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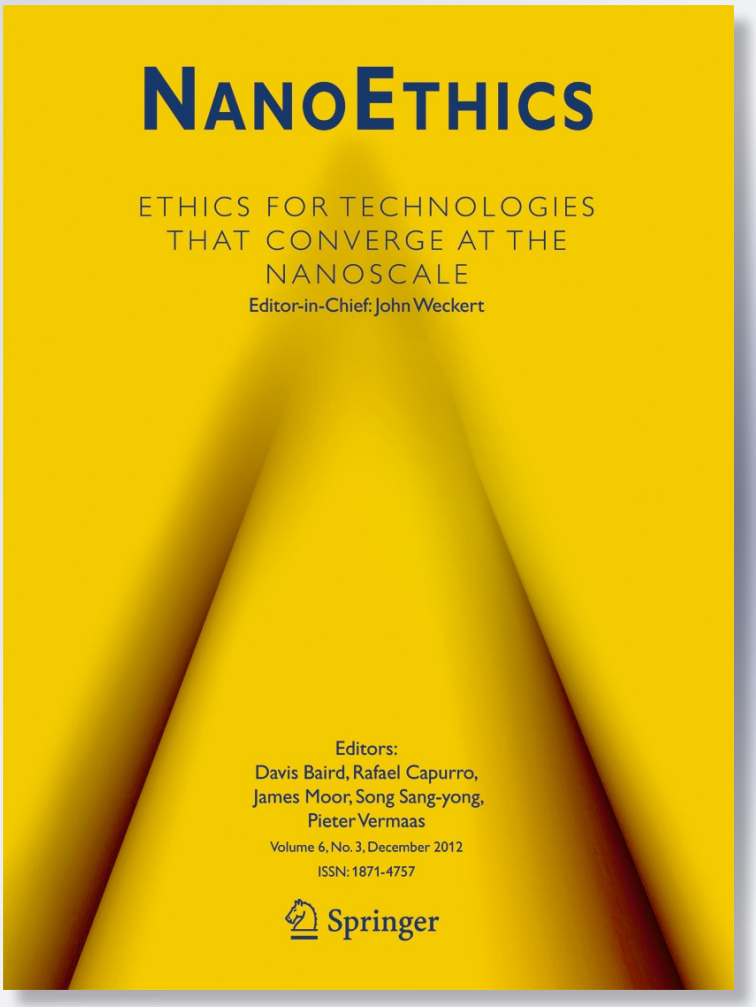

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ORIGINAL PAPER

Integrating and Enacting 'Social and Ethical Issues' in Nanotechnology Practices

Ana Viseu · Heather Maguire

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Abstract The integration of nanotechnology's 'social and ethical issues' (SEI) at the research and development stage is one of the defining features of nanotechnology governance in the United States. Mandated by law, integration extends the field of nanotechnology to include a role for the "social", the "public" and the social sciences and humanities in research and development (R&D) practices and agendas. Drawing from interviews with scientists, engineers and policymakers who took part in an oral history of the "Future of Nanotechnology" symposium at the Cornell NanoScale Facility, this article examines how nanotechnology's 'social and ethical issues' are brought to life by these practitioners. From our analysis, three modes of enactment emerge: enacting SEI as obligations and problems-to-be-solved, enacting SEI by 'not doing it' in the laboratory, and enacting SEI as part of scientific practice. Together they paint a complex picture where SEI are variously defined, made visible or invisible, included and excluded, with participants showing their skill at both boundary-work (Gieryn Am Sociol Rev 48:781–795, 1983, 1999) and at integration. We conclude by reflecting on what this may mean for the design and implementation of SEI integration policies, suggesting that we need to transform SEI from obligations into 'matters of care' (Puig de la Bellacasa Soc Stud Sci 41(1):85–106, 2011) that tend to existing relationalities between science and society and implicate practitioners themselves.

Keywords Integration · Nanotechnology governance · Science policy · Scientific practice · Social and ethical issues

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Introduction

> Thinking about social and ethical issues [SEI], it's great, but you have to do things [and] [t]hat's when it gets sticky
> - George Malliaras

> Well, [SEI] it's not something we do explicitly in a lab because in a lab we're trying to understand the science.
> - Harold Craighead

> The thing about my own research I guess, you might say that maybe I avoid certain areas that I

think would be unpalatable ethically. That might be one thing.
- Christopher Umbach

A concern with the 'responsible development' of nanotechnology has been part of the repertoire and priorities of U.S. science policy since at least the year 2000, when nano entered the public imagination. To ensure it, the *21st Century Nanotechnology Research and Development Act* [45], passed by the U.S. Congress in 2003, mandates the 'integration' of 'social and ethical issues' (SEI) research within scientific and technical agendas and practices. At its core, SEI integration aims to extend the field of nanotechnology by broadening the scope of questions, professions and interests through which nano defined, and specifically by including a role for the social sciences and humanities in its development. However, as the quotes above reveal, from the vantage point of nano-practitioners SEI integration remains a complex issue and practice.

