amounts of stock solution for a gel, I asked whether making a bigger batch could save time. Efficiency discussions were a matter of trial and error: participants appreciated my effort, but had often thought about possible alternatives already. In other cases however, my questions did suggest new alternatives. Applying the decision protocol to a particular experiment that R2A was performing, we determined that the opportunity was to identify a specific chemical compound involved in cell-to-cell communication. R2A was searching for the compound in a bottom-up fashion, by measuring cell reactivity to different candidate compounds. When I proposed a top-down experiment, determining the presence of the compound in a sample where the anticipated cell communication was already occurring, R2A replied:

> My supervisor decided to do it this way. Probably the current experiment was easiest. ... But that might be the way to go, now that this doesn't work. (R2A)

Such efficiency discussions thus served a threefold purpose, serving first of all to elucidate the details of the experiments by questioning them; second, they served to probe whether the perspective of an outsider could potentially lead to new research opportunities; and third, they served to build trust and enhance a sense of co-labor. When I asked R1D at some point whether our interactions led him to perceive new research opportunities, he indicated:

> [It happened] just now. Well, I have to look back, I have to think about what I've done every now and then, to tell you what I did, so to say. So that forces me to some kind of realization. ... At the same time I've been working on a presentation for a work meeting. At that moment I also realize that knocking out those genes could well have more consequences than we think... And then I started reading back, like

> what is the capacity of that transporter, and then I came across a calculating error. ... So, on the one hand, you force me to think, and on the other hand a work meeting forces me to think. So... it comes from both sides so to say. (R1D)

These examples indicate that regular application of the protocol facilitates the occurrence of first-order learning, although it is difficult to pinpoint precisely what triggers the learning process. R1D found his calculating error as a result of being 'forced to some kind of realization'. Perhaps my questions instigated this realization process, or perhaps it emerged from thought processes developing in the researchers' minds as they explained their work to me. Ultimately, however, it was the collaborative process that stimulated mutual learning. There were other instances of this kind of learning, such as when I was discussing one of the draft research overviews with R2A. Looking at the number of research lines he was simultaneously pursuing, he realized how much he had taken on, leading him to the conclusion that he needed to make decisions about which research lines to pursue and which ones to drop:

> ...it's a good following of the process. ... I think you can pretty much see how the thinking evolves, right? I mean, the first insertion, that was my supervisor's idea, and then I came up with other stuff, and we get to the point where I'm thinking about stuff that is not even cyanobacteria genes, but it's something else.

When I enquired later about the relevance of our discussion, he commented that he had never given research planning much thought, but saw the value of it now:

> For me that was the most important point, that I see how much I have to do, or have done, or how sometimes stuff gets entangled with other stuff if you never realize that things are related. Then you end up with a contest, and entrepreneurship, and things which you never thought about, and then... It's also fun to see how you have four lanes, or forks, and then one of them stops, because you're trying to advance the other one, and try to keep all of them running at the same time.

Apart from efficiency discussions, considerations of a more explicitly normative nature did in some cases lead to observable changes in lab practice. I had observed several research participants at work in the lab using two plastic gloves to prevent getting acrylamide on their skin, and subsequently getting something from a cupboard while still wearing both gloves. When I was invited to present my findings to the research group at a final lab meeting after completing my study, I expressed concern for compliance with EHS regulations to the research group, feeding back my observation of the two gloves. The example sparked a hefty debate. Some researchers in the group felt strongly about complying with

EHS regulations, particularly wearing lab coats, but had been unable to convince others to follow suit. A few days later I received unsolicited news from one of the group members that several lab members had now started wearing lab coats again. When I asked for an explanation of what she thought had occurred, she stated:

> It happened many times that when I was handling ethidium bromide gels some drops reached my clothes, or the glove unprotected areas of my hands. ... Meanwhile the lab coat was clean and ironed on my chair since some good months. ... I was thinking that one day I should take the decision to wear mine, even though I'll raise some eyebrows. ... Then came your presentation ... and I remembered how I used to take care of my safety and my clothes. ... Monday, after the seminar, on my way to the lab, I noticed that [S] wears the lab coat - he was spraying nitrogen on some concentrated samples and needed to protect his clothes. I said to myself, 'that's the moment. If I come back fast we will be two wearing the lab coat'. I took it and wear it for the rest of the weeks.

Apparently, the presence of an outsider in the lab enabled a change in laboratory practice. Granted that the impact of this behavioural change applies to one group only and is therefore limited in scope, its significance lies in the fact that this type of laboratory-based collaborative work was able to instigate a type of behavioural change that, e.g., EHS regulations up to that point had not achieved. These examples confirm that MM can encourage first-order reflective learning by elucidating or enhancing considerations at the micro-level of laboratory decisions, serving the improvement of the technology (a more efficient experimental setup, less time-consuming procedures, and the like) or the improved achievement of one's own interests (better research planning, compliance to existing regulations, and so forth).

Such instances of first-order learning, of reflection 'within' the system, may be of value to the research participants for obvious reasons, but more encompassing views, as identified in EE, on the moral duty of scientists and engineers to reflect on the broader socio-ethical context of their work seem to demand forms of reflective learning that go beyond issues of internal compliance and improvement. It requires 'broad and deep' learning (Schot and Rip: 1997, 257), second-order reflection 'on' the system that encompasses the background theories and value systems of the network in which researchers operate. It is these kinds of learning to which we will turn in the following section.

4.5.4. Second-order reflective learning? Reflecting 'on' the system

In addition to microethical considerations, we regularly discussed broader social and ethical dimensions of research during protocol meetings, three indicative examples of which I will present here: the first example concerns the ethics of genetic engineering, the second is on synthetic biology, and the last example discusses social relevance in research.

The first example in relation to the occurrence of second-order reflective learning relates to the moral dimensions of genetic engineering. R1D at one point considered integrating a heterologous gene in the micro-organism with which he was working. He faced a choice between integrating a human gene and a mouse gene, both of which fulfilled the required characteristics. Discussing the choice with his supervisors, he invoked a range of technical considerations such as substrate specificity, affinity, capacity, availability of a plasmid and scientific novelty. The question whether integrating a human gene would be morally acceptable was not discussed. Still, R1D expressed his moral reservations during one of the protocol meetings:

> R1D: I'm cloning a mouse gene, because… I decided like I'm not going to do a human gene. At least, there was a choice between human and mouse, well, then I'll go for mouse, that's a bit… safer.

I subsequently tried to probe for the moral arguments that R1D might have:

> Me: Why would that matter? A gene is a gene, right? A sequence of base pairs that you can reproduce synthetically.
>
> R1D: It's an image-thing. Practically, pieces of DNA from one organism work better than others, and synthetic genes don't always work optimally, probably because of interaction with the genome. Where it comes from is important, it's a bit… ethical. The DNA is still from that person. You put a piece of human in a micro-organism. I would have less difficulty if we would synthesize the DNA based on the sequence of a human fragment of DNA.

R1D's response included several morally relevant dimensions: first, by saying that 'it's an image thing', he showed awareness of possible issues in relation to public concern. Second, there was what seemed to be a practical consideration: 'pieces of DNA from one organism work better than others, and synthetic genes don't always work optimally'. And third, he expressed a moral value with respect to the integrity of the human genome: 'You put a piece of human in a micro-organism'. His response led us to explore each of these dimensions further. The potential for public concern led to a discussion on how to address public concerns about genetic modification. The 'practical consideration' in turn led to a discussion about reductionism: if genes are nothing more than strings of nucleotides, then why wouldn't synthetic genes work optimally? In addition to further practical considerations (synthetically produced genes may have overlooked point mutations for example), we considered the background assumptions behind genetic engineering (the assumption that genes express proteins may turn out more complicated than expected due to unknown gene-gene interactions in the living system). Finally, we explored the possible moral values involved in the acceptability of using genomic material of human origin, including deontological and utilitarian views in ethical decision making and the question of normative pluralism. Evaluating the relevance of these discussions at a later stage, R1D commented:

> I had given it some thought subconsciously, but I never really gave it careful thought. ... Ethics can be very boring, until you reach dangerous territory, and then it becomes fun. (R1D)

This response suggests that the perceived relevance of ethical issues for researchers increases when discussed in relation to concrete situations and, furthermore, that their discussion in close proximity to the research activities that occasioned them may expand the kinds of considerations that researchers invoke when making morally relevant decisions. These are moments when the embedded humanist can introduce broader perspectives and invoke theories from other areas of expertise while maintaining a direct bearing on the research at hand. There were numerous occasions for bringing a broader normative perspective to bear on the work done in the laboratory during the studies, for example on the regulation of research on genetically modified organisms, intellectual property, and the ethics of promising; but the next example of second-order learning I will discuss concerns synthetic biology. While regularly ordering synthetic genes, research participants did not see their own work as being related to synthetic biology, nor to the ongoing debates on synthetic biology in ethics and the social sciences. Upon learning that R1D had ordered a synthetic gene I asked:

> Me: Would you call this synthetic biology?
>
> R1D: That depends. What is synthetic biology? Much of what is now called synthetic biology resembles what we do: putting a piece of synthetic DNA in a host.

> But I think synthetic biology is making all components synthetically. ... Really to develop a cell from scratch might take another twenty years.

R1D did not consider normative questions on the desirability of building cells from scratch to be relevant because of the practical complexities involved and the long time span before that vision might become a reality, whereupon I invited him to take a historical perspective. I referred to the progress that was made in molecular biology in recent decades, and how we probably wouldn't have predicted twenty years ago that ordering a synthetic gene would be a standard procedure by 2010, and invited him to reflect on recent developments again from this broader perspective, where twenty years is just around the corner.

> Then you would need to think about the use, or the goal. If you can build a cell, then you can build other things as well. We shouldn't go into the direction of synthetic higher organisms. There's always a risk that others move into the wrong direction. You shouldn't be using it for other purposes. It's like a knife: you can use it for good or for bad. ... That's why we should maybe think about these things. Then there has to be extra regulation.

Taking the longer-term perspective that ethicists and social scientists may take when reflecting on new developments such as synthetic biology, R1D started to think about his research in a markedly different way. By contemplating the longer term impacts of his work, he started to reflect on the broader purpose and potential outcomes of the developments of which his own work was a part, acknowledging the relevance of such broader reflection. Recalling this interaction during the post-interview, R1D said:

> R1D: Synthetic biology, that discussion, well, it's all about how you define it. Otherwise, we've been doing it for a long time already. Yeah, synthetic genes: I send an email to the company, like I want this gene. Six weeks later I have it. So... It's good to realize it and good to have to give your opinion to someone else, but... I knew how this worked. I'm not sure whether all PhDs have that eh... consciousness. Maybe they should...
>
> Me: should they?
>
> R1D: I think so. You have to know what you're doing. But well, as a PhD you're just being thrown in there, like, have a seat over there. In my curriculum, I think in most curricula there's some ethics, but not... Well, you can get [your grade] without thinking about it.

R1D thus acknowledged the potential value of broadening the 'consciousness' of PhD students with respect to the ethical dimensions of their research, for instance by including relevant ethics education in the science curriculum.
The third and final example of second-order learning concerns the social relevance of research. Questions concerning the future use of research outcomes were regularly discussed in each of the studies. Responses from all eight of the research participants to the two questions on social relevance featured in the pre-interviews shared a similar ambiguity. All participants responded positively to the first question: does society benefit from research?

> One of the main goals is that society benefits, from any research. It's not just a fun thing we're doing here. (C1A)

> I wouldn't see what would be the point otherwise. If it would not help the rest, if that's the reason, than usually... Society should benefit; what would be the point otherwise? (R2A)

While being convinced of the general societal benefits flowing from scientific research, participants had more difficulty in predicting the possible benefits of their own research projects in response to the more concrete follow-up question: does society benefit from your research?

> C1A: I hope so. It's not my immediate goal; I haven't thought much about it. What I'm doing is basic research; this is probably a little bit far away from... What I'm doing is too far away. (C1A)

> R1A: Honestly, I don't see any significant contribution, no. Maybe there is very slightly, slightly, indirectly, related to contribute ideas, maybe there is some technology... But otherwise, the result, for us researchers, we're excited but for other people, who cares? (R1A)

Wanting to pursue this perceived discrepancy between the general benefits of research and the specific benefits of individual research projects, I revisited the question of social relevance throughout each of the studies. Research participants responded in a similar fashion: a general picture emerged in which the ultimate benefits of research cannot and should not be accurately predicted. Participants gave several historical examples of knowledge flowing from basic research that only much later turned out to have practical use like the invention of the light bulb, penicillin or X-radiation, and concluded that free academic research will ultimately increase chances of socially relevant applications more so than directly demanding social relevance. Increasing calls for social relevance were therefore seen to pose a danger to scientific progress, and ultimately to societal progress, by stifling the innovative power of research:

> R1D: If you invest more in society-improvement, then the learning curve of science will become less steep. So… in the end it's less good for science… And in the end maybe also for society… in the long term.

Interestingly, most of the research projects under study relied predominantly on funding from private organizations and were strongly driven by the need to deliver practical applications. When I questioned the amount of freedom involved in privately funded research, research participants readily acknowledged that their freedom is limited because of the expectations of the private investor. They saw this as the inevitable result of decreases in government funding: the only way for a research group to survive is by strengthening links with private industry. But while acknowledging that this shift in funding mechanisms limited their academic freedom, they continued to invoke the principle of free academic research to argue against calls for social relevance. Their background assumptions and value systems seemed to have outlasted recent changes in funding mechanisms.

I subsequently tried to challenge their assumptions by first assuming them: supposing that one cannot predict the societal benefits flowing from research, and that academic research should be free, then how to determine which types of research to fund, given that funding sources are necessarily limited?

> Me: The question is: how do you make the decisions whether I should fund genetic modification of cyanobacteria, or whether I should maybe fund your colleagues who do evolutionary growth of cyanobacteria?
>
> R2A: That's why the, well the way that I thought is that politicians are the voice of the people, and those are the ones that automatically decide who gets the money, because they should have, they should know, what people want. So if people want cleaner fuels, then they give money to cleaner fuel. If people wanted better dogs, than they would find someone else. I think it's driven like that.

To press the question, I would ask how the research participants would decide which research to authorize if they were a policy maker. R2A took recourse in a process of democratic decision making:

> R2A: Right, I guess the policy has to be made, eh, like, on the average of what people think. It's not like the policy can't be made on the thinking of one person only, but of what most people think.

> Me: But how about if big masses of people, like in Europe, say we don't want any genetic modification? Would you say, well, that's the majority vote, I'll just quit my job and find another?
>
> R2A: Probably not like that. But... I tend to be objective on those sorts of issues, so... Someone who can prove to me that that was the best decision, I would follow it. If someone would have a good argument I probably would... not quit my job, but find a different approach. I guess, I don't know.

Such discussions thus problematized the unquestioned assumption that the demand for societal relevance hampers societal benefit. Research participants realized that some kind of demarcation criterion was needed to determine which research to fund, only to realize that this would involve measuring the value of knowledge as a function of some kind of external relevance, contradicting their original assumption that the utility of research cannot be predicted.

The MM feedback mechanisms allowed for attending to the broader questions as they impinge on the daily work of researchers, and pointing to possible tensions or ambiguities present in the research participants' responses. The value of these 'second-order' discussions lies not so much in having motivated directly observable changes in practice, but in the fact that participants engaged in critical reflection on the broader socio-ethical context of their work. Research participants observed the ambiguity in their initial responses, realized that some criterion of relevance is needed 'in the real world' to determine what projects to authorize, and showed interest in reflecting on it in more nuanced ways:

> Yeah, you pull it away from the science a little, you put it in a somewhat different perspective, more like... You look at science as a society so to say, where all kinds of things happen. (R1D)
>
> What I think is useful is that one can indeed think about what kind of societal interest is involved when someone does this kind of research. ... I think it's really interesting that people will start thinking about the use much more. ... Yeah, and in fact the whole story about ... the whole relationship between politics, decision making and the role of scientists in that decision making. And that it's a kind of duel between politics, society, and the people that do the research, and to make it more complex also the growing power of companies. Those are interesting themes. ... Of course it's interesting to hear the opinion from someone who is more in the philosophical corner, so to say. I'll take that with me, also later in discussions. (R2D)

In summary, the research findings suggest several instances where participants began to reflect on the underlying background theories and value systems operative in research. Questioning the 'ethical valence' of research decisions (the extent to which a research decision may include morally relevant dimensions) increased the 'moral conscience' of researchers (the extent to which researchers acknowledge the relevance of critical reflection on the morally significant dimensions). By challenging unquestioned assumptions, discussing what future applications could come out of the research, and sharing different visions on the role of science in society, the socio-ethical context came to life within the context of research - something that participants indicated not having experienced before, neither through their 'ethics and society' curriculum or ethically-oriented funding requirements.

Research participants indicated that the ongoing discussions during and alongside the actual conduct of research did not hamper, but instead added value to the research process in several ways. In the words of R1D, 'stepping into the helicopter' could serve as a guide to research planning, to identify overlooked opportunities, to relate lab research to its broader policy contexts, and to uncover latent normative issues. When during the post-interview I asked R1D whether he thought the study was useful to him, he replied:

> ...everybody should perhaps reserve free space in their agendas every now and then, stop all experiments ... and think. ... Maybe you could... Should one integrate this in each and every PhD project? That someone from outside the faculty comes along, and you need to account for your actions towards that person. And the guy sitting in front of you would only have to ask: why? Why this? Why that? Couldn't you do that differently? And how does it work?

4.6. Discussion

The experience with MM provides insights into how the broader socio-ethical dimensions of research can be rendered visible within the research context and suggests that research participants perceive such broader reflection to be relevant. With respect to the challenge identified in EE, MM served to encourage researchers to address the socio-ethical context of their work through collaboration and in real time. The lab studies thus aligned with the objective of real-time technology assessment in its aim to: 'provide an explicit mechanism for observing, critiquing, and influencing social values as they become embedded in innovations' (Guston and Sarewitz: 2002, 94) while arguing from an overtly normative standpoint: invoking the procedural norm that researchers should engage in critical reflection. Like the earlier MM pilot study (Fisher et al.: 2006), these studies served to bring out latent ethical and societal dimensions of research, rendering explicit those considerations that hitherto remained implicit, at a time when they can influence the kinds of considerations that researchers invoke when making decisions. Unlike the earlier study, they also aimed to bring in relevant socio-ethical knowledge and perspectives, and initiate discussion of specific moral questions as they arise in the laboratory context. As Van de Poel and Verbeek (2006) note:

> Synergy between engineering ethics and STS … could result in an empirical and reflexive research, which is empirically informed and critically contextualizes the moral questions it is asking but at the same time does not shy away from the effort to actually answer them. (Van de Poel and Verbeek: 2006, 234)

The overall approach adopted in these studies isn't morally agnostic. It invokes the procedural norm that researchers have a moral obligation to critically reflect on their research. But this kind of 'deliberative modulation' (Fisher and Calleja-Lopez, unpublished manuscript) should not be taken to imply that the embedded humanist enters the laboratory with a well-defined set of substantive norms, since these can only emerge as a result of the interactions. The type of socio-ethical assessment called for requires an approach that combines two ways of thinking and knowing: those of the laboratory researcher and those of the embedded social researcher (Gorman et al.: 2009). Collaborative exploration of the particular normative issues that pertain directly to the research at hand instils a sense of urgency, concreteness and relevance to the research participants that differs essentially from reading about them in say, a textbook. Conversely, the interactive process potentially allows for early detection and warning signals of the ethical valence of research outcomes that may otherwise go by unnoticed. By focusing on the concrete normative questions that arise within the context of the laboratory, MM can thus support a more focused (and less speculative) approach towards ethical reflection that could lead to more meaningful interactions between scientists and ethicists (*cf.* Nordmann and Rip: 2009).

The perceived value of second-order reflective learning, as envisaged in EE and observed in the lab studies, proceeds by way of the perceived value of first-order learning, of improving the achievement of one's own interests. During the 12-week period, initial reticence from research participants turned into enthusiasm for discussing the research progress as well as the broader aspects of their research. Given that 'rethinking' knowledge production in research systems will at least partially depend on the willingness of research communities to rethink their own practices, such collaborative approaches might be more effective than external forms of critique. On the other hand, the dependency on research participants' willingness to engage implies certain limitations which will be discussed below.

4.6.1. Limits to the embedded approach

The value of MM with respect to encouraging researchers to critically reflect on the broader context of their work lies in the process of real-time collaboration. But the 'voluntaristic' approach towards collaborative engagement builds an asymmetrical relation between the researchers and the embedded humanist. The latter is ultimately a 'guest' in the research group and therefore to some extent dependent on the acceptance and endorsement of the researchers. Engagement cannot be enforced: as a consequence, critical views cannot be allowed to break good relations. This may not be a problem if the collaboration is seen by research participants to be conducive to first-order learning, but could become a problem when there is strong normative disagreement. In those cases, the embedded humanist has no 'jurisdiction'.[18] The need to respect operative conditions and dynamics within the laboratory thus inevitably limits the range of possible critiques. Furthermore, while interdisciplinary collaborations focus on engaging individual researchers, their freedom of movement is constrained by their social and institutional environment which may limit the effects of newly emerging perspectives on research practices. Existing responsibilities often take precedence over a researcher's broader social responsibilities; from a lab-based perspective, responding to social concerns can therefore be expected to take second place.

In light of these constraints, a remaining research task is to more clearly define the capacities and limits of midstream engagement methodologies and to determine potential synergies of laboratory engagement with activities at institutional and policy levels. Further research is needed to explore the boundaries of embedded approaches: to what extent are accepted practices in the lab allowed to be challenged? When do particular issues transcend the responsive capacity of research laboratories, demanding reflection at higher institutional and policy levels in concert with, for instance, governmental ethics committees? How can

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18 Personal communication Anthony Stavrianakis.

midstream engagement initiatives be complemented and reinforced by changes in incentive structures and the formal training of researchers?

The transactional costs of interdisciplinary collaborations have to be weighed in light of their benefits. MM has been found to encourage research participants to critically reflect on the socio-ethical context of their work. Not only is this something that will likely be extremely difficult to achieve without some form of collaborative engagement, it is also arguably a capacity that is needed if other social and ethical programs - upstream engagement, codes of conduct, etc.- are to be themselves successful. Granted that the occurrences of first- and second-order reflective learning documented here as a result of the interactions are only modest evidence of what may be possible, they nevertheless provide an indication of the potential significance of such efforts with respect to the challenge identified in EE: engaging researchers with their moral duty to reflect on the ethically relevant choices they make during research. Following Webster's (2007) insightful analysis, a more 'serviceable' STS:

> ...might act as something of an intermediary, as an agent working on the boundary between science and society, helping to set the terms on which science might be accorded a socially warranted status that in important ways is distinct from, critical of and supersedes the conventional (scientistic) sense in which science has been legitimated. (Webster: 2007, 460)

Wynne (2007, 494) is rightly concerned that the STS researcher could 'go native' and becomes an *'integral co-productionist element of the very structures of power and culture which might be just what STS should be challenging.'* This is the real challenge for the embedded researcher: becoming part of the convergence of goals, strategies and configurations of the laboratory insofar as it provides access to different registers of justification[19] while not loosing sight of the original intentions behind wanting to insert oneself in the laboratory. The critical stance of STS should not be forgotten; but critical reflection may prove to have unexpected and desirable effects when undertaken in collaboration. Walking the thin line between co-labour and critique may serve to allow a different voice be heard at the heart of the R&D enterprise, tapping potentials for change that could prove significant.

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19 Personal communication Arie Rip.

4.7. Conclusion

The results of these studies inspire both modesty and enthusiasm: modesty, because the laboratory engagement studies have been able to provide a mere glance of the potential of interdisciplinary collaborations to encourage critical reflection in a relatively small sample size. There are further questions to be addressed: what are the boundaries to broadening research decisions in light of ethical considerations? Are there more symmetrical ways of building interdisciplinary collaborations? What specific requirements does real-time socio-ethical assessment place on the attitude and capacities of the researchers and the embedded humanist? At the same time, the research findings inspire enthusiasm: they show how broader socio-ethical dimensions can be effectively engaged in the laboratory. MM was found to engender fruitful and meaningful collaborations between social and natural scientists, encouraging second-order reflective learning while respecting the lived morality of research practitioners. Not only did it make broader socio-ethical issues visible in the lab, it also encouraged research participants to critically reflect on these broader issues. Webster (2007) notes that:

> ...the long-standing critical thrust of STS analysis asks quite explicitly how science, technology and the social relations on which they are fashioned can be reconstructed, in a more socially useful way ... acknowledging thereby that the STS critic embraces normative intervention, both as analyst and as 'citizen'. In doing so, critical STS analysis has to address the question of how its critique can provide the basis for constructive engagement with science. (Webster: 2007, 460)

There is still a long way to go. But the procedural norm of reflective learning may guide both the embedded researcher and laboratory practitioners in their ways of determining 'better' ways forward, integrating socio-ethical assessment with ongoing and future research directions.

5 Multidisciplinary Engagement with Nanoethics through Education – The Nanobio-RAISE Advanced Courses as a Case Study and Model[20]

5.1. Introduction

This paper presents and evaluates two postdoctoral advanced courses organised in Oxford as part of the European project Nanobio-RAISE and suggests using their format to encourage multidisciplinary engagement[21] between nanoscientists and nanoethicists.[22] The reason for encouraging multidisciplinary engagement derives from a recent scholarly debate concerning the ethical assessment of emerging technologies. Several ethicists have recently identified the need for 'better' ethics of emerging technologies. Appropriate ethical assessment of emerging technologies, it is argued, requires that ethical deliberation become part and parcel of the R&D process and demands increased collaborations between nanoscientists and nanoethicists. This paper will suggest pedagogical support for such increased collaboration by building on an existing course model that proved successful in bringing together participants with very diverse backgrounds and building interactional expertise between them. This

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[20] This chapter was originally published in Nanoethics (2009) 3: 197-211 and was co-authored with S. Sleenhoff, J. F. Jacobs and P. Osseweijer.

[21] The term 'multidisciplinary' is used here (as opposed to interdisciplinary) to indicate collaborations between actors from different disciplines without necessarily envisioning full integration of those disciplines. 'Engagement' is used (instead of 'interaction' or 'collaboration') to encompass the attitudinal component of multidisciplinary work: the actors' enthusiasm and willingness to learn from disciplines beyond the individual field of expertise.

[22] Strictly speaking, the terms 'nanoscientists' and 'nanoethicists' are overly narrow delimitations of the intended target groups; 'nanoscientists' refers to scientists, engineers and other researchers from the natural sciences involved in nanotechnological research; 'nanoethicists' refers to those scholars from the social sciences and humanities who have taken nanotechnological research broadly as their object of study. For purposes of readability we will however stick to these shorthand notations.

course model will be analysed and used as a model for further course development. Before going into the details of these courses, the following section will outline why scholars have indicated the need for a better nanoethics and what it entails.

5.1.1. Promises of nanotechnology

It is difficult to overstate the expectations that have surrounded the emergence of nanotechnology in recent years. It has been hailed as the next industrial revolution comparable to electrification or the steam engine (Peterson: 2000; Roco and Bainbridge: 2003; Wennersten et al.: 2008), providing unparalleled technological and social progress in almost any field imaginable. Nanotechnologies are repeatedly claimed to provide radical advances in medical diagnosis and treatment (Nanoforum: 2009), electronics (Allan: 2003), cheap sustainable energy (Cientifica: 2007), environmental remediation (Joo and Cheng: 2006), more powerful IT capabilities (Anton et al.: 2001), and improved consumer products (Maynard et al.: 2006). Whether or not these promises will hold true, they have served to generate considerable investments: worldwide R&D funding of nanotechnology was approximately 14 billion US dollars in 2007 and rose to 18 billion in 2008 (Lux Research: 2009). As research into diverse areas of applications continues, a range of nano-enabled consumer products like sunscreens containing nanosized titanium dioxide and food storage containers with nanosilver is entering the market (The Nanotechnology Consumer Products Inventory: 2006). The world market for such products was around 150 billion US$ in 2007 and is forecast to grow to $ 3.1 trillion in 2015 (Lux Research: 2008).

Despite the promises of nanotechnology, expectations and investments have been accompanied by expressions of doubt and concern ever since the ignition of the nano-boom in the early years of the 21st century. Concerned scholars have argued that if this emerging technology is indeed as revolutionary as promised, it would be wise to assess its wider ethical and societal ramifications. In addition to uncertainty about the human and environmental health risks of nanoparticles (Dunford et al.: 1997; Federici et al.: 2007; Poland et al.: 2008), and regulatory challenges (Cerutti: 2006), nanotechnology was feared to pose deeper ethical challenges with respect to human enhancement (Bruce: 2007a), equity (Singer et al.: 2005), privacy (Hansson: 2005) and security (Altmann: 2004).

Leaving aside the question of whether these ethical issues are essentially 'new' or rather reiterations of an ongoing debate (Shrader-Frechette: 1997), large numbers of scientists, ethicists and policy makers in the early years of the 21st century seemed to agree that nanotechnology wasn't 'business as usual' and called for ethical assessment. Moreover, failure to address the broader ethical and social dimensions of nanotechnology was generally feared to unleash a 'social backlash' against nanotechnology similar to the case of genetically modified crops in Europe. The UK Royal Society and Royal Academy of Engineering nanotechnology report of 2004 noted:

> As recent debates in the UK and elsewhere demonstrate, developments in science and technology do not take place in a social and ethical vacuum. Widespread discussions of issues such as nuclear energy, agricultural biotechnology and embryonic stem cells illustrate this point only too clearly. ... Given this backdrop, it seems highly likely that some nanotechnologies will raise significant social and ethical concerns (51).

Although the assumption that nanotech will be 'the next GM' has been contested (Sandler and Kay: 2006), the potential for a social backlash against nanotechnology encouraged policy makers to demand attention for the broader dimensions of nanotechnology, giving rise to a new field of social and ethical enquiry. From the outset, the aim of this burgeoning field of nanoethics has been to 'close the gap' between the accelerated speed of developments in nanotechnology and its ethical assessment (Mnyusiwalla et al.: 2003). But due to the intrinsic novelty of the technologies as well as deep uncertainty about future directions and possible impacts of the research, the appropriate role and remit of this developing discipline has remained a matter of considerable debate (Weckert: 2007). Nanoethics has been criticised for speculating about improbable futures and strengthening the hype and myth of nanotechnology by if-and then reasoning (Nordmann: 2007). If traditional methods for ethical deliberation and assessment lag behind the speed of development of new technologies, then what is needed for nanoethics to 'catch up'?

5.1.2. 'Better' nanoethics?

In response to these challenges, several leading ethicists have recently proposed a re-examination of the processes of ethical deliberation in light of the very nature of emerging technologies. Engineering ethicist Joe Herkert has analysed the propositions of both computer ethicist James Moor and bioethicist George Khushf for a 'better' nanoethics that can keep pace with the ethical challenges of emerging nanotechnologies (Herkert 2009, unpublished manuscript). Moor

(2005) argues that anticipated 'major technological upheavals' require *'...Better ethical thinking in terms of being better informed and better ethical action in terms of being more proactive.'* He suggests three improvements: first, the acknowledgement that *'ethics is an ongoing and dynamic enterprise;'* second, the employment of a multidisciplinary approach that includes *'better collaborations among ethicists, scientists, social scientists, and technologists;'* and finally, the development of *'more sophisticated ethical analysis.'* Herkert notes how bioethicist George Khushf has similarly suggested redefining traditional methods of ethical reflection in light of radical ethical challenges put forward by the radical possibilities associated with new technologies: *'Faced with the prospect of increasingly accelerating, radically new technologies, we must completely reassess how ethical issues are addressed and how ethical debate informs broader public and legal policy.'* Emerging technologies thus pose: *'an ethical challenge not just in the number, scope, and depth of issues that are raised but also in the very form that ethical reflection takes'* (Khushf: 2006, 258). For both Khushf and Moor, 'better' nanoethics requires both that ethical reflection should become more tightly integrated with the R&D process itself, and requires increased collaborations through new multidisciplinary engagements between nanoscientists and nanoethicists. Herkert's representation of the views of Moor and Khushf, particularly the suggestion to reassess the very form that ethical reflection should take, links in with the views of Nordmann and Rip (2009) who recently argued for a 'more focused approach' in nanoethics that 'could lead to more meaningful interactions' between scientists and ethicists.