Recently Jasanoff [24] has argued that current approaches to social discussion of scientific issues have strengthened, rather than weakened, the split between the domain of facts and the domain of values [24]. This development, she argues, runs counter to the prevailing understanding among scholars of science and society that facts and values are mutually constitutive [23]. In order to agree, or disagree, with Jasanoff's assessment more needs to be done to examine the workings of post-ELSI policy models. Our article is a modest contribution to this debate. In it we examine how nano-SEI integration is working from the standpoint and practices of scientists. Our goal is not to reach a normative assessment, declaring them to be good or bad practices, instead we seek to understand why some enactments are chosen over others and for what purposes, that is, to examine their accomplishments in the social worlds of science. To do so we draw upon interviews with nano-practitioners (here meant to encompass scientists, engineers and policymakers working within the field of nanotechnology) who participated in 'The Future of Nanotechnology' symposium organized in June 2007 to celebrate the 30th Anniversary of the Cornell NanoScale Facility (CNF). Our goals are to examine how 'social and ethical issues' are defined and enacted by participants within the practice of their work, and what this may mean for the policy of SEI integration. We put in evidence the complexity, contradictions and tensions that arise from three modes of enactment that emerged from the analysis of practitioners' narratives: enacting SEI as obligations and problems to be solved, enacting SEI by 'not doing it,' and enacting SEI as part of scientific practice. These three complementary modes paint a complex picture in which interviewees both struggle to bring SEI into the laboratory and keep them out, and display the ways in which SEI are already part of their scientific practices. We conclude by reflecting on what this means for the design and implementation of SEI integration policies, suggesting the need to transform SEI from obligations into 'matters of care' [46].

Nanotechnology Governance: SEI and the Policy of Integration

While the term SEI integration is most readily connected to current nanotechnology funding and policy initiatives, efforts to include the social sciences and the public within scientific governance are older. In this history, where precursors and rationales are often used interchangeably, we find the rejection (in Europe) of genetically modified organisms [2, 11, 52]; the growing critiques of the 'public understanding of science' model in which the public's resistance is deemed caused by a deficit of scientific education and information [22, 32, 64, 65], and last but not least, the Human Genome Project's 'ethical, legal, and societal implications' (ELSI) program [34, 38, 62]. The latter, in particular, is often cited as having influenced the current mode of nanotechnology governance [9, 39].

In the past 10 years the rapid increase in funding for nanotechnology has been accompanied by calls for governance models that facilitate or mandate its 'responsible development'. As early as the year 2000 the National Science Foundation (NSF) organized a workshop on 'Societal Implications of Nanoscience' [51], and money was set aside to fund SEI research within the newly-founded National Nanotechnology Initiative (NNI), the entity that oversees research at the nanoscale in the United States. Three years later the *21st Century Nanotechnology Research & Development Act* (Public Law 108–153) was passed into law, recommending that social, ethical and legal concerns and issues be considered *during* and, 'insofar as possible' be *integrated with* techno-scientific research and development. The Act broadens the scope of disciplines, questions, and actors involved in nanotechnology research and development (R&D), and emphasizes the need to do this while

nanotechnologies are being developed. It is within this context that nanotechnology is frequently hailed as representing 'a new kind of science' ([1], cited in [27]: 132). However, even a generous reading of the law shows that SEI remain loosely defined, encompassing almost anything—from artificial intelligence to cost analysis studies. Moreover, it can be argued, as it was with the Human Genome Project's 'ethical, legal, and societal implications' (ELSI) program, that by constituting SEI as its own entity the Act works to reify rather than blur the boundaries between science and its social dimensions [24, 31]. Last but not least, the Act is mute on pragmatic issues of power and implementation—the power to decide what should be studied and by whom, or by what means it should be put into practice.

In the United States, and across the Western world, a number of SEI integration research activities have been conducted. In a 2008 survey of nano-practitioners conducted at the nanotechnology infrastructure network led by the Cornell Nanoscale Facility (CNF), McGinn asked over 1,000 practitioners about their views and beliefs on ethics and nanotechnology, concluding that they 'exhibited medium or high levels of sensitivity to ethics in relation to nanotechnology' ([36]: 101; for other surveys see [5, 43, 53]). He found, for instance, that 58 % of respondents thought that it is 'quite' or 'very' important that ethical issues related to nanotechnology be considered. This is an important figure, even if, as McGinn concedes, the numbers would probably change if practitioners had been asked if these same ethical issues should be considered by them as opposed to someone else ([36]: 104). By virtue of its survey design, McGinn's study did not provide room for practitioners to have an in-depth discussion or reflection on nano-SEI. Moreover, its focus was not on practice but instead on thinking, views and perspectives. When actual practices were alluded to, the survey portrayed a complex picture in which 43.4 % of respondents found the ethical dimensions of nanotechnology to be 'as important as' its scientific dimensions, yet almost a quarter of respondents said 'no action' would be taken if a fellow researcher took a prohibited shortcut while conducting research. The varying responses portrayed within this survey reveal the complex scenario of SEI enactment.

The past few years have also seen a modest growth in experiments with integration. Primarily driven by a desire to intervene and influence the research process (and/or policy making process) through the fostering of increased reflexivity among scientists, these studies and resulting articles have often been framed as reflections on the experience of integration by social scientists or as models for further interventions[1] [6, 7, 10, 12, 16, 37, 49, 54, 55, 57, 60]. In his engagement with two laboratories Schuubiers' [54] found that reconstructing scientific decisions with his subjects and reflecting on the process and practices of research, resulted in his subjects' expanded understanding of the (scientific) system within each they work to include 'societal and ethical issues.' Like the findings we present here, Schuubiers suggests the need for working with the existing practices of scientists (the third enactment mode). However, others have pointed out the limited inroads that have been made in changing the discursive and material practices of scientific culture [17]. An early exchange between Schuurbiers and a participant in his study illustrates this point: 'Does [the engagement with an embedded social scientist] change my thinking? Yes. Does it change what I do on a daily basis? No' ([55]: 426). Citing this quote, Rip argues that 'this need not be a message of despair' ([49]: 667), and while this may be the case, it is certainly, as he acknowledges, a sign that more must be done and, we suggest, done differently. It also signals that we need further examinations of how scientists enact SEI within their practices and what understandings of SEI are implicated in those enactments, so that we can start to understand what this may imply for the design of policies of SEI integration. It is to this literature that our article adds. The accounts depicted herein show practitioners struggling to make sense of SEI integration, and bring into evidence the contradictions and complexities that emerge through the processes of doing science and doing SEI, while simultaneously working to maintain the boundaries of 'proper' science. However, it also points to the ways in which scientists enact SEI as part of the scientific practice and see themselves as moral agents in this process.

Before exploring our participants' stories we introduce them, along with the symposium that brought them together and whose oral history we tell here.

[1] A few methodologies have been devised to accomplish such goals, namely 'anticipatory governance' [4, 25], 'constructive technology assessment' [47–49] or 'midstream modulation' [10, 12], each possessing its own set of contingencies that are beyond the scope of this article.

The Future of Nanotechnology: An Oral History of the CNF 30th Anniversary Symposium

The Cornell NanoScale Facility (CNF) is a nanofabrication user facility that features a fully equipped clean room worth upwards of $100 million, and has over 700 users per year (http://www.cnf.cornell.edu). At the time of the symposium the CNF was the leader of the National Nanotechnology Infrastructure Network (NNIN), a partnership of 14 user facilities spread across the USA. The NNIN is a key component of the larger vision for nanotechnology in the United States as laid out by the National Nanotechnology Initiative's (NNI) implementation plan [42]. In it, George Whitesides and Paul Alivisatos state that 'to make rabbit stew, you must first catch a rabbit. Likewise, in order to work in nanoscience, one must be able to fabricate and characterize nanostructures' ([42]: 69) and for that, one needs the equipment and support that are facilitated through the NNIN. However, the life of the CNF is significantly longer than that of the NNI or NNIN. It was created in 1977 as a university-based 'national research and resource facility for submicron structures' and was, as it has become fashionable to say, doing nano before nano was nano.

In 2007, the CNF celebrated its 30th Anniversary with a one-day symposium entitled 'The Future of Nanotechnology.' Held on June 14, this event was simultaneously a celebration of the CNF's legacy, a look into the future, and a testimony to nanotechnology's longevity. With approximately 380 attendees, the symposium was a large, well-publicized event preceded by a one-day journalist workshop organized by the Kavli Institute [26]—which included activities such as speed-dating with scientists—and followed by a broadcast discussion on National Public Radio's 'Science Friday' [13]. It was organized into three main tracks—NanoTech, NanoMed, and Nano&Us—each with a plenary speaker in the morning and a number of parallel sessions held in the afternoon that together featured 22 speakers. When asked about the decision to include a 'Nano&Us' stream focused on 'social and ethical issues', George Malliaras, then CNF Director said,

> It's an important and very emerging area. It's also an area where we have leadership within the [NNIN] network. It's an area where we want to build strength at Cornell. […] Also, again, the goal is to educate the [CNF's] users. […] So I do see it as a very important part of the facility despite the fact that it's only a small fraction of the budget […]. On the other hand, it doesn't require the infrastructure that nanotechnology requires. Maybe a machine is a multi-million dollar investment; social sciences do not require that. So yeah, I think it's very important. (Malliaras)

In other words, SEI is both very important for the CNF, and has the added benefit of being inexpensive. This has all the more meaning since, as Malliaras goes on to argue, the CNF is a technical facility and 95 % of its budget is dedicated to supporting this mandate. Importantly, the CNF is a pioneer in SEI integration, having had one in-house social scientist in its ranks since the network's inception. The first author served this role for 3 years—2004 to 2007—and was deeply involved in the organization of the symposium (see [7]). The analysis presented here is informed both by her experience at the CNF and the oral history of the event that she conducted. The goal of the oral history was to provide an in-depth illustration of a particular moment in the history of the nanotechnology—a snapshot of an assemblage of perspectives and lived experiences of scientists, engineers, and policymakers working in the field. It entailed an ethnographic component, performed during the event by the first author and a team of three graduate students. The resulting ethnographic tales [59] relayed the opinions and beliefs of some of the nearly 400 symposium attendants; they also described the talks that took place in each of the three streams. The ethnographic notes were used to build scripts for the oral history interviews that were later conducted with symposium speakers and organizers. These scripts were semi-structured and emphasized the work and research conducted by each participant.

The success of the 'Nano&Us' stream was a matter of debate. Some participants argued that it was well attended, while others expressed disappointment at the low turnout. Most of the afternoon speakers attended their 'own' streams; however a few were present for some Nano&Us presentations. When asked if he had learned something from these talks, Robert Corn, Professor of Chemistry at University of California, Irvine, said that he enjoyed it and that he 'learned

what people are interested in.' This general response was echoed by George Malliaras who said,

> I talked to a lot of the scientists who attended the [SEI] sessions, and they found it very interesting and easy to relate, easy to relate to. There wasn't very much nano in the sense that it was like… you could replace nano with nuclear or nano with biomedical or nano with genetic engineering, and address the same issues.

Malliaras indicates here that SEI discussions were deemed to portray an interesting scenario, but one that is not specific to nanotechnology. This ambiguity is reflected in the interviews, making it possible for SEI to be something that is both part, and not part, of participants' nano-scientific practices. More critical in his appraisal was Edward Wolf, a retired Director of the CNF and Professor Emeritus in the School of Electrical and Computer Engineering at Cornell University, who, acknowledging the sensitivity of his remarks, said that he 'heard condescending snickers and body language by those on the podium and in the audience when they were talking about scientists and engineers,' going on to say that he spoke to other attendees who felt the same. Despite these mixed assessments, in purposefully incorporating the social sciences, the symposium stood as an example of the kinds of SEI integration that are at the core of the U.S. nanotechnology policy. It was, in the words of a policy officer[2] in attendance, something that had 'never happened' before.