While the theoretical contours of 'doing' nanoethics differently are slowly becoming visible—notably the vision of bringing ethical assessment 'closer' to R&D processes and increasing collaborations between nanoscientists and nanoethicists—precisely how to implement this broad vision is as yet unclear. In 1959 the British physicist C.P. Snow introduced his now famous notion of the 'Two Cultures' in his Rede lecture, arguing that the divide between the sciences and the humanities was a 'hindrance to solving the world's problems' (Snow: 1959). Fifty years later, the two cultures seem to be more strongly separated than ever with respect to the topics addressed, questions asked, methods used and worldviews. Although new forms of collaboration between natural scientists and engineers and social and human scientists are emerging in various places (Gorman et al.: 2004; Schuurbiers and Fisher: 2009) and recent studies suggest that nanotechnology researchers appear receptive to ethical issues in relation to nanotechnology (McGinn: 2008), multidisciplinary engagement between nanoscientists and nanoethicists still faces significant challenges. Due to differences in training and cultural 'formation' between the disciplines, it has proven very difficult to establish common ground for meaningful discussion between nanoscientists and nanoethicists. Reflection on the broader dimensions of research does not form an integral part of lived practices in the laboratory as a consequence of both long-standing institutional arrangements and educational structures that have fostered a 'laissez-faire' attitude with respect to engaging with the broader dimensions of research (Beckwith and Huang: 2005; Mitcham: 2003). Particularly young researchers often operate in a 'protected space', effectively shielded from outside pressures by their lab directors (Rip: 2003). Senior researchers are hesitant to add social and ethical 'digressions' to already extremely demanding science curricula. Conversely, nanoethicists have in some cases been hesitant to 'get their hands dirty' and have preferred to engage in theoretical reflection and conceptual analyses rather than engaging with research practices directly (Guston and Sarewitz: 2002; McGregor and Wetmore: 2009). Here, as in the natural sciences, the academic careers of young researchers largely depend on publications in traditional, mostly monodisciplinary journals.

Bringing ethical assessment closer to R&D practices will thus at some point require the rapprochement of the Two Cultures. This remains a major challenge, one that depends both on further research into interdisciplinary collaborations (defining new forms of multidisciplinary engagement in the laboratory) and on training initiatives (building the appropriate knowledge, skills and attitudes that the actors require in order to engage). Indeed, innovative approaches are emerging in various places that aim to bridge the cultural divide between the sciences and humanities such as trading zones (Gorman et al.: 2004), scenario workshops (Robinson: 2009), midstream modulation (Fisher: 2007; Schuurbiers and Fisher: 2009), ethical parallel research (Zwart et al.: 2006), biographical narratives (Consoli: 2008), and initiatives aimed at increasing the 'moral imagination' of researchers (Van der Burg: 2009). These interdisciplinary research initiatives largely focus on collaborations during the R&D process itself.

In addition to researching the *processes* by which actors engage in multidisciplinary collaboration, the *capacities* of actors (i.e. the appropriate knowledge, skills and attitudes) are fundamental prerequisites as well. The National Science Foundation has stressed the need for building such broader capacities for integration among the academic workforce as a condition for the responsible development of nanotechnology:

> Many nontechnical advanced students will need to learn about nanotechnology, and future nanoengineers will need to study the ethical and societal implications of their work (Roco and Bainbridge: 2005).

The 'Opinion on the Ethical Aspects of Nanomedicine' of the European Group on Ethics in Science and New Technologies to the European Commission suggests to:

> ...cluster experts from different fields, promote deeper understanding of the ethical issues arising from nanotechnology and nanomedicine, promote education in the fields above, and facilitate interaction between the community of ethicists and nanotechnologists and the embedding of ethics into research practices (European Group on Ethics: 2007, 61).

Whereas the need to build capacity for multidisciplinary work is thus widely recognized, the potential for encouraging multidisciplinary engagement in educational settings has thus far remained relatively underexplored. This paper therefore suggests an extension of ongoing explorations into new forms of ethical deliberation in the lab by providing pedagogical support for multidisciplinary engagement between nanoscientists and nanoethicists (Van de Poel: 2008; Schuurbiers et al.: 2009). Our aim here is to complement ongoing research efforts with dedicated course work, building on an existing course model that proved successful in bringing together participants with very diverse backgrounds and building interactional expertise between them. We will present and evaluate two advanced courses organised in Oxford as part of the Nanobio-RAISE project below. The courses created a multidisciplinary learning environment for nanoscientists and nanoethicists through engagement with nanotechnology and its broader societal and ethical dimensions. We will focus on the advantages and drawbacks of this particular type of design, and will suggest in what way theses types of courses might be used as a model to encourage improved nanoethical deliberation

5.2. Nanobio-RAISE

The courses were organised as part of the European project Nanobio-RAISE, a 6th Framework Programme Science and Society Co-ordination Action funded by the European Commission from November 2005 until October 2008. This project aimed to combine science communication with ethics research in nanobiotechnology. The project was developed in response to a specific call from the Commission which had recognised the need for responsible development of nanotechnologies in its Communication *Towards a European strategy for nanotechnology* where it stressed that:

> Nanotechnology must be developed in a safe and responsible manner. Ethical principles must be adhered to and potential health, safety or environmental risks scientifically studied, also in order to prepare for possible regulation. Societal impacts need to be examined and taken into account (European Commission: 2004, 3).

The Commission had also taken up the development of model courses: *'in order to raise the awareness of researchers in the field of ethics'* as an explicit action point in its Science and Society Action Plan (European Commission: 2002, 22). The Nanobio-RAISE project therefore brought together in 2005 a multidisciplinary group of nanotechnologists, ethicists, social scientists and communication specialists with the aim to horizon-scan for developments likely to cause concern, clarify the ethical issues involved and carry out strategies for public communication to address the emerging questions. These objectives were implemented by means of a series of meetings of an expert working group on human enhancement (Bruce: 2007a), three horizon-scanning workshops, a series of convergence seminars aimed to assess public opinion in the four corners of Europe (Godman and Hansson: 2009), a citizen engagement activity using the DEMOCS game (Bruce: 2007b), four sets of briefing papers, an information and dissemination programme and two international advanced courses on 'Public Communication and Applied Ethics of Nanotechnology' (Schuurbiers et al.: 2007). See also Fig. 12 for an overview of the project components.[23]

[23] Further information on the results of the Nanobio-RAISE project can be found on the project website: http://nanobioraise.org.

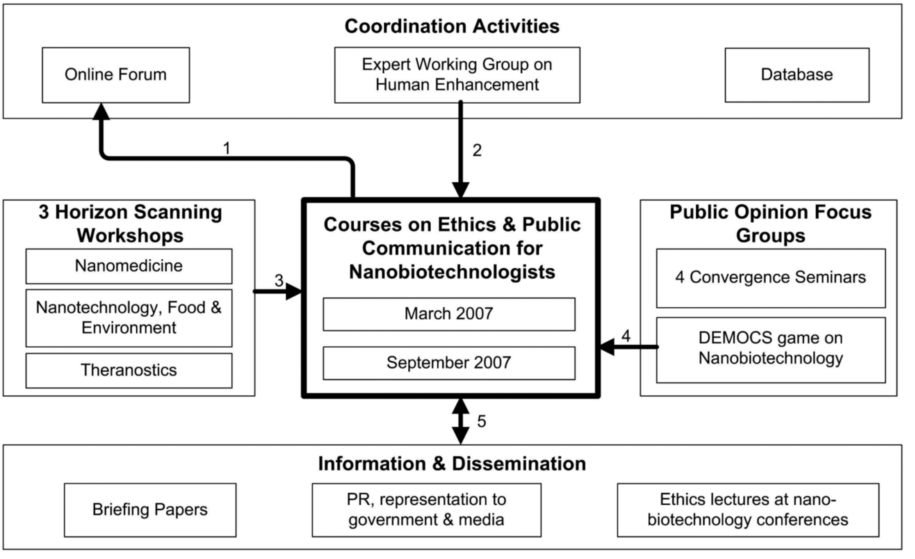


Figure 12. Schematic overview of the Nanobio-RAISE project. Arrows represent relations between the different work packages and the course:
1. The website and online forum facilitated further contact between course participants.
2. Results from the Expert Working Group were used as input for the courses.
3. Results from the Horizon Scanning Workshops were used as input for the courses.
4. The Deliberative Meetings of Citizens (DEMOCS) game was played during the course.
5. The course was presented during conferences to discuss the format and results.
Participants also organised follow-up activities using the course material as input.

5.2.1. Two Nanobio-RAISE Advanced Courses

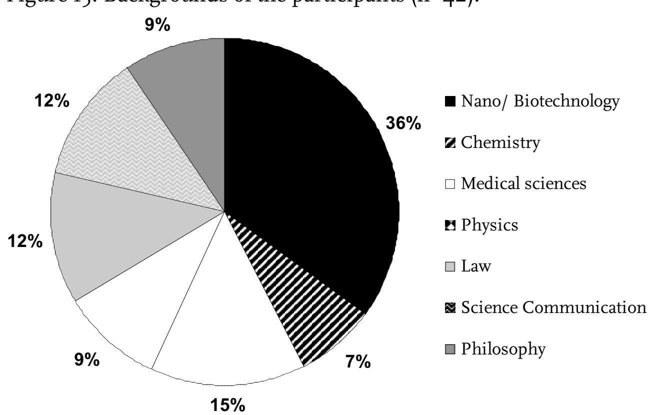
As one key component within the overall Nanobio-RAISE project, two five-day residential advanced courses on ‘Public Communication and Applied Ethics of Nanotechnology’ were organised. Both courses were held at St. Edmund Hall, Oxford, UK, on 11–16 March 2007 and on 23–28 September 2007 respectively.[24] The courses were developed on the basis of a series of earlier courses on public perceptions of biotechnology (Osseweijer et al.: forthcoming) and aimed ‘to increase knowledge and awareness of the ethical, legal and social aspects of nanotechnology’ and ‘to enable the participants to carry out a wide variety of public communication activities discussing the wider implications of their work

[24] The Nanotechnologies Industry Association organised a similar course in collaboration with Cambridge Biomedical Consultants and with funding from the UK Royal Academy of Engineering on 22–27 March 2009. Although this course was modelled after the Nanobio-RAISE courses, its particular setup and programme falls outside the scope this paper.

with confidence'.[25] The specific learning objectives of these one-week, intensive courses were to provide to the participants knowledge of the relevant ethical, legal and social aspects of nanotechnology; skills to communicate effectively with interlocutors outside the peer community including the media and lay audiences; and a broad understanding of 'horizontal' issues involved in public awareness and perceptions of nanobiotechnology. The results from the other activities performed within the Nanobio-RAISE project fed back into the course content and design.

The courses brought together some twenty-five postdoctoral researchers and faculty from a range of nanotechnology related fields and disciplines. Participants came from a wide range of backgrounds including nano/biotechnologies, medical sciences, chemistry, physics, law, science communication, and philosophy (see Fig. 13). In each case, approximately two thirds of the participants were natural scientists and engineers and one third were from the social sciences and humanities; two thirds were working in academia and one third in industry.

Figure 13. Backgrounds of the participants (n=42).



25 See the course programme at http://files.nanobio-raise.org/Downloads/nbrp2.pdf. Accessed 20 July 2009.

5.3. The course programme

The course programme combined lectures on nanotechnology and its ethical, legal and social dimensions with practical and hands-on training.[26] The specific topics and activities scheduled in the course will be discussed directly below, followed by an evaluation of the course and discussion of the central elements identified as encouraging multidisciplinary engagement.

5.3.1. Course topics

To enable a common ground for meaningful discussionof the broader dimensions of nanotechnology, the course programme provided a broad overview of both the state of the art in nanotechnological research and the 'horizontal' issues involved: in addition to ethical issues, broader themes including policy dimensions, public perceptions and media relations were part of the course programme (see Table 6). The program provided a variety of leading nanoscientists as well as speakers in public affairs and communication, ethics, public perceptions, risk assessment, law and regulatory affairs of nanotechnology with the aim to provide a comprehensive overview of actual and possible future developments in the field.

[26] A detailed programme is provided in the Appendix.

Table 6. Topics covered in the course programme.

Nanoscience and technology - the state of the art
Nanobiotechnology
Nanomedicine
Nanotechnology in food
Ethical, legal and social issues
Nanoethics
Law and regulatory affairs
Toxicology and risk assessment of nanoparticles
Public policy development for nanotechnology
Commercialisation of nanotechnology
Nanotechnology and developing countries
Public perceptions of nanotechnology
Public opinion surveys
Risk perceptions and attitudes
Learning from the GM debate
Science Communication
Communication stategies
Nanotechnology, PR and the media
How do the media work?

In addition to raising general interest and awareness of the broader ethical, legal and social issues surrounding nanotechnology, the course programme aimed to explore how these issues could be related to nanoscientific practices. The course material therefore aimed to enable nanoscientists to make direct links with their work without assuming extensive training in ethics or social sciences—and vice versa: providing a scientific knowledge base to social scientists and humanists without offering too much scientific detail. Both lectures and activities therefore aimed to stay close to the lived experience of the researchers. Leading representatives from diverse areas of nanotechnological research were invited to share personal encounters with the broader issues—a researcher in nanomedicine would describe the hurdles to approval of a new drug for instance. Participants were also encouraged to discuss how they thought the issues were related to their own work.

5.3.2. Hands-on activities

A series of practical activities were integrated in the programme to enable the participants to carry out a variety of basic communication activities, discussing the state of the art as well as the ethical, legal, and social implications of their work (see Table 7). By discussing and practicing with each other, participants also learned to interact with researchers from other disciplines. The activities will be described below, followed by evaluations from participants.

Table 7. Hands-on activities within the course.

Activity	Description	Duration
Introductory presentations	Participants present their prime personal objective in a brief presentation to the group	15 minutes each; 2,5 hours total
DEMOCS game	Deliberative Meetings of Citizens card game in which players discuss ethical dilemmas regarding new technologies	2 hours
Debate session	A 'House of Commons' debate in which two parties defend or oppose statements submitted by the participants	2 hours
Role play	Re-enacting political decision making processes by playing out roles of various stakeholder groups	2 hours
Communication plan	Participants work in break-out groups and present communication plans for their fictitious company	1 day (several sessions)
Media training	Participants are trained in writing and presenting their work to a lay audience.	1,5 day

Introductory presentations

Each participant presented their prime personal objective for this course during a brief introduction at the beginning of the course. Participants predominantly stated that they wished to enhance their skills to communicate with the public, but also indicated an interest in the ethical, legal and social concerns surrounding nanotechnology. These personal objectives were discussed halfway through the course and at the end: participants were asked whether their objective was addressed and what needed further attention, which unexpected learning elements they had experienced and whether this had changed their objective.

DEMOCS game

Participants played the DEMOCS (DEliberative Meetings Of Citizens) card game on nanobiotechnology created for the Nanobio-RAISE project in collaboration with the New Economics Foundation which devised the concept in 2002. DEMOCS is a novel form of lay participation in the form of a card game around which participants discuss for approximately two hours and come to agreed or divergent views on national or local policy issues or on general principles.[27]

[27] The game was originally devised with sponsorship from the Wellcome Trust by Perry Walker of the new Economics Foundation, in consultation with experts in ethical and social issues and in innovative engagement with publics.

Examples of applications discussed by way of the game were using nanotechnology to assist in early diagnosis; targeted drug delivery; tissue regeneration; fortifying foods; and human enhancement (Bruce: 2007b).