In the course of this oral history project, 27 recruitment emails were sent to all the speakers, organizers, attending policy officers, and a few selected attendees who were identified during the ethnography as important actors. In total, 20 persons agreed to be interviewed: four social scientists, two museum curators, two policy officers, the remaining 12 have a background and career in the sciences (with some doubling as part of the CNF organization). On average the interviews lasted about 1 hour, with half being conducted face to face and the rest over the phone. Participants were explicitly asked permission to use their real names because their identity as experts in the field adds value to the opinions and experiences they express. The interviews were later transcribed and carefully read, reviewed and coded by the authors. Through this method, a number of modes of enacting SEI integration emerged, which led to the selection of 11 participants for further analysis in this article (see Table 1 below; see also footnote 4).

[2] This participant is not identified here due to an expressed wish to remain anonymous.

Enacting SEI in Nanotechnology

Analysis of the interviews was informed by the following overarching questions: How do participants enact SEI in their scientific practices? And, how are these enactments connected to particular characterizations and definitions of SEI? These questions highlight the performative character of SEI integration as a 'contingent enactment of a specific version of the real' [33]. SEI and SEI integration are then not a 'given'; they 'become' through and within particular discursive and material assemblages [20], 'intra-actions' [3] and knowledge politics [46]. Three modes of performing SEI were identified: (1) In the most common enactment mode SEI emerge as obligations and problems (of the public, of the media, of other scientists) that practitioners tackle in the course of their activities through proper communication, outreach and education. (2) In the second mode, practitioners go on to erase their agency and expertise, enacting SEI as something that is not done in the lab and that should instead be decided by (and in) society, or as matters to think about (rather than do). (3) Finally, SEI are enacted as something that practitioners do as both a matter of personal choice and as part of everyday safety procedures and toxicology. Although these modes emerge as being potentially independent, with practitioners using ones and not others, they are not mutually exclusive and taken together they offer a complex picture of how SEI integration is (and is not) working in practice, and with what consequences for scientific policymaking and governance.

SEI as Obligations and Problems-to-be-Solved

As discussed earlier, in the U.S. the integration of SEI within nanotechnology R&D is desired by policymakers and mandated by law, even if that same law does not prescribe actual mechanisms for its practice or enforcement. Instead, as with past regulations that require grant applicants for public funding to attend to the 'wider societal benefits' of their research and,

Table 1 Overview of participants included in the analysis

Name	Role in symposium	Position
Rosalyn Berne	Speaker; nano&Us stream	Professor of Science, Technology and Society at the University of Virginia
Robert Corn	Speaker; nanoTech stream	Professor of Chemistry, University of California at Irvine
Harold Craighead	Speaker & organizer; nanoMed stream	former Director of the Cornell NanoScale Facility; co-Director of the Nano-Bio-Technology Center, Cornell University
Lawrence Goldberg	Plenary speaker; NSF officer	Senior Engineering Advisor, National Science Foundation
George Malliaras	Plenary speaker; CNF Director (at time of symposium)	Director, Cornell NanoScale Facility; Associate Professor, Department of Materials Science and Engineering
Christopher Murphy	Speaker; nanoMed stream	Professor, Comparative Opthamology, University of Wisconsin
Michael Sheetz	Speaker; nanoMed stream	Professor, Cell Biology, Columbia University
Donald Tennant	Symposium organizer; CNF Director of Operations	Director of Operations, Cornell NanoScale Facility
Christopher Umbach	Speaker; Kavli Journalist Workshop	Assistant Professor, Department of Materials Science and Engineering, Cornell University
Stanley Williams	Plenary Speaker; nanoTech stream	Director, Information & Quantum Systems Lab, Hewlett-Packard
Edward Wolf	Plenary speaker; former CNF Director	Professor Emeritus, School of Electrical and Computer Engineering, Cornell University; retired Director, Cornell NanoScale Facility

describe how they will 'disseminate results', SEI integration often translates into the obligation to include an SEI component within research projects so as to ensure compliance with funders' requests. The NNIN, the network led by the CNF, is itself an example of the enforcement of such policy, and in her tenure at the CNF, the first author was often told that the high quality of the Cornell led network's SEI component was what gave it a leading edge over its competitors. Most interviewees primarily enact SEI in this mode: as part of a set of obligations imposed on them by funders and policymakers, their importance not withstanding. George Malliaras, then Director of the CNF and Associate Professor in the Department of Materials Science and Engineering, describes this well saying, 'You have to have [an SEI component]. You have to. [Funding agencies] will not give you money [without it], even on the single PI level.' Malliaras goes on to describe how that obligation is enacted saying,

> The vast majority of grants, you *have* to think about *outreach*, you have to think about […] social and ethical issues. The larger the grant, the more you have to think about this. It's a good thing. It is a very good thing. (our emphasis)

While other participants disagreed on its good or bad character, outreach activities (often interchangeably used with educating the public) were cited by *all* participants as the primary means to attend to the obligation of integrating SEI. The rationale for this privileging is explained by Robert Corn, Professor of Chemistry at the University of California at Irvine, who states,

> *The biggest problem is that people don't know enough science*. And that's a big problem. And I want to talk to people about science so I really encourage people to take more science. So I'm an educator. I believe in that. I believe firmly that […] an informed public can make the best decisions about what's important, and these questions about what gene tools to take, what bioterrorism methods to use…Scientists can give you answers and can give you options, but *it's really up to the public to decide what's the correct course*. So right now in the debates, you name it, on stem cell research, on abortion, and all these things, quite often, it's the lack of scientific knowledge that is limiting. It is the [lack of] generic scientific knowledge of the public that is limiting our ability to do a good job. So I fully believe that as an educator, my job is to educate people about science. That is the number one issue. (Corn; our emphasis)

The vision put forward by Corn resonates with larger discourses regarding the role of science and its interactions with society [8]. Corn constitutes scientists as

educators and experts—they are the knowledgeable elite who can provide authoritative and objective assessments about a science that is assumed to be neutral and certain. The public is then deemed uninformed and uneducated, or 'emotional' in the words of another participant, thus limiting the development of science. The problem-to-be-solved then is that of the public and its lack of 'generic scientific knowledge'. This, as Corn goes on to say is solved through inclusion in 'all' his grants of 'a component which includes outreach and education on how to educate the public' so that this public is able to make the, presumably, right choices. By describing SEI as a problem of the public Corn is also placing it outside the realm and responsibility of proper science, a position which was common among participants. The public-as-the-problem replicates and promulgates the much-criticized [8, 21, 27, 64] model of 'public understandings of science' whereby resistance to technoscientific endeavours and authority are understood as failures of the public to understand science. Importantly, it also coincides closely with larger discourses regarding the relationship between science and society, which are materialized within the National Nanotechnology Initiative's (NNI) understanding of the goal for SEI. For instance, in 2005, the year in which the figure of the public made a forceful entrance into the 'Societal Dimensions' component of the NNI, it was accompanied by an emphasis on activities related to 'public understandings of nano,' 'cultivating public trust,' and 'public interaction and outreach' ([40]: 28). In this same report one of the main goals of the 'societal dimensions' program is to foster 'research directed at identifying and *quantifying* the broad *implications* of nanotechnology for society, including social, economic, workforce, educational, ethical, and legal implications' ([40]: 28; our emphasis), a causal and mechanistic definition that is still being used by the NNI today (see [41]). Recently, Guston has estimated that only 0.5 % of the funding for 'societal dimensions' research is spent on actual research, with education taking up at least two thirds of the money [18]. Education and outreach are certainly important activities, but they are too often based on models of knowledge transfer (from expert to layperson) as depicted in the narratives of participants, rather than as dialogues or exchanges. Thus, SEI integration is enacted here as a 'reinvention' of the public understanding of science model which it was supposed to replace.

The problem of being required to reach out and educate the misinformed public is also reflected in practitioners' concerns with 'hype' in nanotechnology discourses. Hype is first and foremost understood as a product of science fiction and the media, both of which are seen as being able to elicit responses from the public that are detrimental to the practice of science. As Malliaras succinctly puts it, 'things that scare the public are bad. Another Crichton novel—that will keep me up at night because we will have to go out and educate the public to know this is nonsense.' The problem of hype is then intimately connected with the problem of how to communicate with a susceptible public. Harold Craighead, former Director of the CNF and co-Director of the Nano-Bio-Technology Center at Cornell University speaks of the need to address the public in ways that 'are not National Enquirer-like,' saying,

> I think there's a danger of oversimplifying and over-hyping opportunities. In dealing with the press, there's always the question of, 'Well, what impact is this going to have?' and 'How is this going to change the lives of individuals?' So people come up with an answer which is, 'OK, this is going to cure cancer.' What they mean is, 'If everything works right and things go great, 20 years from now everything might improve'. But it gets shortened to 'This will cure cancer.' There's a little danger in that because then if you say, 'This is instantly going to cure cancer,' then maybe it's instantly going to inadvertently cause cancer. (Craighead)

Two particular demands are identified here by Craighead—scientists are increasingly asked by funders and policymakers to justify the broader usefulness and impacts of their research, and they are also increasingly exposed to the media. Faced with these obligations, he argues, many scientists give abbreviated accounts of their research that end up overhyping its promise, resulting in situations where what the scientists say is not what they mean. For Craighead, the solution relies on providing scientists with better communication skills (through education), or alternatively on outsourcing this job to social scientists who are, he argues, more suited to the task of relating to the public. This echoes the experience of Rosalyn Berne, Professor of Science, Technology and Society at the University of Virginia, who said that in the course of her own research with nano scientists they relayed feeling 'pressured' to deal with SEI. Berne argued she was often called upon by former interviewees

who wanted to see if 'they could write [her] in their grant' thus making the SEI component a 'sort of add-on as opposed to part of the fundamental work.'

Craighead goes on to point to the inconsistencies between the mythology of nano and the lived experiences in the lab, reflecting an uneasiness that is expressed by other participants as they grapple with having to simultaneously manage hype in the public realm, work in a field that lives off these promises, and examine their own material engagements with it. This sentiment is echoed by Christopher Umbach, Assistant Professor in the department of Materials Science and Engineering at Cornell University, who remarks that hype is part of the 'culture of nanotechnology.' Arguing that 'nano has a life of its own' and is 'in the popular mind,' he goes on to say that 'it's a world that nanotechnologists have created, and *they're* going to have to deal with that and figure out how that affects them,' a proposition that could be 'bad, or could be good.' (our emphasis)

Hype then emerges as a hybrid entity—part social, part science; inside of science but outside 'good' science—and although participants recognize this mixed character, the most common strategy for dealing with the uneasiness it creates is one of 'boundary-making' [14, 15] or 'othering': in the narratives of many participants, it is 'they' or 'people' who will have to find out how hype affects them. This boundary making strategy serves as a means to exempt themselves (or their laboratory practices, to be more precise) from being part of SEI. It is important to note that such views were held even when the vast majority of participants were upfront in recognizing tweaking their research in order to be eligible to benefit from nanotechnology funding.

Enacting SEI by 'Not Doing It'

The previous section considered the main mode in which SEI integration is defined by practitioners: as an obligation related to the funding requirements. Within this enactment mode doing SEI means, primarily, engaging in activities of outreach and education so as to solve the problem of the public thus replicating the much-criticized 'public understanding of science' model. It also entails learning how to communicate with the public, while at the same time recognizing the very 'hyped up' character of the field and culture of nanotechnology. Yet despite these ways of doing SEI, participants simultaneously state that SEI integration is something they do not do in the course of their work. This paradox, as we have hinted at before, relies heavily on a divide between what counts as a scientific (i.e., laboratory) practice and as an 'extra-curricular' scientific activity. It is this boundary and tension that we explore here: what does it mean to both do and not do SEI? Why and in what ways are SEI not done in scientific practice?