Debate session

A debate session was held on the second day of the course in the form of a 'House of Commons Debate', with two parties defending or opposing a number of statements. Participants had submitted 'debatable' statements (i.e. statements that one can reasonably be either for or against and are not likely to leave all participants on one side) about nanotechnology before the start of the course. During a strictly timed session an anonymised selection of these statements was debated. Examples included: 'Public acceptance of nanomedicine depends first and foremost on the communication of factual descriptions of this newly emerging field;' 'Nanotechnology will be the new GM;' Nanotechnologies should, but currently do not, address health issues in developing countries'. The aim of the exercise was both to get acquainted with the different perceptions and attitudes within the group and to learn to explain oneself to a multidisciplinary audience.

Role play

The role play session on the third day consisted of the re-enactment of political decision making processes on controversial technologies. By playing out the role of various stakeholder groups, participants were encouraged to discuss the logic of different types of rational argumentation. In particular, this exercise introduced the different visions that various stakeholders in the debate may have.

Communication plans

The drafting of a communication plan was integrated in the course as a central element in the hands-on training. This activity ran throughout the course, with dedicated sessions for group work over several days. Participants worked in small groups on a communication plan for their fictitious company (a university spin off, a small consultancy, a medium-sized enterprise, a multinational corporation and a non-governmental organisation) with the assignment to draft a structured communication plan, following general instructions on a handout. Halfway through the course, students presented their preliminary plans upon which a 'nasty situation' followed, an unexpected event such as an explosion, court trial or terrorist attack. These nasty situations all involved one of the other companies, encouraging communication and negotiation between the groups.

Final presentations, presented on the last evening, needed to address this nasty situation as well as incorporate the lessons learned from the lectures earlier in the week.[28]

Media training

The media training was held at the end of the week. An experienced radio broadcaster and a science journalist trained the participants in writing and presenting their work to a lay audience. The day started with a simulated press conference, in which participants assumed the role of reporter and had to write a short piece for their local magazine on the visit of a well-known scientist. In the afternoon, the press releases that participants had prepared in advance were discussed, and at the end of the day participants tested their verbal skills during a simulated radio interview. Participants were informed on how the media works, including the day-to-day realities that journalists have to work with—approaching deadlines, quick decisions, and stubborn editors—and how to maintain good media relations.

Social networking

The social networking—that naturally occurs during a five-day intensive course—was facilitated deliberately by extended stay of lecturers, residential stay, and combined social activities. This facilitated information-sharing among participants and lecturers so that in addition to the stand-alone course module itself, participants were encouraged to entertain relations with scholars from other fields during and after the course. In order to facilitate a longer term networking environment for further discussion and activities within the group a Nanobio-RAISE Hyve was established shortly after the course on the popular social networking site Hyves.nl. Most participants enrolled in the Hyve and continued to share their thoughts, pictures, documents and further information including the lecturers' presentations.

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28 The assignment also functions as a competition: each participant can buy or sell 'shares' in another company (not their own); all companies start out even, and shares are bought and sold after the presentations. A panel of experts, with considerably more shares, place their shares after evaluating the final presentations as well. The company that manages to accumulate most shares, wins.

5.3.3. Evaluation by participants

Participants were asked for their feedback both during the course by way of a mid-term evaluation and after the course finished, through feedback forms. They evaluated the organisation, theoretical and practical programme and general aspects of the course very positively. Responses to the question 'What overall score would you give this course as a whole?' averaged 4.1 out of 5. Participants welcomed the integration of a practical, hands-on approach to the range of complex theoretical issues in ethics and social sciences through interactive work such as the role playing exercise and the debate session. They especially appreciated the quality and diversity of the lecturers, whose input, combined with the very diverse backgrounds of the participants themselves, they thought constituted a good learning environment and generated fruitful discussions. As one nanobiotechnologist noted: *'This was the other side of science that I had missed seeing all these years. It's been a 'mind opening' course.'* Participants enjoyed the group work, especially the debate session, communication exercise and introductory presentations. A postdoctoral researcher in the philosophy of science said: *'I am not a fan of group work generally, but here it gave lots of fun and insight.'* The variety of backgrounds of participants was found to provide synergy to the group. A participating medical doctor noted that: *'It was not easy to cooperate due to diverse background knowledge. In the end, these diversions provided enormous synergies for the team work.'*

5.3.4. Follow-up

The courses also facilitated longer-term networking, as can be seen from a variety of follow-up activities: one participant recently organised a very similar course in her home country; another participant organised a public outreach activity in Asia; several lecturers were involved in the supervision of a research project submitted by one of the participants; and many participants have kept in touch with each other. Although those contacts are mostly informal, several participants have drafted joint papers and built collaborative projects. In summary, the courses served to bring diverse audiences together. This is why we suggest using this format for encouraging multidisciplinary engagement between nanoscientists and nanoethicists.

5.4. Discussion

Considering the positive evaluations from participants and the range of follow-up activities, the courses provide a successful format for bringing together scholars with diverse backgrounds and laying the foundations for multidisciplinary engagement with the broader dimensions of nanotechnology. Particularly, the participation of a broad range of backgrounds proved to be a fertile breeding ground for multidisciplinary engagement. For this reason, we would like to suggest using the existing format of these courses to address the need identified above—increased collaborations between nanoscientists and nanoethicists—in an attempt to bridge the divide that exists between the two cultures. By creating a multidisciplinary learning environment and providing a broad knowledge base required for successful collaboration, such courses may complement ongoing interdisciplinary research efforts in the lab by providing participants with the necessary knowledge, skills and attitude to engage in multidisciplinary work. We will first suggest three central elements that in our opinion proved to stimulate multidisciplinary debate, and subsequently present some modifications that might gear future courses more towards the specific challenges for nanoethics.

5.4.1. Three elements that encourage multidisciplinary engagement

Looking back on the courses, we have identified three central elements that can build the interactional expertise (Collins and Evans: 2002) required for nanoscientists and nano-ethicists to engage in meaningful multidisciplinary dialogue about the topics at hand in the 'trading zone' of the ethical and social dimensions of nanotechnology (Gorman et al.: 2004): first, providing a broad knowledge-base of relevant horizontal issues; second, building interactional skills among nanoscientists and nanoethicists; and finally, stimulating network building.

1) Multidisciplinary knowledge: providing a broad knowledge-base of relevant horizontal issues.

The courses addressed a broad range of topics: beyond those that would strictly speaking fall within the category of 'ethics', it included those topics deemed necessary for ethical reflection in the broader sense of the word like the reasons for politicians to fund scientific programmes, the politics of science, the diffusion of new technologies in society, issues of public acceptance and the role of the media. A shared knowledge base among participants is a vital aspect to the integration of ethical deliberation with R&D processes. By complementing the state of the art in science and reflection on its ethical issues with this broader picture that includes politics, public perceptions and the media, the course programme places scientific developments in their wider socio-political context, allowing for a convergence of perspectives from within and outside the science. By discussing and engaging with these different perspectives, participants do not only acquire a basic level of knowledge on the kinds of approaches to the technological developments at hand, but also obtain a deeper understanding of the different 'lifeworlds' that exist in different communities of expertise.

The breadth of topics necessarily comes at the cost of in-depth treatment. The unequal distribution of knowledge and expertise is to some extent unavoidable in multidisciplinary settings—due to symmetry of ignorance—so the challenge is to provide sufficient levels of information without losing the audience. From previous course evaluations it became clear that detailed philosophical analyses turned out to be beyond the level of comprehension of nanobiotechnologists and vice versa. Rather than speculating about distant futures, course topics could focus on less dramatic but more urgent and more realistic scenarios—issues of intellectual property, regulation, etc. As Nordmann and Rip (2009) indicate: *'Scientists find it difficult to relate to the grand claims of speculative ethics, so a more focused approach could lead to more meaningful interactions.'*

2) Multidisciplinary skills: building interactional skills among nanoscientists and nanoethicists.

In addition to the knowledge component, a second central element concerns the specific skills required for engaging with others outside the community of expertise such as being able to explain one's work without the use of jargon, to combine different perspectives on a topic and rhetorical skills. Particularly activities like the role play and debate session have served to help participants to come to understand and work with perspectives of other stakeholders in the debate. By opposing or defending different positions, the debate session establishes a common ground for discussion between the diverse disciplines present in the group. Interestingly, the debate session quickly demonstrates how 'facts' become subordinate to effective rhetoric in a multi-stakeholder debate, arguably reflecting 'real' public debates. The debate session also offers participants an opportunity to discuss their personal views and to engage in discussion about them. The role play offered another way in which participants were exposed to alternative visions: a scientist having to defend the perspective of a non-governmental organisation or a social scientist playing the role of a news reporter may come to see the internal logic of the position of another stakeholder. By interacting about contentious issues beyond the personal field of expertise, participants importantly experience how each is expert in one field and lay in another. The debate then serves to explore how different perspectives on the same topic can be brought together. These interactions all require rhetorical and performance skills which deserve and have been given special attention in a course where interaction and engagement are central.

3) Multidisciplinary attitudes: stimulating network building

With a view to seeing the course as a first step towards increased collaborations between experts from different disciplines, the overall attitude it engenders may ultimately be more important than the basic knowledge and skills it imparts. This is why we have used the term multidisciplinary *engagement*: indicating the importance of the willingness and enthusiasm to interact among participants. The follow-up after the course shows that successful interactions during course work can lead to increased collaborations afterwards. The course should therefore not be a stand alone module, but rather functions as the start of a social network, encouraging members to stay in touch and collaborate. From the experience of previous similar courses the participants take what they have learned back to their colleagues and institutions, acting as 'amplifiers', undertaking and organising further outreach and representational activities and working to establish these approaches in the courses and activities of their own institutions.

5.4.2. Modifications

Having sketched this general outline on the basis of previous experience, some modifications with respect to the earlier courses will be required to gear the course towards the specific goal of engagement between nanoscientists and nanoethicists. The first modification would be to shift emphasis from public communication to deliberation on the broader dimensions of nanotechnology as they affect the R&D process itself. The emphasis of the previous courses, as part of the Nanobio-RAISE project, was more on training scientists to communicate the broader dimensions of their work to the media and the general public with confidence. One might say their focus was 'from the inside out': how to communicate the results of one's work to various audiences? This focus was reflected in the central role for the media training and the communication plan. The ethical, legal and social issues were introduced insofar as they supported the communication component, as a precondition for improved communication. Although communication and interaction inevitably play an important role in all types of engagement with other stakeholders, the intention to bring ethical deliberation closer to the R&D process itself necessitates a balancing act between an inside-out perspective and a view 'from the outside in': how to bring broader social and ethical considerations to bear on scientific work? The courses envisaged would focus on the collaborative exploration of ethical and social issues as they affect the R&D process; the deliberative aspects will thus take precedence over the dissemination aspects. Insofar as public engagement would be addressed, the focus would be more on how to integrate public values in research decisions or in science policy, rather than on how to better inform the public about nanotechnological research. Our aim would thus be to 'open up' the research processes, exploring the ethical dimensions of research processes themselves and the question of how to address public values within these. The emphasis on ethical deliberation instead of public communication invites the question of how to encourage nanoscientists to attend the course. Communication skills training suggests a direct benefit for nanoscientists: the ability to communicate effectively with the public is becoming an accepted requirement for furthering one's career in research. Indeed, most participants explicitly mentioned the acquisition of communication skills among their prime personal objectives. Increasing one's ethical deliberation skills may not have such immediate benefits, although participants did also express interest in learning more about the ethical issues surrounding their research. The ability to perceive and address relevant ethical issues might however become more important to acquiring research funding in the near future—funding agencies increasingly require that attention be paid to ethical issues in research proposals. That said, further initiatives may be needed to convince nanoscientists of the relevance of ethical deliberation for their research. The question how to encourage scientists to participate in ethical deliberation efforts is a critical question and one that may need further support from lab directors and funding agencies. In addition to the question of how to engage nanoscientists, the question of how to bring broad ethical consideration to bear on the 'micro-level' of individual research projects inevitably remains a challenge and will need to draw on ongoing policy and lab engagement studies. One possible way of modifying the current course programme could be by turning the communication plan exercise into a tentative 'midstream modulation' study (Fisher: 2007) to collectively think through how ethical issues could be integrated in research decisions by merging the expertise of nanoethicists and nanoscientists in mini-research projects. Another modification that could be useful from both a research and a pedagogical perspective is to pay close attention to the multidisciplinary learning that occurs during course work, monitoring the learning process by way of an ongoing 'opinion survey' during the course, to estimate if and to what extent participants' opinions on the relevance of other forms of expertise change in light of exposure to different perspectives. In addition to being a learning environment, the course then becomes a valuable source of research data in itself. This could be done by way of voting on participants' statements and monitoring for changes in opinion throughout the week. A final point to consider is whether the type of multidisciplinary engagement envisaged in this paper will in fact serve as the stepping stone toward integrating ethical reflection with the R&D process itself. Although the kinds of follow-up initiatives undertaken by participants after the course do seem to indicate that networking and collaboration persists over time, it is as yet uncertain to what extent such engagement 'among colleagues' has led to interdisciplinary engagement 'in the lab'. Follow-up questionnaires that enquire for these questions on the longer term (several years after the course) could shed further light on the eventual integration of the lessons learned during the courses in daily research practices. Such long-term post-evaluations as have been held with respect to the courses predating the Nanobio-RAISE courses (Osseweijer et al.: forthcoming) suggest that participants keep using the course material up to several years after the course, but to what extent this will lead to significant changes with respect to integrating ethical reflection in research practices is still to be determined.

5.5. Conclusion

Multidisciplinary approaches towards ethical deliberation as envisaged in recent views on 'better' nanoethics—integrating ethical issues in the earliest possible stages of research and development of nanotechnology—will at some level depend on the knowledge, skills and attitudes of the actors involved. As the contours of better ways of doing nanoethics are slowly becoming visible, practical implementation still leaves open many questions, both at the level of training and of research. In this paper we have suggested how dedicated course work on multidisciplinary engagement could be used as a natural complement to ongoing multidisciplinary research efforts 'in the lab.' We have derived from the existing format of Nanobio-RAISE courses three central elements to encourage engagement between nanoscientists and nanoethicists and have suggested modifications to support 'better' ethical reflection, balancing the 'inside-out' and the 'outside-in' perspective. To be sure, these are only the first steps towards the challenge of bridging the divide that exists between nanoscientists and nanoethicists. Transcending the barriers between the two cultures is likely to be one of the main challenges that the developing field of nanoethics is facing. It will require educational reform—increasing the capacity of scientists and engineers to recognize and address ethical and social issues in their work as well as the capacity of ethicists to bring ethical and social issues directly to bear on scientific work—as well as organizational reform—creating an institutional environment in which attention to the broader issues and increased collaboration is both encouraged and rewarded. Further explorations of different forms of multidisciplinary engagement may be indispensible in designing 'better' nanoethics. Courses like the ones discussed here may assist in paving the way for multidisciplinary engagement. To do so we need to engage and involve nanoscientists with the broader dimensions of their work; urge nanoethicists to take a focused approach towards ethical dimensions of research; and explore the common ground between scientific and ethical expertise from which the wider ramifications of scientific developments can be assessed at the earliest possible stage. As Moor suggests: *'At the very least we need to do more to be more proactive and less reactive in doing ethics.'* With these courses, we have aimed to do just that.

6 Conclusions and Discussion

The previous three chapters presented individual case studies within each of the three areas of intervention identified in the introduction: codes of conduct, interdisciplinary collaboration, and education and training. They approached the question of social responsibility in research from different angles. This concluding chapter will review the main findings and conclusions of the individual studies and their respective areas of intervention in light of the overall research objective of this thesis: identifying opportunities and constraints for the practical realisation of a broadened conception of social responsibility, one that includes the moral responsibility of researchers to critically reflect on the socio-ethical context of their research (table 1 from page 11 is reproduced below for convenience).

Table 1. The case studies and their areas of intervention

Area of intervention	Case study
Codes of conduct	Implementing the Netherlands Code of Conduct for Scientific Practice
Interdisciplinary collaboration	Applying midstream modulation to encourage socio-ethical reflection in the laboratory
Education and training	Evaluating the Nanobio-RAISE Advanced Courses on Public Communication and Applied Ethics

To do so, I will begin by answering the first research question of this thesis and consider the effects of the specific interventions with respect to: 1) encouraging researchers to critically reflect on the socio-ethical context of their work, and 2) bringing broad social and ethical considerations to bear on research decisions. I will subsequently review the interventions in terms of more general practical criteria: their cost effectiveness, time-commitment and reach. After having thus analysed the actual effects of the interventions in the case studies, I will answer the second research question about the possible opportunities and constraints that further initiatives within the broad areas of intervention may offer for encouraging a broadened conception of social responsibility in research. Then, I will answer the third research question by suggesting an approach towards the practical realisation of a broadened conception of social responsibility in research that combines the strengths of each of the respective interventions, one in which codes of conduct *articulate* societal expectations and the normative commitments of the research community, interdisciplinary collaborations *specify the meaning* of such broad normative commitments, and education *builds the reflexive capacity* needed for these commitments to take hold in research practice. Lastly, the concluding section of this chapter considers relevant institutional design aspects of efforts to revalue value-neutrality in the applied sciences and suggests new inroads for research.

6.1. Effects of the interventions in the case studies

This section reviews the main findings and conclusions from each of the individual case studies and highlights the effects of the interventions with respect to the requirements identified in the introduction. To what extent did the interventions encourage researchers to critically reflect on the socio-ethical context of research (increasing the researcher's willingness and enthusiasm to integrate broader perspectives in research decisions)? And did they serve to make ethics 'relevant', bringing broader ethical and societal issues to bear on research practice (translating normative and social dimensions into the context of individual research decisions)? Table 8 identifies the effects of the interventions with respect to these particular objectives, distinguishing between the different dimensions of reflection outlined in chapter two: the socio-ethical premises, the methodological norms of the research community, its ontological and epistemological assumptions, and the socio-ethical consequences of research (the scores in the table will be explained below).

Table 8. Effects of the interventions in the case studies.

Objective	Code of conduct	Midstream modulation	Advanced courses
Encouraging critical reflection on:			
- Socio-ethical premises	-	+	++
- Methodological norms	+/-	+	+/-
- Ontological / epistemological assumptions	+/-	+	+/-
- Socio-ethical consequences	-	+/-	+
Making ethics 'relevant'	+/-	++	+

++ : strong positive effect; + : positive effect; +/- : uncertain effect; - : negative effect

6.1.1. Encouraging critical reflection

I will first consider to what extent the interventions encouraged researchers to critically reflect on the socio-ethical context of research. Admittedly, there are no simple performance criteria for assessing the impacts of broad-level interventions such as the ones described here. The interventions were obviously aimed at ‘soft’ impacts: increasing capacities and willingness to critically reflect on the broader context of research. Furthermore, it is virtually impossible to determine causal relations between the intervention, changed ‘states of mind’, and observed or reported changes in behaviour. The available evidence will thus to some extent always be dependent on context and interpretation. Nevertheless, there are several indicators to suggest a change in willingness or capacity for critical reflection such as research participants’ self-reporting and evidence of learning and skills development. Table 9 summarises the evidence for the encouragement of critical reflection in terms of the observed learning effects.

Table 9. Evidence for the encouragement of critical reflection in the case studies.

	Code of conduct	Midstream modulation	Advanced courses
Positive reactions from participants	-	+	++
Reported awareness of socio-ethical context	+/-	++	++
Evidence of learning (increased knowledge)	+/-	+	+
Skills development	-	+	+
Observed changes in research practice	+/-	+	+/-

++ : strong positive effect; + : positive effect; +/- : uncertain effect; '- : negative effect

There were distinct differences in research participants’ responses to the interventions. Granted that self-reporting of participants is not a decisive indicator for actual learning effects, it is nevertheless a relevant factor for the evaluation of the interventions because, as argued in the introduction, critical reflection on the socio-ethical context of research cannot be enforced but has to be encouraged: it is to a large extent dependent on its uptake from ‘within’. Both the midstream modulation studies and the advanced courses fulfilled this requirement. As for midstream modulation, research participants indicated that the ongoing discussions in the laboratory added value to the research in several ways: by strengthening their research planning, the identification of overlooked opportunities and the consideration of broader policy contexts. Similarly for the advanced courses: participants welcomed the opportunity to consider their work in a broader perspective. By contrast, the Netherlands Code of Conduct for Scientific Practice was not received well. The interview results from chapter three point out that even though codes of conduct were generally seen as an opportunity to initiate dialogue on the norms that govern research conduct, the majority of respondents did not consider this particular code to be effective in achieving that aim. Admittedly, the purpose of the code was restricted to encouraging adherence to the methodological norms of the research community only (and was not intended to encourage reflection on the broader socio-ethical dimensions). But even in this more restricted sense, the code did not succeed in encouraging reflection. Its implementation was met with resistance, since the code failed to address vital questions of enforcement, practical integration and the distribution of responsibility.

A similar effect occurred with respect to increasing knowledge and awareness of the broader socio-ethical context of research. Research participants of the midstream modulation studies confirmed the relevance of critical reflection to their work; in terms of the normative framework for social responsibility, second-order reflective learning occurred with respect to the value-based socio-ethical premises of research: the wider policy context and the 'telic' enterprises in which research projects operate (consider the ongoing discussions on the social relevance of research for example); the methodological norms of the research community (e.g. RID's reflections on the ethical aspects of genetic engineering, discussing hitherto implicit value commitments in research decisions); its epistemological and ontological assumptions (ongoing discussions on scientific reductionism and the underdeterminacy of research evidence); and finally, the socio-ethical consequences of research (e.g. pertinent questions on the long term implications of research outcomes, economies of scale and innovation processes). Such critical reflection moreover led to observed changes in behaviour, as the researcher's decision to use lab coats on the work floor may indicate (see the results-section of chapter four for a more detailed discussion of these findings).

As the evaluation of the advanced courses in chapter five suggests, the advanced courses also presented several opportunities for encouraging critical reflection on the wider societal context of nanotechnology by providing a broad overview of relevant concerns and expectations surrounding nanotechnological research. Exposure to this broader perspective encouraged participants to reflect on the value based socio-ethical premises (particularly the political motivations behind the increase in funding for nanotechnological research) as well as the possible socio-ethical consequences of research (the ways in which research outcomes may ultimately affect the wider society, both in terms of the opportunities and risks of nanotechnology innovations and resulting public perceptions). Some participants described such reflection on the contextual value commitments operative in their research to be a 'mind-opening' experience (see page 107).

6.1.2. Making ethics 'relevant'

In addition to encouraging the willingness of researchers to critically reflect on the socio-ethical context of their work, a second requirement was identified in the introduction: the realisation of a broadened conception of social responsibility in research practice requires that broad normative commitments are brought to bear on research decisions. This implies both that the meaning of normative principles is 'translated' into the concrete context of day-to-day research decisions, and that the abstract levels of analysis of ethics and the social sciences as academic disciplines are applied in the context of individual research decisions.

What were the effects of the interventions in the case studies with respect to making ethics 'relevant' at the level of research practice? Looking at the code of conduct, regardless of their willingness to adhere to the principles set out in the code, respondents were unclear as to how these principles relate to daily practices. This puts forward the question of how the principles are to be *applied, interpreted or understood* in practice: what course of action do the principles prescribe in concrete situations? The text of the code in itself does not provide an answer to these questions. This is why chapter three emphasised the importance of the implementation phase following the adoption of the code of conduct: questions of interpretation can be addressed by holding discussion sessions on real-life cases and dilemmas during the implementation phase.

The laboratory engagement studies were more successful in bringing normative commitments to bear on research decisions. The methods and techniques employed during the interactions in the laboratory rendered the wider socio-ethical context of research visible 'in real time' in the laboratory, bringing the ethical and social dimensions of research to bear directly on research decisions. In a sense, ethical reflection came to life within the context of research (Schuurbiers and Fisher: 2009). The advanced courses similarly succeeded in pointing out the relevance of socio-ethical deliberation in research, although not in the real-time, hands-on way as the lab studies.

In conclusion, the midstream modulation studies and the advanced courses provided opportunities for encouraging critical reflection in ways that the code of conduct did not. To be sure, several constraints were identified as well. One question that in a sense applies to all the case studies is to what extent the observed increase in research participants' willingness and awareness to critically reflect on the socio-ethical context of research at the time of the intervention ultimately contributes to the integration of social and ethical considerations in concrete research decisions. The rationale for encouraging critical reflection was after all to increase the likelihood of broader considerations becoming embedded in research decisions, and ultimately in innovation trajectories. While both the midstream modulation studies and the course evaluations report indicative changes in practice (see page 80 and 107), the extent to which these observations have the capacity to bring about lasting changes in research practice is an open question that merits further enquiry. Is such critical reflection to continue after the studies have finished? And does broadening the considerations and perceived alternatives indeed lead to more 'socially robust' outcomes? Like with the code of conduct, the further implementation stages following researcher engagement and education initiatives warrant attention: the steady integration of broader considerations in research decisions presumably demands continuing efforts.

6.1.3. Assessing the interventions against general practical criteria

Having reviewed the effects of the interventions in the individual case studies with respect to the requirements identified in the introduction, it seems that midstream modulation and the advanced courses provide strong opportunities for encouraging critical reflection in research and making ethics relevant. Given the general objective of this thesis to consider opportunities and constraints for the practical realisation of a broadened view of responsibility, this section will also review the interventions in light of more 'practical' criteria: their cost-effectiveness, time commitment and reach (see table 10).

Table 10. Cost-effectiveness, time commitment and reach - individual cases.

	Code of conduct	Midstream modulation	Advanced courses
Cost-effectiveness	++	+/-	-
Time commitment	+	-	+/-
Number of researchers reached	+	-	+/-

++ : strongly positive; + : positive; +/- : neutral; - : negative

These criteria result in a markedly different scoring distribution: the code of conduct scores better than the other interventions in this respect. The drafting of the code text may take up a considerable amount of time but once established, it can be disseminated widely throughout the community at relatively low cost (although the time commitment here is variable: as chapter three indicated, proper implementation would require significantly more effort than merely distributing the code). Midstream modulation, by contrast, devotes significant resources to a strongly limited target group. The time commitment required both from the side of the research participants and the embedded researcher represents a significant cost. And while the advanced courses reach a somewhat larger group of researchers, their reach is still limited to several dozens of researchers. Considering table 8 and 10 jointly then, those interventions that performed better in terms of addressing the requirements set out in the introduction do not score well in terms of overall cost- and time-efficiency. Conversely, more 'efficient' interventions do not seem to achieve the intended effect of raising the researchers' awareness and enthusiasm. This may be to some extent inevitable: to address the particular *complexity* of the question of social responsibility a time-intensive, in-depth intervention is called for; but to address its *scope*, a broad-range, community-wide intervention is called for.

This suggests that the practical realisation of a broadened conception of social responsibility requires dedicated efforts at both the in-depth, individual and higher institutional levels. In the following sections I will suggest an approach that aims to combine the strengths of the different interventions (see figure 14). Before doing so, I will widen the scope of consideration, discussing further opportunities and constraints of the broad areas of intervention beyond the actual effects of the interventions in the case studies. The following section will therefore consider further relevant initiatives in each of the areas of intervention that may contribute to the practical realisation of a broadened conception of social responsibility in research practice.

6.2. Opportunities and constraints of the areas of intervention

Zooming out from the actual effects of the individual case studies presented in this thesis (and in response to the second research question), what further opportunities can be identified in the areas of intervention that may assist in encouraging critical reflection and bringing the broader socio-ethical context to bear on research practice? I will briefly review each area of intervention, identifying possible complements to a combined approach to address social responsibility in research practice.

6.2.1. Codes of conduct

As was argued in the introduction, the VSNU Code of Conduct was chosen as a case because the Department of Biotechnology at Delft University of Technology was considering its implementation at the time of research; it thereby provided a good opportunity to engage in concrete and focused discussion about the effects of its implementation with the researchers at the Department. The interview results presented in chapter three however pointed out that this particular code was not deemed effective in encouraging reflection on the norms that govern science, due to both the particular type and content of the code as well as the way it was implemented. Abstracting from the individual case study and looking at codes of conduct as a broad area of intervention, could there be different types of code, or codes with a different content, that would better serve the overall objective of encouraging a broadened conception of social responsibility?

There are many different types of code. Considering again Rappert's (2007) distinction between codes of practice, codes of conduct, and codes of ethics in chapter three,[29] the latter, which *'aim to set realistic or idealistic standards as well as alert individuals to certain issues'* (146), may be more appropriate for defining a broadened conception of social responsibility in research. A code of ethics could serve to cover the prospective dimensions of responsibility, defining its communal aspirations, rather than focusing on the adherence of the members of the research community to an established set of norms. The drawback of a code of

[29] Codes of conduct have been classified in different ways: Frankel (1989) distinguishes aspirational, educational and regulatory codes. Hogenhuis (1993) mentions aspirational, advisory and disciplinary codes. Rappert's classification is used here because his definition of codes of ethics, while incorporating the relevant distinctions from Frankel and Hogenhuis, fits well with the normative framework identified in chapter two.

ethics could be that it does not suggest any particular course of action, but then, as we have seen with the VSNU code, this applies to advisory codes as well. A code of ethics describes the aspirations of the community – codes of practice: *'enforceable codes that prescribe or proscribe certain behaviour'* (ibid.) are needed to guide behaviour in concrete settings.

Another important variable in codes of conduct is of course their particular content. The VSNU code of conduct concentrated on specifying the internal norms of the research community, being based on a 'Mertonian' conception of the normative principles of research. But other codes can be identified that explicitly identify external responsibilities of the research community in addition to its internal responsibilities, such as the code of conduct established by the Royal Institute of Engineers in the Netherlands (KIVI NIRIA) for instance. The first principle of this code states that *'when making technical decisions, we take the health and safety of man and the environment into account'* (KIVI NIRIA: 2006). The consideration of such external responsibilities is traditionally accepted as part of the responsibilities of the *engineering* community, but, as this thesis argues, this responsibility towards 'the health and safety of man and the environment' also applies to researchers in the applied sciences (restoring the Baconian ideal of science identified in chapter two). The European Commission's recent Recommendation for a Code of Conduct for Responsible Nanosciences and Nanotechnologies Research (2008) also provides explicit references to the broader societal impacts of nanotechnological research, indicating that research is to be *'conducted in the interest of the well-being of individuals and society in their design, implementation, dissemination, and use'* and *'encouraging progress for the benefit of society and the environment'* (European Commission: 2008). The particular content of such codes thus expresses a commitment and a concern for the wider socio-ethical context in which research operates.

These examples suggest that different types of code could serve to express a different interpretation of responsibility (including prospective as well as retrospective dimensions of responsibility), as well as a different scope (broadening the field of responsibility to include a concern for the health and well-being of man and the environment). As such, they could work as *enablers* for an approach aimed at broadening the conception of social responsibility, serving as a top-down stimulus to initiate a dialogue on responsibility within research communities. What the particular effects of the establishment of such a code of ethics would be is a matter for further research. But the overall potential of codes of conduct in encouraging critical reflection shouldn't be dismissed. They provide opportunities to *articulate* the normative commitments of the research community – particularly those codes of ethics that include the research community's broader responsibilities towards society can invite reflection on the socio-ethical context of research. Naturally, regardless of the type and content of the code, the question of implementation remains crucial. The normative commitments that the code expresses need to be brought to life within the context of research. This, it will be argued below, is where codes of conduct can be complemented by work in the other areas of intervention: interdisciplinary collaboration and education.