During the course of the interviews, and usually following a more general discussion on nano-SEI, participants were specifically asked about how they integrate social and ethical issues within their research. For the most part, the answer was, 'I don't.' Understanding such lack as a fault, participants often engaged in explanations about why that was so. As Craighead succinctly puts it, 'Well, it's not something we do explicitly in a lab because in a lab we're trying to understand the science.' Umbach further expands on this difference saying,

> It's not so much in my research [that I do SEI] as it would be in teaching. I think in teaching you try to help students understand the context of technology and science and how what they're doing might have a social effect, how what they're interested in might be supported by society, might not be supported by society. These are, I think, things that are… certainly as a teacher, you are responsible to your students to help them at least get some sense that what they're doing is not occurring in a void, it's not unrelated to the rest of the world. (Umbach)

Here Umbach discusses the relationship between science and its social effects, and speaks of scientists' responsibility to introduce students to the notion that science operates in the world, rather than the void. Society and the social are presented as powerful actors, yet they also remain largely reactive, immersed in causal relationships with science. Importantly, this is a responsibility that falls under the realm of teaching and not of research, giving rise to a scientific practice that is socially situated but not social.

Defining SEI as belonging outside of research and the laboratory enables another recurrent mode of not doing SEI, whereby participants work to devalue their expertise and self-describe as not knowing more than the 'ordinary citizen,' while simultaneously conjuring 'society' as the place where SEI discussions and decisions should be had. The following exchange with

Michael Sheetz, Professor of Cell Biology at Columbia University, illustrates this,

> *Sheetz*: […] I think the concern I have is that a few people […] talking about these ethical issues [in a symposium] and so forth does not make a change in society unless they get their word out or raise societal questions. In other words, I as a practitioner am no more, let's say, vital to that question than is the man-on-the-street. So the ethical issues really have to be addressed by the man-on-the-street. And […] to the extent that getting the word together is useful, these meetings [such as the CNF 30th] are useful, but it ultimately has to be taken beyond that, and asking me about it is no different than asking someone off the street or one of the undergraduates at Cornell what he thinks about that.
> *Viseu*: I understand your opinion that this should be part of a larger debate rather than a mere academic one, but I'm wondering if, because you are a practitioner and because you have your hands on this transformation, if your responsibility isn't higher … than the man on the street. Also your knowledge is arguably more… you have more knowledge about the possible implications and…
> *Sheetz*: Yeah, I mean I don't see a real big problem here in the same sort of way of cloning and so forth, basically.

In this exchange Sheetz performs a series of strategic reality-building displacements. He begins by describing an issue that remains a problem for scholars in general, and in particular for those who study and do science policy, that of how to link the gap between the discussions that take place in academia and the world beyond it [34, 61]. He then reformulates this problem as one of how to reach and educate the 'man-on-the-street,' and it is in this regard that he performs an agency erasure that allows him to become no more a stakeholder than a Cornell undergraduate, and therefore no more accountable than the general public. This stands in strong contrast to the previous mode where scientists depict themselves as sources of expert knowledge who must inform the public through outreach and education activities. When questioned on his role as a practitioner, Sheetz then provides a kind of 'if nano was *x*' answer that is echoed by other scientists: if nano dealt with cloning, (or stem cell research, or nuclear proliferation, or genetics, some of the examples provided by other participants) then he, as a scientist, would be more accountable and responsible. This argument is generally justified by a belief that the field of nano poses no new social or ethical questions (a position that was reiterated by the President's Council on Bioethics [44]), even if participants simultaneously express a feeling of excitement at the novel possibilities posed by doing research at the nanoscale.

The paradoxical crafting of the scientist as authoritative and ordinary and the public as ignorant and empowered (and likewise of SEI as part of scientific practice but outside of the lab) is worth examining further, not only because it was expressed by numerous participants, but also because even when prompted by the interviewer none of the participants discussed mechanisms used by them to incorporate the public's 'social expertise' within their research agendas. In our interviews we identified several complementary rationales for such enactment—having to do with defensive reactions to SEI, with its antagonistic placement vis-à-vis science, with specific understandings of scientists' skills, and with the underlying difference between thinking and doing. The following exchange with Donald Tennant, the CNF's Director of Operations, illustrates these matters,

> So it's not that people can't *think* about [SEI], it's that you'd be taking an amateur SEI person and entering into a discussion with somebody who was deeply involved in the research and thought leadership in that field and it's kind of *not a fair fight*, right. Not that it's a fight, but you know what I'm saying, I just use that as an analogy. So just like you wouldn't want to take one of the SEI people and have them come in and start questioning the biology or the physics or something because they wouldn't have sufficient background to be poking there. (Tennant)

Tennant describes the actual engagement in SEI as an uneven playing field where scientists are at a disadvantage because of their lack of training. This is certainly an important issue for policymakers (and STS scholars) to consider—how much more can we ask scientists to do?—but it is also one that relies on the notion that doing SEI is different from doing science. As we saw above such boundaries are blurred in engagements with outreach and education but, we argue, remain deep-seated in the laboratory. It is also important to note Tennant's description of this

engagement as a 'fight.' Used as an analogy, the term hints of an antagonistic relationship between the practice of science and its social and ethical issues. This positioning was expressed by other subjects and is described in the literature mounting back to Snow's description of the 'two cultures' [56] and more recently to the human genome project's 'ethical, legal and societal implications' program [50, 62, 63]. Finally, within this landscape SEI emerge as a proper theme for scientists to think about, but not for them to do, which harkens back to the quote by Malliaras with which we opened this article. This positioning is not new. It has been described by science scholars engaging with participation efforts and in lab-based experiments [55]. Van Oudheusden [60], for instance, describes it as a rationale that remains anchored in traditional causal models of innovation and technology assessment. Driving a further wedge between the knowing subject and the acting subject, these claims of non-expertise help constitute SEI as outside the competencies of scientists thus working to further relieve them from responsibility and/or reduce accountability.