6.2.2. Interdisciplinary collaboration

The results of the laboratory engagement studies presented in chapter four suggest that midstream modulation provides significant opportunities both to encourage critical reflection and to bring ethical and social considerations to bear on research decisions. But the research findings of further interdisciplinary initiatives that have recently emerged may be equally relevant to the practical realisation of a broadened conception of social responsibility. Midstream modulation forms part of a broader range of methods being developed in response to the perceived need to integrate wider considerations in research decisions. Stegmaier (2009) identifies the emergence of a body of 'convergence workers', crossing the boundaries between different academic disciplines and perspectives in an attempt to build bridges between the 'Two Cultures' (Snow: 1959). Indeed, such convergence work is also emerging in the laboratory, as the different types of study identified throughout this thesis indicate – Gorman's trading zones (Gorman et al.: 2004), Rip and Robinson's scenario workshops (Robinson: 2009), Fisher's midstream modulation (Fisher: 2007; Schuurbiers and Fisher: 2009), Van de Poel's ethical parallel research (Zwart et al.: 2006), Van der Burg's 'moral imagination' exercises, and Consoli's biographical narratives (Consoli: 2008), among others. This new range of laboratory studies extend the traditional laboratory ethnographies of the 1970s and 80s (Latour and Woolgar: 1979) to include distinct engagement tools in addition to observation.[30]

Further research in this emerging field of convergence work in the laboratory, and particularly comparative analyses of the pros and cons of each of these methods, may assist in identifying further opportunities for broadening reflec-

30 One could therefore characterise them as 'lab studies 2.0' (personal communication Henk van den Belt).

tion in research. The findings of the various interdisciplinary collaborations leave open a range of further questions: what are the likely roles that embedded researchers can assume, and how do the different roles play out in terms of broadening reflection (Calvert and Martin: 2009)? At what stages of the R&D process is the explicit consideration of social and ethical concerns most likely to affect research decisions? What *kinds* of concerns should be addressed? How to strike a balance between collaboration and critique? And how to overcome power differences and avoid the risks of co-optation that inevitably adjoin the various forms of 'embeddedness'? Another question that in a sense applies to all activities in this broad area of intervention is whether, and if so, to what extent the interactive methods currently being developed can be made more effective and efficient, reaching higher numbers of participants in a more cost- and time-efficient manner. These are difficult questions, and the data presently available do not suffice to draw definitive conclusions on these matters. Ongoing attempts at shaping and institutionalising alternatives to the neutrality view are still part of a larger social experiment that needs more testing, reconfiguring and fine-tuning.[31]

While the search for relevant and focused forms of socio-ethical deliberation continues (Nordmann and Rip: 2009), some form of interdisciplinary collaboration between social and natural researchers may be indispensable to realise a broadened conception of social responsibility in research practice. If the purpose of codes of conduct is to *articulate* normative commitments, the purpose of interdisciplinary collaborations is to *specify the meaning* of such commitments. As Gorman et al. (2009) note:

> The role of an ethicist is to ask normative questions: What is the value of this project? What are the possible positive and negative outcomes? Are there any possibilities that have not been explored? How will the success of the project contribute to human or even planetary well-being, and what are the possible dangers involved? Moreover, well-trained ethicists can often step back from the particular context to take a more disengaged perspective on the technology or technologies in question (Gorman et al.: 2009, 186).

31 The results of the twenty laboratory studies currently being carried out as part of the Socio-Technical Integration Research (STIR) project funded by the US National Science Foundation (Fisher and Guston: 2008) will also shed further light on the necessary conditions for successful interdisciplinary collaborations aimed at responsible science and innovation.

Without some form of interdisciplinary collaboration, and given the cultural commitment to value-neutrality in research communities, the broader questions that ethicists and social researchers usually bring to the table may not be asked at all. The importance of asking these normative questions during early stages of research is that they may broaden the kinds of considerations invoked in research decisions. Rip (2009) notes that the effect of recent interdisciplinary studies has been limited, leading to: *'a few modifications in research agendas and some increased reflexivity'* (2). While this is true for the pilot studies discussed above, interdisciplinary collaborations seem to have a potential for having more lasting effects on research directions, especially when such initiatives at the 'midstream' are complemented by appropriate initiatives at higher institutional levels (see also below). Recalling the Catch-22 from the introduction (see page 7), the convergence of the 'Two Cultures' serves to internalise 'external' stimuli. Ultimately, the social integration of social scientists and humanists in the laboratory may create an opportunity:

> ...to build into the R&D enterprise itself a reflexive capacity that...allows modulation of innovation paths and outcomes in response to ongoing analysis and discourse (Guston and Sarewitz: 2002, 100).

6.2.3. Education and training

Moving on to education and training as a broad area of intervention, the advanced courses presented in chapter five are but one example of a wide range of educational efforts that have attempted to broaden the knowledge, skills and abilities of researchers - opportunities for encouraging reflection through education abound. A full review of the available options is beyond the scope of this thesis, but it seems clear that some form of dedicated education and training will be crucial for the realisation of a broadened conception of social responsibility in research practice. Coming generations of researchers working in use-inspired, multidisciplinary applied research contexts need to be both capable and willing to recognise and address broader socio-ethical dimensions if and when they arise. This includes knowledge and awareness of the wider social contexts in which research is taking place, skills to integrate technical, social and ethical considerations in research decisions, and a willingness to engage in critical reflection on such broader contexts of research, a sense of social responsibility (*cf.* Callahan: 1980).

Considering the findings in chapters four and five, several characteristics can be identified that support the encouragement of critical reflection. First of all, both the laboratory engagement studies, the code interviews and the evaluation of the advanced courses pointed out that the encouragement of critical reflection works best when there is a direct connection with the lived practices of researchers. This relates to the question raised in chapter five about the extent to which participants' enthusiasm does indeed lead to changes in practice: if educational activities can link course material directly to the work performed in the laboratory, this may both increase their perceived relevance and increase the likelihood of being integrated with research decisions. For example, the discussion with R1D on the ethical aspects of genetic engineering (see page 82) offers relevant material for an ethics course to students in the life sciences – this is an exemplary case of the kinds of issues that the students will likely encounter at some point in their careers. Thus linking course work with concrete cases from the lab might prevent ethics courses from being a 'one-off' in the first year of education and then forgotten.

The realisation of a broadened conception of social responsibility depends on a broadened set of knowledge, skills and attitudes of researchers, and this in turn depends on their education. Education can build the reflexive capacity needed to broaden social responsibility in research practice. This presumably requires sustained efforts throughout the curriculum. Taking this further, one could imagine a process of what Davis (2006) has called 'micro-insertion', integrating the consideration of ethical dimensions during technical courses themselves.

6.3. A combined approach

Combining this review of each of the areas of intervention with the findings of the individual case studies, distinct opportunities and constraints for each type of intervention can be identified (see table 11).

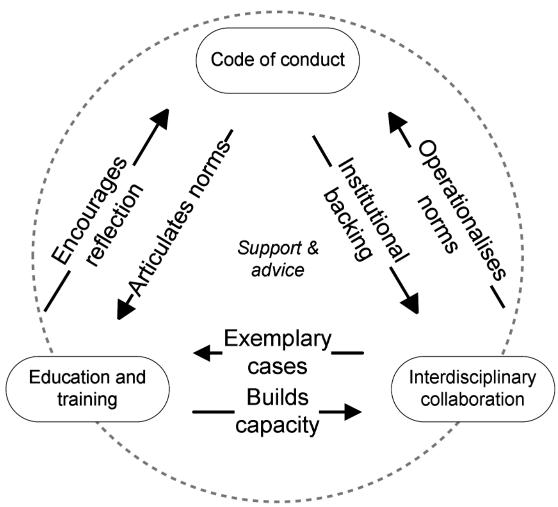
Table 11. Opportunities and constraints of the areas of intervention.

	Opportunities	Constraints
Codes of conduct	Articulate normative commitments in the community	Relating principles to practices
	Wide reach at low cost	Acceptance and endorsement
Interdisciplinary collaborations	Encouraging critical reflection on the socio-ethical context	Limited reach at high cost
	Bringing normative commitments to bear on research practice	Dependency on goodwill
Education and training	Building reflexive capacity in the community	Effect on research practices uncertain
	Raising enthusiasm for the socio-ethical context	Learning occurs away from the work floor

This overview suggests that the practical realisation of a broadened conception of social responsibility in research is best served by an approach that combines the strengths of the individual areas of intervention. Codes of conduct provide an opportunity to *articulate* a broadened conception of social responsibility, provided that the code fulfils the criteria outlined above, i.e. addressing both the internal responsibilities of the individual researcher towards the research community as well as the research community's external responsibilities towards society. They can serve as enablers, inviting reflection on the value-based premises and possible socio-ethical consequences of research. They can furthermore be made available to all the members of the community at relatively low cost.

The effectiveness of such codes in encouraging reflection however depends on their implementation. To prevent the kind of 'ethical backfire' as observed with the VSNU Code of Conduct, inducing resistance rather than reflection, the implications of the normative principles for research practices warrant attention. The principles need to be connected to the practices: what do they *mean* in specific research contexts? What are the possible consequences of the normative prescriptions for individual research decisions? How are researchers to resolve possible tensions between internal and external responsibilities? The effect of macro- or meso-level prescriptions remains tangential if not addressed from 'within'. This is where the establishment of a code can link up with interdisciplinary collaboration and education. Interdisciplinary collaborations can *specify* the broad normative commitments expressed in the code, encouraging critical reflection as well as showing how abstract normative principles can be brought to bear on research decisions (figure 14 below identifies mutually reinforcing relations between the different types of intervention). As the research findings of the laboratory engagement studies indicate, the specific meaning of abstract normative principles such as impartiality and reliability became more meaningful when discussed on the 'work floor'. The presence of an 'embedded humanist' thus served to facilitate reflection on complex moral issues. Conversely, the presence of a code of conduct can serve as a form of institutional backing for midstream engagement initiatives. One of the constraints identified in the laboratory engagement studies was that the embedded researcher has no 'jurisdiction' in case of moral disagreement. Now if there is a clear mandate for the consideration of the socio-ethical context of research, this may strengthen the position of the embedded researcher.

Figure 14. Possible synergies between the interventions.



Similarly for education and training: whereas a code articulates the norms of the research community to new generations of researchers, dedicated courses can serve to discuss the meaning and relevance of those normative principles and how they relate to the future work and careers of students. A code that expresses a broadened conception of responsibility may encourage students to consider such broader dimensions, not just because they are held to it by external parties, but because it is seen as part of the responsibility of the research community itself. At the University of Amsterdam for example, the Code of Conduct of the Netherlands Institute for Biologists is used as the framework for an obligatory ethics course for biology students. The principles in the code form the backbone of the course programme. The meaning and relevance of each of the principles is presented and extensively discussed in dedicated sessions. The students thus reflect on the meaning and applicability of the principles in concrete, hands-on case work.

Possible synergies between interdisciplinary collaborations and education and training can also be identified. Interactions in the laboratory serve to identify 'hot' issues in the laboratory, identifying new kinds of ethical and social concerns that may play a role in research. Interdisciplinary work thus keeps a finger on the pulse of developments in the laboratory and can transfer these findings into education, ensuring that the topics discussed in ethics courses are directly relevant to the future work of the students, gearing ethics education towards the researchers' lifeworld. Conversely, education can strengthen the competencies that students require to address the broader socio-ethical context in which their research operates.

6.4. Institutional design aspects

The previous section identified possible synergies between the different areas of intervention for broadening the conception of social responsibility in research practice: where a code of conduct can articulate the normative commitments of the research community and interdisciplinary collaborations specify the meaning of such normative commitments, education and training serve to build reflexive capacity in the research community. But as Swierstra and Jelsma (2006) suggest and the findings in the case studies indicate, the capacity of individual researchers to address their broader responsibilities towards society is enabled and constrained by the institutional context. In addition to encouraging individual researchers to critically reflect on the socio-ethical context of their work, the encouragement of social responsibility at the midstream will therefore require organisational reform - creating an institutional environment in which attention to the broader issues is both encouraged and rewarded and a commitment to reflection is embedded in the research culture. This section will therefore consider relevant institutional design aspects. I will first discuss elements of institutional design at the research group or department level. Then, I will consider wider institutional contexts: the international research community, the university, and relations with public and private funding bodies.

6.4.1. Institutionalisation at the research group / department level

The institutionalisation of a combined approach towards broadening social responsibility at the research group or department level requires the coordination of separate initiatives such as codes of conduct or training courses that may or may not be present. One possible way to achieve this is by formalising the presence of a coordinating entity, a 'societal advisory unit', that could advise as needed on relevant social and ethical issues emerging from the research, translate relevant insights from the social sciences and humanities into the context of ongoing research in the group, and build synergies between different types of initiative occurring in the group: for example, responding to policy mandates for the integration of social and ethical dimensions of research, and coordinating ethics and 'science and society' courses. Its institutional role could be comparable to a safety officer which is by now present in many research laboratories (but with the crucial difference that its remit is not in terms of compliance to existing regulations, but in terms of broadening reflection). This entity could take one of several forms: as an advisory body, a dedicated research group, or a single individual, depending on the size of the research group. The Working Group on Biotechnology and Society at the Department of Biotechnology in Delft presents one possible example of the institutional integration of a social research group in an applied research department. Other forms that have been tried (on a larger scale) are the establishment of social research centres as part of larger research initiatives (such as the Centre for Society and Genomics which is a Centre of Excellence in the Netherlands Genomics Initiative, the Center for Nanotechnology in Society which forms part of the US National Nanotechnology Initiative, and the Dutch Nanoned Technology Assessment flagship which is part of the Nanoned-initiative). Such opportunities for institutionalisation of course depend on ongoing dynamics and are to a considerable extent dependent on the endorsement of group leaders and department directors. Is there a general willingness to interact with 'outsiders' beyond the peer group, or to open up to broader considerations? Will precious education time be allocated to build broader reflexive capacities of students? The experiences gained at the Working Group on Biotechnology and Society shows that the integration of a social research group within a biotechnology research department can lead to fruitful collaborations that both deepen the level of ethical reflection and strengthen the accountability of the research group. This type of 'social integration' between natural and social researchers inevitably presents new kinds of questions that warrant attention: when the purpose of the work of the 'embedded humanists' is construed as merely lending support to ongoing dynamics or as a 'social lubricant' between the research department and other stakeholders, or when the freedom to ask critical questions is severely limited, such attempts at integration may be reduced to a window-dressing exercise without exerting real influence on the kinds of considerations that drive research decisions. On the other hand, when the social researchers revert to addressing critical questions only and interactions become adversarial, the window of opportunity for meaningful collaboration may simply evaporate. The challenge, then, is to identify spaces for reflection within ongoing dynamics that may productively broaden the considerations invoked in research decisions - performing the politics of the possible. Such forms of social integration are relatively new and undoubtedly require further social experimentation. But the research findings of the case studies presented in this thesis suggest that the formalised presence of social researchers in the research group or department may serve to encourage reflection on an ongoing basis and:

> ...can shed some light on the complex question of how philosophy can contribute to the legitimation of scientific-technological development in a critical way without identifying itself with this development (Verhoog: 1980).

6.4.2. Wider institutional contexts

While the institutionalisation of a societal advisory unit may facilitate the realisation of a broadened conception of social responsibility at the level of research groups or departments, research groups are themselves enabled and constrained by wider institutional contexts such as the international research community, universities and relations with funding bodies. Commitments to broadening reflection compete with other demands and expectations that researchers and their institutes face: the need to meet the conditions for research grants and demands from funding organisations; expectations from the peer community to conform to established traditions and normative structures; requirements of research journals. While a detailed discussion of these wider contexts is beyond the scope of this thesis (which focused specifically on individual researchers and research groups), these demands and expectations significantly influence the extent to which researchers can and will integrate broader considerations in their work. The following section will therefore briefly reflect on these wider contexts and the opportunities and constraints they offer for realising a broadened conception of social responsibility.

The international research community

Individual researchers and research groups form part of much broader, global research communities with their own cultural norms and social dynamics. As

Ziman (1998) has indicated, the neutrality view is deeply engrained in the normative structure and institutional arrangements of these wider research communities and cannot be 'uninstalled by a keystroke'. The cultural entrenchment of the neutrality view thus presents a significant challenge for broadening the conception of social responsibility in research: individual researchers may be motivated to broaden the kinds of considerations taken into account, but this possibly presents problems, particularly when their work is assessed by anonymous peers who may not be so inclined to reward or encourage such broader reflection. Since research careers strongly depend on peer review processes (for instance to get research papers accepted in journals and for research proposals to be positively evaluated), there may be more reward in sticking to accepted norms of neutrality than to deviate from these norms.