Enacting SEI as Part of Scientific Practice

Having enacted SEI as things that they do not do in their own research, participants often go on to discuss how SEI are done. If the agency of the individual practitioner is made invisible when exploring how SEI are not done in the laboratory, here the scientist emerges as a moral agent, and SEI are defined as a matter for which the scientist is personally responsible during the course of his[3] work.

In describing how he enacts SEI within his work, Umbach, a Cornell materials scientist who works on characterizing and processing the surfaces of materials, describes the process of crafting his research so as to avoid unpalatable ethical issues, and encompass issues that have broad (societal) value. He says,

> The thing about my own research I guess, you might say that maybe I avoid certain areas that I think would be unpalatable ethically. That might be one thing. I think that I am interested… if there is some way of making my research valuable in a broader way, I would like to pursue that. (Umbach)

Umbach proceeds to explain that making his research useful is not an easy venture because he focuses on fundamentals, and its applications are not always directly obvious. It is there, at the level of applications that he, and most other interviewees, imagine potential problems arising, in a reification of the (still) prevalent notion that the social is most relevant in the downstream processes of development and implementation [27]. Other participants explicitly speak of their efforts to shape their research agendas so as to avoid particular topics. When reflecting upon his own research on nanobiotechnology and the problems that need to be solved in order to develop technologies that 'work well in contact with humans,' Craighead says,

> I think in the medical area it's quite apparent that you have to now study very thoroughly what the *safety and effectiveness* is of any of these processes, particularly, *not really things that I'm doing*, but [that are done] in the general community, [for instance when] drugs are being enhanced with nano particles, that's an area where clearly the *safety* of such a thing, […] where the full impact of that has to be determined. That is something *I explicitly have not done in my research because I think that takes a major part of your activity to thoroughly evaluate that*. So by design, I've decided not to work in those areas. (Craighead; our emphasis)

Craighead points to safety and effectiveness as time consuming SEI activities, and describes his personal choice not to pursue these matters. However, this scenario is complicated by Goldberg, a senior National Science Foundation officer who says,

> A lot depends on the interests in the individual student when he or she becomes a faculty person. […] But, there has to be a positive incentive, however, to enable an environment for change, and I think that's the responsibility of the university. They have to […] provide an environment where these issues are part of the education of the students and that the faculty are involved and aware of it and that there is some reward basis for being active as a faculty member in it. (Goldberg).

What Goldberg recognizes is that depicting SEI as a personal research choice obscures institutional obligations, requirements, and incentives. According to him, along with the personal component, there must be an institutional push that enables and rewards interdisciplinarity and

[3] We use the masculine here to reflect the predominance of males in our study and science at large.

the integration of SEI with the research process. This is obviously not a new issue; rather, it points to prevalent narratives of science that emphasize the actions of individuals rather than the sociomaterial arrangements within which they act and are implicated [3, 19, 28, 29, 58]. It is telling, for instance, that those few participants who had previous contacts with social scientists working on nano described them not as collaborations but as 'enriching' conversations.

Figuring prominently in the matter of crafting research agendas, 'safety as SEI' is also enacted as 'toxicology'. McCarthy and Kelty [35] have recently described 'environmental, health and safety' (EHS) as both a means by which nano-practitioners make 'responsibility do-able' by enabling a shift from using the tools and language of implications and risk to a practice of responsibility—towards the public, and towards nanotechnology itself—and as a missed opportunity for science and technology scholars who tend to disregard it as a category independent from SEI. Our interviews show a more ambiguous picture where some shy away from the issue (recall the quote above by Craighead), while others embrace it. For instance Christopher Murphy, Professor of Comparative Opthamology at the University of Wisconsin, speaks of 'fulfilling the obligation' of putting SEI into practice by 'discussing… the possible toxicologic downside of nanotechnology' in a 'broad ethics and science course' that is attended by all students and post-docs in science, and also by doing some of 'that work' in his laboratory.

Importantly, safety also emerges as a more mundane and daily practice and concern, that is, a matter of enforcing the safe operation of the laboratory. Malliaras, for instance, describes it as the first level[4] of a scientist's responsibility, an operational level which has to do 'with how you keep the lab safe for everybody and [not] impact[ing] the environment.' Likewise, when describing the functioning of the CNF, Tennant argues,

> I mean we spend most of our time here [at the CNF], whenever we bring anything in, carefully studying the safety implications, how are we going to do this to make people safe and still allow them to have access to a technology. So we don't just bring things in and ignore safety. We don't ignore the influence on humans. It's an *integrated* part of the way we operate, I believe. (Tennant, our emphasis)

Within this enactment mode SEI integration is a reality. Positioned both as part of the scientific process and as a social and ethical issue, safety is able to transgress boundaries and the walls of the laboratory. As Murphy says when asked about potential downsides to his research, '[b]eneficial or not… so you want to talk about toxicity?'

Conclusions: SEI as Matters of Care

Throughout the article we have explored how nano-practitioners make sense of, integrate and do SEI within their technoscientific practices. We identified three modes of SEI enactment—as obligations or problems to be solved, as something that is not done in the laboratory, and as part of scientific practice. Together these ways of doing and not doing paint a complex picture where SEI are variously defined, included and excluded, with participants showing their skill at both boundary-work [14, 15] and integration. In what follows we will use these enactments to reflect on the broader issue of the current U.S. policy of integration.