The entrenchment of the neutrality view thus inevitably presents a considerable challenge for attempts to broaden reflection in research – attempts to 'revalue value-neutrality' inevitably imply tampering with one of the foundational principles upon which scientific research rests. This is also why a certain measure of pushback is inevitable: those that are accustomed to the value-neutral tradition will see the new responsibilities as flying in the face of what they see as 'good science'. The realisation of a broadened vision of social responsibility thus ultimately faces the deeper challenge of re-evaluating the normative commitments of the research community. This will require structural changes in the overall incentive structure governing research careers: it requires social responsiveness to be built into the research system. Given that the neutrality view is deeply entrenched both culturally and historically, this is a daunting challenge, exemplified by the marginal influence that insistent calls against the neutrality view have had over the last few decades. That said, recent changes in the rhetorics of science policy documents worldwide and changing visions of the researcher's role in society may well present a window of opportunity for the re-evaluation of the neutrality view, facilitating more integrated visions of the role of science in society. To what extent such broadened visions will ultimately affect the ways that research is conducted remains to be seen. But the openness and willingness from the side of the research community to reconsider the ultimate goals to which research aspires seems to grow stronger. This in itself presents an opportunity to rethink the norms and values that govern research practices in light of the desired role of research in society.

The university

As the main employers of publicly funded researchers, universities also influence the ways that researchers interpret and address their responsibilities. The establishment of a code of conduct for instance may support a certain interpretation of the responsibility of the researcher, reinforcing or weakening the neutrality view as chapter three has pointed out. But even if the text of the code itself broadens the sphere of responsibility of researchers, it is unlikely to have an effect if such claims are not supported by university policies - for instance, if a researcher's career in the university is determined by citation scores only. Changes in the conception of responsibility thus require changes in the overall incentive structure that governs research careers: if initiatives to broaden reflection in research are encouraged and rewarded, for instance in terms of career opportunities or even by simple recognition of the value of such efforts, the integration of broader reflection in research decisions may be more likely to be taken up. As an example, the explicit emphasis that the President of Arizona State University Michael Crow has placed on social relevance and interdisciplinarity, by directly rewarding those types of projects, resulted in a wide range of interdisciplinary research projects with an increasing focus on application in a few years time. The immediate effect of his efforts may depend on the entrepreneurial spirit in the United States and may not apply directly to the management of universities in Europe, but there are signs that Delft University of Technology's explicit commitments to sustainability in recent years have similarly enabled a stronger focus on sustainability in research projects. In a similar fashion, a commitment to the integration of broader ethical and social considerations in research could potentially affect the researchers' understanding of the importance of such considerations. In conclusion, efforts at realising a broadened conception of social responsibility will therefore also require initiatives at higher levels within the university.

Funding bodies

Specific funding requirements also potentially modulate conceptions of responsibility. Indeed, funding bodies have in recent years emphasised the need to integrate broader considerations in research decisions making, as witnessed by the European Commission's calls for *'the integration of social concerns at an early stage'* (European Commission: 2007) and the requirement to consider *'ethical, legal, environmental, and other appropriate societal concerns... during the development of nanotechnology'* in the 21st Century Nanotechnology Research and Development Act in the United States. Similarly, the 'Responsible Innovation' research programme of the Netherlands Organisation for Scientific Research presents an example of a funding initiative that explicitly demands the integration of broader considerations and the inclusion of different forms of knowledge in research networks. While a detailed discussion of these developments is beyond the scope of this thesis (moving from the 'midstream' level of R&D to the 'upstream' questions of what R&D to authorise), the establishment of specific criteria for funding may support efforts at the micro-level of research decisions.

In conclusion, the practical realisation of a broadened conception of social responsibility in research depends on the alignment between individual encouragement and institutional incentives at various levels. A balance needs to be struck between top-down institutional incentives and bottom-up engagement and encouragement. If implemented properly, top-down initiatives create an incentive for reflection, but they only have the desired effect when taken up by the research community. Efforts to broaden reflection in research will need to take ongoing dynamics into account; as Rip (1981, 7) notes, the ideas and guidelines for socially responsible action have to take into account the existing social order and margins for change.

6.5. Conclusion

In this thesis, I have examined opportunities and constraints for the practical realisation of a broadened conception of social responsibility that includes the moral responsibility of researchers to critically reflect on the socio-ethical context of their research. I have argued that the social significance of current-day applied research calls for reflection on the socio-ethical context of research, particularly in emerging areas of applied research such as nano- and biotechnologies. As Susanna Hornig Priest indicates:

> That science is largely 'sold' on a promise that it will address fundamental human needs and desires entails a profound obligation to contemplate, at least on occasion, just what these needs and desires might be (Hornig Priest: 2005, 298).

Social responsibility in research has been a topic of central concern in a range of academic disciplines including the philosophy of science and technology, science and engineering ethics, science studies and so forth. Interestingly enough, these academic debates often go by largely unnoticed by the research practitioners themselves. For just this reason, the research presented in this thesis has explored possibilities to connect the academic debate on social responsibility in research with the research practices they are in fact about. The case studies have focused on concrete opportunities to encourage contemplation on the broader socio-ethical context of research at the 'midstream' stage of the R&D cycle. The purpose of such interdisciplinary efforts has been, as Michael Ruse has put it, to *'marry the strengths of science with the insights of its critics'* (Ruse: 1999, 34). The emphasis on communication and translation of the various academic insights into workable methods for broadening reflection in research practice has inevitably come at the cost of much of the nuance that characterises ongoing academic debates. In my view however, these costs have to be weighed against the benefits of having gained new insights into the potential ramifications of the debate on social responsibility for research practices.

The research findings suggest opportunities and constraints for realising a broadened conception of social responsibility in research practice. At the individual level, several opportunities were identified to encourage researchers to broaden the kinds of considerations invoked in research decision making. Such broader reflection was found moreover not to hamper, but instead to add value to the research process itself. At the same time, the freedom of individual researchers to broaden reflection was found to be constrained by the institutional environment. The research community's commitment to the neutrality view poses a challenge to the practical realisation of a broadened conception of social responsibility in research practice. This thesis has only been able to scratch the surface of the deeper challenges that attempts to revalue value-neutrality in the applied sciences face. The challenge is to safeguard research as the discovery, in the words of Philip Ball, of *'deep and elegant truths, so far as truths can ever be discerned, about the way the universe works'* (Ball: 2007, 39), while recognising that such 'truths' are ultimately bound to the values, beliefs and aspirations of the society from which they emanate. The 'revaluation' of value-neutrality depends on a culture change in the wider institutional contexts in which researchers operate, requiring a concerted effort at various stages of the R&D process. Ultimately, the successful integration of broader socio-ethical dimensions in research practices may lead to more robust forms of knowledge production that harness *'the immense possibilities of scientific knowledge and technological innovation ... 'for the relief of man's estate''* (Edge: 1995, 19).

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Summary

Social Responsibility in Research Practice - Engaging applied scientists with the socio-ethical context of their work.

How to encourage researchers to critically reflect on the socio-ethical context of their work? That is the central research question in this thesis. It starts from the assumption that the neutrality view – the view that researchers have no business with the social and ethical dimensions of their work – has become untenable, at least as far as applied sciences such as nano- and biotechnology are concerned. Instead, this thesis adopts a broader view, one in which the social responsibility of researchers includes, in addition to their responsibility to adhere to the internal norms of the research community, the moral responsibility to critically reflect on the socio-ethical context of their work. This normative viewpoint itself is not uncommon: the argument that researchers should integrate broader ethical and societal considerations in their cogitations has been put forward by philosophers and sociologists of science as well as by concerned scientists at various moments in history. Yet the neutrality thesis remains a dominant frame of reference in daily research practice. The specific contribution this thesis aims to make to the ongoing debate is to 'revalue value-neutrality in the applied sciences': to explore the opportunities and constraints for realising a broadened conception of social responsibility in daily research practice. This is done by way of three empirical interventions: the implementation of a code of conduct for scientific practice, interdisciplinary collaborations between social and natural scientists, and the development of 'science and society' education.

The case studies are aimed at nano- and biotechnological research, two examples of applied science in which the neutrality view is untenable. According to the neutrality view, it is the exclusive responsibility of the researcher to produce reliable, objective knowledge about the world through a process of disinterested, curiosity-driven research. But applied research does not operate in a socio-ethical vacuum: ethical and societal considerations play an important role in the motivation, practice and outcomes of nano- and biotechnological research. Nanotechnology has been hailed as the next major technological revolution,

comparable to electrification or the steam engine, providing unparalleled technological and social progress. Likewise for biotechnology: the capacity to modify biological entities at the molecular level potentially unlocks a wide array of industrial, agricultural, medical and other applications. At the same time, advances in both nano- and biotechnology have given rise to strong normative uncertainty and social concern. This intrinsic value-ladenness of the research implies that the socio-ethical context deserves attention not just before and after, but also during research.

This calls for a broader conception of the social responsibility of the researcher. The normative framework underlying the case studies is that the 'sphere of responsibility' of the researcher includes the moral responsibility to critically reflect on the broader socio-ethical context of research (Verhoog, 1980). This broadened conception of social responsibility integrates both retrospective and prospective dimensions. Whereas the interpretation of responsibility as accountability dominates present-day responsibility discourse, it is this latter, prospective sense of responsibility, as an intended character-trait of the researcher, which plays a central role in the normative framework outlined above. The responsibility of the researcher is not delimited to the development of their science only, but also includes the development of society - doing research is, in a sense, doing ethics.

In three different case studies, opportunities and constraints for encouraging critical reflection on the socio-ethical context of research have been explored, with the aim to 'marry the strengths of science with the insights of its critics' (Ruse: 1999, 34). The first case study considered the implementation of the Netherlands Code of Conduct for Scientific Practice at the Department of Biotechnology of Delft University of Technology. A series of interviews held with researchers at the Department pointed out that the utility of scientific codes of conduct for encouraging reflection is not self-evident. While respondents agreed that discussion of the guiding principles of scientific conduct is called for, they did not consider the code as such to be a useful instrument. As a tool for the individual scientific practitioner, the code leaves a number of important questions unanswered in relation to visibility, enforcement, integration with daily practice and the distribution of responsibility. The interview results indicated that there is more at stake than merely holding scientific practitioners to a proper exercise of their duties; the implementation of scientific society codes of conduct also concerns the further motives and value commitments that gave rise to their establishment in the first place.

The second case study applied the method of 'midstream modulation' in two molecular biology research laboratories (in Delft, The Netherlands and in Tempe, Arizona). The results of these studies show that the methods and techniques used during the interactions can encourage critical reflection in the laboratory. Particularly the potential for second-order reflective learning, in which underlying value systems become the object of reflection, is significant with respect to addressing social responsibility in research practices.

The third and final case study concerned two advanced courses for nanotechnologists on public communication and applied ethics organised as part of the European Nanobio-RAISE project. The advanced courses presented several opportunities for encouraging critical reflection on the wider societal context of nanotechnology by providing a broad overview of relevant concerns and expectations surrounding nanotechnological research. Exposure to this broader perspective encouraged participants to reflect on the value-based socio-ethical premises as well as the possible socio-ethical consequences of research.

The research results of the case studies suggest that the practical realisation of a broadened conception of social responsibility in applied research is best served by an approach that combines the strengths of the individual areas of intervention: one in which codes of conduct articulate the normative commitments of the research community, interdisciplinary collaborations specify the meaning of such commitments, and education and training build reflexive capacity in the research community. Codes of conduct, particularly those codes of ethics that include the research community's broader responsibilities towards society, can invite reflection on the socio-ethical context of research. They can serve as enablers, inviting reflection on the value-based premises and possible socio-ethical consequences of research. But the effect of such codes in encouraging reflection remains tangential if not addressed from 'within', bringing normative commitments to life within the specific context of research. This is where interdisciplinary collaboration and education can complement a code of conduct, by elucidating how abstract normative principles apply to concrete research decisions.

This thesis has only been able to scratch the surface of the deeper challenges that attempts to revalue value-neutrality in the applied sciences face. Although the case studies suggest several opportunities to encourage critical reflection in research, they also lay bare certain constraints. The case studies have mainly focused on individual researchers, but the institutional context also plays an important role: individual researchers and research groups are themselves enabled and constrained by wider institutional contexts such as the international research community, universities and relations with funding bodies. As Ziman (1998) has indicated, the neutrality view is deeply engrained in the normative structure and institutional arrangements of these wider research communities and cannot be 'uninstalled by a keystroke'. In addition to the commitments and capacities of individual researchers, an institutional environment is required in which attention to broader ethical and societal issues is both encouraged and rewarded and a commitment to reflection is embedded in the research culture. The 'revaluation' of value-neutral research requires a synthesis between the view of research as the discovery, in the words of Philip Ball, of 'deep and elegant truths, so far as truths can ever be discerned, about the way the universe works' (Ball: 2007, 39), while recognising that those truths are not absolute, but bound to the values, beliefs and aspirations of the society from which they emanate. The successful integration of broader socio-ethical dimensions in research practice may thus lead to more robust forms of knowledge production that harness 'the immense possibilities of scientific knowledge and technological innovation ... 'for the relief of man's estate'' (Edge: 1995, 19).

Daan Schuurbiers, September 2010.

Samenvatting

Maatschappelijke verantwoordelijkheid in de onderzoekspraktijk.

Hoe kunnen onderzoekers aangemoedigd worden om kritisch te reflecteren op de ethische en maatschappelijke context van hun werk? Dat is de centrale onderzoeksvraag in dit proefschrift. Het uitgangspunt is dat de neutraliteitsthese (de heersende opvatting dat onderzoekers zich verre dienen te houden van de ethische en maatschappelijke aspecten van hun werk) onhoudbaar is, althans voor wat betreft toegepaste wetenschappen als nano- en biotechnologie. Dit proefschrift gaat uit van een breder perspectief waarin de maatschappelijke verantwoordelijkheid van de onderzoeker, naast de verantwoordelijkheid om te voldoen aan de interne normen van de onderzoeksgemeenschap, ook de morele verantwoordelijkheid omvat om kritisch te reflecteren op de socio-ethische context van zijn of haar werk. Dat normatieve uitgangspunt is op zich niet uniek: het argument dat onderzoekers bredere overwegingen in hun werk dienen te integreren, is op verschillende momenten in de geschiedenis voorgesteld door wetenschapsfilosofen en -sociologen evenals door bezorgde wetenschappers. Toch blijft de neutraliteitsthese een dominant referentiekader in de dagelijkse onderzoekspraktijk. De specifieke bijdrage die dit proefschrift aan het debat levert, is de 'herwaardering van waardevrije wetenschap': een verkenning van de mogelijkheden en beperkingen voor de verwezenlijking van die bredere interpretatie van maatschappelijke verantwoordelijkheid in de dagelijkse onderzoekspraktijk. Dat gebeurt aan de hand van drie case studies: de implementatie van een gedragscode, interdisciplinaire samenwerking tussen natuur- en sociale wetenschappers, en de vormgeving van onderwijs op het gebied van wetenschap en maatschappij.

De case studies zijn gericht op nano- en biotechnologisch onderzoek, twee voorbeelden van toegepaste wetenschap waarin de neutraliteitsthese onhoudbaar is. Volgens de neutraliteitsthese zijn onderzoekers slechts verantwoordelijk voor de productie van betrouwbare, objectieve kennis over de wereld door een proces van belangeloos, nieuwsgierigheidsgedreven onderzoek. Maar toegepast wetenschappelijk onderzoek vindt niet plaats in een socio-ethisch vacuum: ethische en maatschappelijke overwegingen spelen een belangrijke rol bij zowel de motivatie voor nano- en biotechnologisch onderzoek als bij de uitvoering en de uiteindelijke resultaten. Nanotechnologie is verwelkomd als de volgende grote technologische revolutie, vergelijkbaar met elektrificatie en de stoommachine, en is omgeven door beloftes van onbegrensde technische en maatschappelijke vooruitgang. Zo ook voor biotechnologie: het aanpassen van biologische systemen op moleculair niveau zou een breed scala aan mogelijkheden in de industrie, landbouw en de zorg onstluiten. Tegelijkertijd is er grote maatschappelijke bezorgdheid over de mogelijke gevolgen van deze ontwikkelingen. Die intrinsieke waardegeladenheid van het onderzoek impliceert dat de ethische en maatschappelijke context niet alleen voor en na, maar ook al *tijdens* het doen van onderzoek de aandacht verdient.