Mandating nano-SEI integration is expected to help transcend the struggles between the social and ethical issues and the technical aspects of nanotechnology R&D, thus enforcing—through their incorporation into scientific practices and agendas—a broader definition of 'nanotechnology'. This has, at least, one immediate effect: it places SEI in the landscape of nanotechnology providing it with both visibility and funds. To put it in the words of Stanley Williams, Director of the Information & Quantum Systems Lab at Hewlett-Packard, who was involved in the early strategic discussions to create the National Nanotechnology Initiative,

> I think that the first answer [to the question of whether integration is working effectively] is that we're doing nothing explicit to exclude [SEI studies]. And from that point there we're almost superior to any other group that's ever come along. But, that said, are we doing a great job? I would say no. (Williams)

The analysis conducted here shows that scientists are indeed engaging in and with SEI. In fact it could be argued that SEI has been normalized through the work

[4] The second level involved citing previous research in publications, and the third involved an ambiguous 'wear[ing] your hat as a citizen of this world'… and 'satisfy[ing] your moral side by just doing the best to promote technology you think is best,' which again relate to enactments of SEI as personal choices.

of funding agencies and policymakers, becoming part of scientists' repertoire, particularly if or when we consider outreach and education activities as synonymous with SEI. As Umbach succinctly puts it,

> The way one's research develops is the way in which the funding trends go, right, because you can't just research what you want, you have to research what people are willing to pay you to do.

This being said, depictions of SEI integration as an obligation rely on the figure of the public as the problem, as well as on the equally troubling notion of knowledge-transfer rather than dialogue, confirming Wynne's assessment that 'strikingly, [the public understanding of science model) has been continually reborn, almost in the same breath as its burial' ([66]: 499). Thus, as Williams acknowledges, including SEI is not sufficient.

Making matters more complicated, the second mode of enactment identified in this article—where SEI integration is done by not doing it in the lab—works to reify, rather than blur traditional assumptions regarding the boundaries between science and society. Here, participants perform an agency erasure, portraying themselves as members of the public thus being no more accountable than the public. The public, previously disempowered, now appears as the decision-making actor, and SEI become things that are thought of, rather than done. (We note that it is always difficult to separate thinking from doing, and that, to some degree, incorporating thoughts about SEI is already doing SEI). We do not dispute these arguments nor do we seek to resolve them. Instead we recognize, among others, that scientists do possess authority, that scientists are part of the public, and that the public can be rendered susceptible. What interests us is their strategic use, that is, the reasons why each kind of argumentation is used and the accomplishments and worlds they help bring about. In this case, we argue agency and authority erasures are used to construct a world where technical science is done in the lab, and the lab is outside of the realm of society.

Taken together these two enactment modes seem to underline Jasanoff's [24] assessment that contemporary policy of SEI integration has not done much to disturb the divide between facts and values, science and society (see also [17]). The case of hype is exemplary: while recognized as part of the culture of nanotechnology it is also 'othered' as a problem of other scientists and thereby excluded from our participants' scientific practices. Mody's [39] early assessment that current science policy does not direct the gaze inwards at science but rather outwards at society, resonates with our findings, as do previous criticisms that the law does put in place enforcement mechanisms for SEI integration [11, 18].

Yet, in the third enactment mode identified in this article we find ways in which SEI are integrated with scientific practice—as both matters of personal choice and as part of a repertoire of safety in research and as studies of toxicology. The enactment of SEI as personal (and moral) choices can be taken as a sign of increased reflexivity on the part of participants, thereby meeting one of the goals of many of the studies and experiments reviewed earlier [6, 10, 12, 16, 37, 49, 55, 57]. Equally important, when describing themselves as moral agents, participants acknowledge that ethics is part of what they do as scientists, and thus enact an expanded version of the practice of science. The issue of SEI as safety and toxicology has received attention lately and we point to the article by McCarthy and Kelty [35] for a helpful examination of how the issue of toxicology enables scientists to make their responsibility do-able.

Not unexpectedly the picture we paint here is one of mixed results. There is no one answer because the issue is itself complicated. One of the recommendations is that policymakers acknowledge this complexity, rather than attempt to simplify it. But stating this is not enough. One way to think further about this complexity is to explore how these different enactment modes (and the definitions of SEI they draw upon) mobilize and implicate nano-practitioners, or to put it differently, to examine their positionings in regards to affect. To do so we draw upon Puig de la Bellacasa's [46] work on 'matters of care. 'Matters of care,' writes Puig de la Bellacasa, pertain to a knowledge politics that is inclusive of ethico-political concerns; it is both a mode of thought and a research ethos that has practical effects: it seeks to make visible what is neglected, but it also seeks to make a difference even if only through a speculative commitment to how things could be otherwise (ibid: 96). In her article Puig de la Bellacasa advocates matters of care as a means for science scholars to engage their objects/subjects differently. But, we argue, the same principle can be applied to natural scientists in their engagements with

science and SEI. In the first two modes SEI are primarily described as matters of fact or perhaps as 'matters of concern' [30], with the public (or other scientists) remaining the object to be moved. However, the last mode involves a significant shift in the articulation of affect so that the scientist becomes a moral agent situated in the world, with the power of caring (or not caring) for others, for instance, through thinking about the broader value of their research, or through engagements in safety and toxicology. Here the object/subject to be moved is deeply integrated within scientific practices, with SEI emerging as part of a scientific practice that is inclusive of a moral/ethical dimension. In sum, defining SEI as problems-to-be-solved or obligations forces practitioners to do them which is important but not sufficient. It is not sufficient because, as practitioners show us, SEI remain outside the scope of 'proper' science and therefore of scientific practice. If integration—or the broadening of the field of nanotechnology—is to be fulfilled we must also find ways to tend to the existing (and possible) relationalities between science and society so as to implicate practitioners in the practice of their care and make SEI worthy of care.

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