Dit vraagt om een bredere visie op de maatschappelijke verantwoordelijkheid van de onderzoeker. Het normatieve kader dat aan de case studies in dit proefschrift ten grondslag ligt is dat het 'verantwoordelijkheidsbereik' van de onderzoeker de morele verantwoordelijkheid omvat om kritisch te reflecteren op de bredere socio-ethische context waarin het onderzoek plaatsvindt (Verhoog, 1980). Deze interpretatie van verantwoordelijkheid omvat zowel een retrospectieve als een vooruitziende dimensie. Verantwoordelijkheid wordt tegenwoordig vooral begrepen als de plicht zich te verantwoorden. Maar in het geschetste normatieve kader ligt de nadruk op de vooruitziende dimensie van verantwoordelijkheid, op verantwoordelijkheid als deugd, als karaktertrek van de onderzoeker. De verantwoordelijkheid van de onderzoeker blijft daarmee niet beperkt tot de ontwikkeling van de wetenschap, maar ook voor de ontwikkeling van de maatschappij: onderzoek doen is in zekere zin ook ethiek bedrijven.

In drie verkennende case studies zijn mogelijkheden en beperkingen in kaart gebracht om kritische reflectie op de socio-ethische context van onderzoek aan te moedigen, met als doel 'de kracht van de wetenschap te verbinden met de inzichten van haar critici' (Ruse: 1999, 34). De eerste case study bestudeert de implementatie van de Nederlandse Gedragscode voor Wetenschapsbeoefening bij de afdeling Biotechnologie van de Technische Universiteit Delft. Een reeks interviews met onderzoekers op de afdeling toont aan dat deze gedragscode niet vanzelfsprekend reflectie op de onderzoekspraktijk bevordert. Hoewel respondenten het erover eens waren dat een discussie over de heersende principes van de wetenschap aan de orde is, zagen zij deze code daarvoor niet als een nuttig instrument. De code laat een aantal belangrijke vragen onbeantwoord met betrekking tot zichtbaarheid, handhaving, integratie met de dagelijkse praktijk en verantwoordelijkheidsdeling. De interviewresultaten laten zien dat het debat over de principes van de wetenschap meer behelst dan wetenschapsbeoefenaren te houden aan de correcte uitoefening van hun taken; de achterliggende motieven en waardeoordelen die aan de wetenschappelijke gedragscode ten grondslag liggen, verdienen eveneens de aandacht.

In de tweede case study is de methode van 'midstream modulation' toegepast in twee laboratoria voor moleculaire biologie (in Delft en in Tempe, Arizona). De resultaten van deze studie laten zien dat de methoden en technieken die tijdens de interacties in het lab zijn gebruikt kritische reflectie op de bredere socio-ethische context in het lab bevorderen. Vooral het potentieel voor tweede-orde reflectief leren, waarin onderliggende waardesystemen het onderwerp van reflectie worden, is van belang voor het realiseren van maatschappelijke verantwoordelijkheid in de onderzoekspraktijk.

De derde en laatste case study betreft twee cursussen voor nanotechnologen over publiekscommunicatie en toegepaste ethiek die werden georganiseerd als onderdeel van het Europese Nanobio-RAISE project. De cursussen boden verschillende mogelijkheden om kritische reflectie op de maatschappelijke context van nanotechnologie te bevorderen door de relevante belangen en overwegingen rond nanotechnologisch onderzoek in beeld te brengen. Door blootstelling aan dit bredere perspectief werden cursisten aangemoedigd kritisch te reflecteren op zowel de achterliggende doelstellingen als de mogelijke maatschappelijke gevolgen van nanotechnologisch onderzoek.

De onderzoeksresultaten van de case studies doen vermoeden dat voor de verwezenlijking van een brede interpretatie van maatschappelijke verantwoordelijkheid een aanpak nodig is die de kracht van de verschillende interventiegebieden combineert: een aanpak waarin een gedragscode de normatieve principes en overtuigingen van de onderzoeksgemeenschap articuleert, interdisciplinaire samenwerking de concrete betekenis van die principes en overtuigingen specificeert; en onderwijs zorg draagt voor de opbouw van reflexieve capaciteiten in de onderzoeksgemeenschap. Gedragscodes, in het bijzonder het type ethische code dat de bredere verantwoordelijkheid van de onderzoeksgemeenschap naar de maatschappij benoemt, kunnen uitnodigen tot reflectie op de socio-ethische context van het onderzoek. Maar het effect van zulke gedragscodes blijft oppervlakkig zonder complementaire aanpak 'van binnenuit', waarbij normatieve principes en overtuigingen door explicitering en discussie in de specifieke onderzoekscontext tot leven gebracht worden. Dit is waar interdisciplinaire samenwerking en onderwijs een gedragscode kunnen aanvullen, door aan te tonen hoe abstracte normatieve principes op alledaagse onderzoeksbeslissingen van toepassing kunnen zijn.

Dit proefschrift geeft slechts een eerste aanzet tot de herwaardering van waardevrije wetenschap. Hoewel de case studies verschillende mogelijkheden in beeld brengen om reflectie op de socio-ethische context van onderzoek te bevorderen, leggen ze ook hindernissen bloot. De case studies waren vooral gericht op individuele onderzoekers, maar de institutionele context speelt ook een belangrijke rol: onderzoekers en hun onderzoeksgroepen maken zelf weer deel uit van bredere institutionele omgevingen zoals de internationale onderzoeksgemeenschap, universiteiten en subsidienetwerken. Zoals Ziman (1998) heeft aangegeven is de neutraliteitsthese diep in de normatieve structuur van wetenschap verankerd, en kan zodoende niet met een 'druk op de knop' verwijderd worden. Los van de overtuigingen en capaciteiten van individuele onderzoekers is een institutionele omgeving nodig waarin het belang van kritische reflectie in de onderzoekscultuur is ingebed en waarin aandacht voor ethische en maatschappelijke aspecten wordt aangemoedigd en gewaardeerd. De herwaardering van waardevrije wetenschap vraagt om een synthese tussen enerzijds het beeld van de wetenschap als de ontdekking van 'diepe en elegante waarheden, voorzover waarheden ooit waargenomen kunnen worden, over de manier waarop het universum werkt' (Ball: 2007, 39), en anderzijds de erkenning dat die waarheden niet absoluut zijn, maar afhankelijk van de specifieke waarden en overtuigingen van de maatschappij waaruit zij voortkomen. De geslaagde integratie van bredere socio-ethische overwegingen in de onderzoekspraktijk kan tot meer robuuste vormen van kennisproductie leiden, zodat 'de immense mogelijkheden van wetenschappelijke kennis en technologische innovatie benut kunnen worden (in de woorden van Bacon) 'voor de leniging van de menselijke toestand'' (Edge: 1995, 19).

Daan Schuurbiers, september 2010.

Appendix

Programme

Sunday 23 September 2007

Theme: Introduction - course programme & participants' objectives

14.00 Introduction to course programme
Daan Schuurbiers
14.30 Introductory presentations by course participants
16.00 Tea
16.30 Continuation of introductory presentations by course participants
19.00 Dinner
20.30 Public communication - do's and don'ts in practice
Dr Patricia Osseweijer

Monday 24 September 2007

Theme: Explaining science / Ethical issues

09.00 Nanotechnology - the state-of-the-art and the public arena
Prof Vinod Subramaniam
10.00 Coffee
10.30 Harnessing nanotechnology to improve health in developing countries
Dr Fabio Salamanca-Buentello
11.30 Nanotechnology in Food
Dr Frans Kampers
12.30 Lunch
13.30 Explaining nanotechnology in public
Prof Dr Wolfgang M. Heckl
14.30 Ethical issues in nanobio-technology
Dr Donald Bruce
16.00 Tea
16.30 Debate session
19.00 Dinner
20.30 The view from a nano-technology company
Dr Barry Park

Tuesday 25 September 2007

Theme: Understanding and responding to ethical, legal and social issues

09.00 Law, ethics and regulatory affairs
Prof Julian Kinderlerer
10.00 Coffee
10.30 Role play
12.30 Lunch
13.30 The toxicology and risk assessment of particles - an introduction
Prof Ken Donaldson
14.30 Public policy development for nanotechnology
Prof Sir John Beringer
15.30 Introduction to group work on communication plan
Daan Schuurbiers
16.00 Tea
16.30 Group work on strategic communication plan
19.00 Dinner
20.00 Continuation of group work on strategic communication plan

Wednesday 26 September 2007

Theme: Public perceptions of nanotechnology / Public communication

09.00 The Eurobarometer public opinion surveys, stakeholders and issues in Europe
Prof George Gaskell
10.00 Coffee
10.30 Risk perception, attitudes and compensation
Dr John Adams
11.30 Nanotechnology, PR and the media
Richard Hayhurst
12.30 Lunch
13.30 Group work on communication plan
16.00 Tea
16.30 Presentations by the groups of draft communication plan
18.00 Mid-term evaluation & feedback from participants
Daan Schuurbiers
19.00 Dinner
20.30 Greenpeace's communication strategy in Nanotechnology
Dr Douglas Parr

Thursday 27 September 2007

Theme: Media training

09.00 Simulated press conference - Be a reporter for an hour
Dr Bernard Dixon and Peter Evans
10.00 Coffee
10.30 How do the media work?
Dr Bernard Dixon and Peter Evans
12.30 Lunch
13.30 Reviewing participants' articles (in two groups)
Dr Bernard Dixon and Peter Evans
15.00 Writing about science for non-scientists
Dr Bernard Dixon
16.00 Tea
16.00 Oral communication
Peter Evans
19.00 Dinner
20.30 Group work on communication plans

Friday 28 September 2007

Theme: Media training (continued) / Public communication - the full plan

09.00 The GM food furore - lessons for nano?
Dr Bernard Dixon
10.00 Coffee
10.30 Radio interviews
Peter Evans
12.30 Lunch
13.30 Continuation of radio interviews
Peter Evans
14.30 Group work finalisation of communication plans
15.30 Presentations by the groups of their communication plans
16.00 Tea
16.30 Presentations by the groups of their communication plans
17.30 Panel review
18.00 Course evaluation
19.00 **Formal course dinner and diploma ceremony**

Programme of the second course 'Public Communication and Applied Ethics of Nanotechnology' held in September 2007, showing the overall themes and the combination of lectures with practical work.

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Because they represent such a sudden shift in tone and mood, acknowledgement sections in PhD-theses have always struck me as distinctly odd. While the thesis author usually remains safely concealed behind a veil of objectivity and disinterestedness throughout most of the work, the veil is lifted right before the end in a brief and sudden outburst of familiarity, uncovering the person, the friend, the lover behind the independent scholar. While it is good to know that people of flesh and blood exist behind the great wall of academic objectivity, the abrupt shift from an obsessively factual narrative to a deeply personal tale emphasizes the incongruity of both. It is almost as if the TV newsreader would end by saying: *"This was the eight 'o'clock news, thank you for watching. Oh and darling, would you put the kids to bed? I'll be home by ten."* On the other hand, skipping the entire section merely for the sake of literary consistency might be even more awkward: it might seem to suggest that no acknowledgements are in order. In fact, quite the opposite is true: it is highly likely that this thesis would never have seen the light of day without the continuing support of a number of people, to whom I am truly grateful. So for all its awkwardness and breach of style, here goes: many thanks to my supervisors Patricia Osseweijer and Julian Kinderlerer for bearing with me throughout the years, I'm very glad we stuck together. As Edmund Hillary said: *"It is not the mountain we conquer but ourselves."* I would also like to express my heartfelt appreciation to my official and unofficial co-supervisors, mentors and friends Ibo van de Poel and Erik Fisher, without whom I would never even have made it to base camp, let alone conquer the mountain. A special thank you also to Harro van Lente for supporting me in difficult times at the end of my research, to David Guston for hosting me at Arizona State University, to Walter Valdivia for making my stay in Tempe unforgettable, and to David Bennett and Arie Rip for subtle but very helpful nudging in the right directions on the right moments. Thanks also to the members of the Working Group on Biotechnology in Society, the staff and researchers of the Centre for Society and Genomics, the STIR-group, folks at CSPO / CNS-ASU, the philosophers at TPM in Delft, the members of the Task Group on Public Perceptions of Biotechnology, the Nanobio-RAISE partners and participants and everyone at WTMC, and all the inspiring individuals and eminent scholars to be whom I had the fortune to meet and discuss with over the years: thank you all for discussing wild ideas, sharing good thoughts and answering silly questions. To everyone at the Department of Biotechnology and the Photosynthesis group at ASU's School of Life Sciences, especially R1, R2, D1 and D2: thank you all for being such exemplary model organisms. Commiserations also to my friends and family: thank you for bearing with me in times of despair and for patiently listening to my ramblings about social responsibility and how to solve the world's problems. Thanks mom, for everything, and especially for your insightful suggestion to study philosophy. Annette and Wouter, thank you for being my 'paranimfs' and taking the heat for my philosophical propositions. And thank you, Bram, for all the late-night philosophising. But my very deepest gratitude goes out to Marije, my love, who has had to suffer me day in, day out. Without your patience, resilience and unflinching support I would never have made it through the tunnel: you truly are my light in the dark.

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Curriculum Vitae

Daniël Schuurbiers was born in Akersloot, The Netherlands on 22 February 1975. From 1987 to 1993 he followed pre-university education (VWO) at the Rijksscholengemeenschap Noord-Kennemerland in Alkmaar. He then went on to study Chemistry and Philosophy at the University of Amsterdam. He obtained his propedeuse in Philosophy *cum laude* in 1996 and received his Master of Arts degree in the Philosophy of Language (including a minor in Chemistry) in February 2000. After a period of tour guiding in Latin-America and Europe he started working as a project manager for Cambridge Biomedical Consultants in Delft in August 2002. Through his work for the Task Group on Public Perceptions of Biotechnology of the European Federation of Biotechnology in that period, he became interested in the philosophical and sociological dimensions of scientific and technological innovation. In April 2005, Daan started as a PhD-student at the Working Group on Biotechnology and Society of Delft University of Technology, where he carried out the research project 'Empowering Scientists in their Social Responsibility' for the Centre for Society and Genomics in Nijmegen. In this period he obtained the Teaching Qualification for Higher Education in 2008 and completed the graduate training programme of the graduate school on Science, Technology and Modern Culture (WTMC) in 2009. He was also project manager for the European Commission Co-ordination Action Nanobio-RAISE from 2005 - 2008 and co-founder of the Imagine Foundation. Since January 2010, Daan works as a postdoctoral researcher at the Innovation Studies Group of Utrecht University.

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Simon Stevin (1548-1620)

'Wonder en is gheen Wonder'

This series in the philosophy and ethics of technology is named after the Dutch / Flemish natural philosopher, scientist and engineer Simon Stevin. He was an extraordinarily versatile person. He published, among other things, on arithmetic, accounting, geometry, mechanics, hydrostatics, astronomy, theory of measurement, civil engineering, the theory of music, and civil citizenship. He wrote the very first treatise on logic in Dutch, which he considered to be a superior language for scientific purposes. The relation between theory and practice is a main topic in his work. In addition to his theoretical publications, he held a large number of patents, and was actively involved as an engineer in the building of windmills, harbours, and fortifications for the Dutch prince Maurits. He is famous for having constructed large sailing carriages.

Little is known about his personal life. He was probably born in 1548 in Bruges (Flanders) and went to Leiden in 1581, where he took up his studies at the university two years later. His work was published between 1581 and 1617. He was an early defender of the Copernican worldview, which did not make him popular in religious circles. He died in 1620, but the exact date and the place of his burial are unknown. Philosophically he was a pragmatic rationalist for whom every phenomenon, however mysterious, ultimately had a scientific explanation. Hence his dictum 'Wonder is no Wonder', which he used on the cover of several of his own books.