8 Making and Doing: Engagement and Reflexive Learning in STS

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Introduction: Turning STS Lessons onto STS Work

A collection of faculty and graduate student scholars integrate science and technology studies (STS) with design practices to "frame" the educational experiences of undergraduate majors in engineering, computer science, business management, and communication (Nieusma et al. 2015). Seven STS scholars strive to persuade the European Science Foundation to frame policies for science in society, such as making space-time for scientists to engage in "reflexive work" (Felt et al. 2013). An STS scholar teaches a collection of nurses how to produce video ethnographies of themselves to help them "problematize" their own deficit model of safety and learn from them how they accomplish safety in practice (Mesman 2015). STS scholars "stand with" women living at the borderline of personality disorders to engage their lived experiences "diffractively" (Whynacht and Westby 2015). STS scholars mobilize an online "platform" to pose questions to federal scientists and ministers on matters of public and environmental health and safety, inspiring more than 4,000 letter writers to raise their voices (Myers et al. 2015). An STS scholar produces a "manual" for participants in controversies over science and technology, to foster more fair and open debate (Martin 2014). A collection of STS scholars prototypes a "feedback website" to reflexively rate such feedback websites as TripAdvisor, Yelp, and Amazon reviews (Ziewitz, Woolgar, and Sugden 2015). STS scholars developed interactive exhibits, hands-on activities, and research projects that helped more than eleven million people in 2015 teach themselves about the "social dimensions" of nanotechnology (Ostman, Bennett, and Wetmore 2015).

Science and technology studies has long provided intellectual and institutional space for projects that extend beyond the academic paper or book, both to make STS knowledge and expertise travel as quickly and widely as possible and to produce and express STS knowledge and expertise in novel ways. The contents, forms, and scope of such work are expanding rapidly, challenging and redrawing boundaries around the

notion and practices of STS scholarship. The main purpose of this chapter is to call your attention to these projects, whether as a prospective or an existing STS researcher or STS practitioner.[1] We hope to persuade you to consider developing, enhancing, and reflecting critically upon your own versions.

To that end, we highlight in this review those examples through which STS researchers have been turning STS lessons about the production, expression, and travels of knowledge and technologies back onto their own initiatives and experiences in their fields of study. We examine a distributed collection of projects, identifying constituent elements, highlighting key dimensions of their ecologies, and diving down into three distinct clusters. We call this distinctively performative array of scholarly practices "STS making and doing."

Building on Engagement and Reflexivity

STS work has frequently built on critiques of the linear model of knowledge creation, diffusion, and utilization. This widely held image pictures sciences and technologies as produced in a social vacuum by individual human creators who diffuse their creations into the world, where they become facts and technologies that other people use for various purposes. Developing alternative accounts, STS researchers have shown that technologies and forms of knowledge always develop in specific social settings and that myriad agents and agencies participate in their production, expression, and travel.

STS accounts have ventured into a multitude of empirical domains for studying the work required to produce knowledge (e.g., Knorr Cetina and Mulkay 1983), transform it into facts (e.g., Latour and Woolgar [1979] 1986), and make technologies function and act (e.g., Bijker, Hughes, and Pinch 1987). Following both the shaping of technoscience and the way it brings specific worlds into being also opened up sciences and technologies to empirical analyses of in-built assumptions about what those worlds should become, including who benefits from particular versions and who bears the costs (Star 1991; Traweek 1988). STS work has also found material devices to possess potentially powerful and often surprising agencies, whether by dissolving the human/nonhuman dichotomy (Latour 1988) or articulating the active, often tricky, visions of technologies and their knowledges (Haraway 1991).

Since repeated studies have shown how the creation, materialization, travel, and utilization of the facts and artifacts under examination were intertwined right from the start, it should come as no surprise that many STS researchers are trying to cultivate scholarly self-understandings that recognize the same in their own work. How can STS

scholars, including both researchers and practitioners, avoid separating the work of conceptualizing objects of study from that of diffusing research outcomes to knowledge recipients where it could have, hopefully laudable, effects and implications? Via findings about the nonlinearity of knowledge and the materiality of scholarly practices, students of science and techonology become symmetrically obliged to consider their relations with their own fields of study and action.

STS making and doing is, therefore, a mode of scholarship that involves attending not only to what the scholar makes and does but also to how the scholar and the scholarship get made and done in the process. On the one hand, this entails examining how STS scholars and scholarship actively engage the settings they study or otherwise enter, including the agents that occupy them (Hackett et al. 2008; Sismondo 2008), asking such questions as what consequences does STS scholarship have in these settings, and might STS notions help STS scholars determine whether and how their work may or may not bring value to those settings? On the other hand, it involves reflecting critically on how the work and identities of STS scholars are constructed in the process. Such reflection implies mobilizing STS notions—whether one prefers such offerings as "(social) construction" (Latour and Woolgar [1979] 1986), "translation" (Callon 1986), "boundary objects" (Star and Griesemer 1989), "socially robust knowledge" (Gibbons et al. 1994), "co-production" (Jasanoff 1996, 2004), or "undone science" (Frickel et al. 2010)—as relevant not only for the fields we study but also for understanding STS scholarly practices.

Practices of STS making and doing build upon those of engagement and reflexivity. In the examples offered at the outset, STS scholars venture into undergraduate education, science policy, nursing practice, medical diagnostics, environmental policy, science controversy, crowdsourced judgment, and informal science education. Each project engages audiences in the field, beyond the boundaries of academic STS. And arguably each project reflexively mobilizes and adjusts STS notions in its formulation.

What warrants the label "STS making and doing" is therefore simultaneous attention to the engagement of actors and practices in STS fields of work and to reflexive learning from those actors and practices. Even as you, the aspiring or established STS researcher or practitioner, offer your interlocutors something new to inflect their understandings of themselves and possible future actions, accepting the challenge to theorize in situated, localized, and material terms also challenges you to learn from the interlocutors and settings in which you work. Practices of STS making and doing thus both draw upon and extend academic critiques of the linear model by enacting two-way, or multiple-way, travels of knowledge production and expression.

Practices of STS Making and Doing

We draw on two sets of sources in this review. The first is a selection of contributions to the inaugural STS Making and Doing Program that took place during the 2015 annual conference of the Society for Social Studies of Science (4S).[2] The program included but was not limited to projects that resulted in (a) policy papers, recommendations, regulations, devices, decision-making practices, or other policy outcomes; (b) design and creation of products, graphics, spaces, and landscapes; (c) artistic creations, including those in audiovisual format or in public installations, exhibits, and performances; (d) practices for education and training; and (e) informational or material infrastructures for the construction, operation, and travel of STS as a field or discipline. The second set of sources for the analyses below consists of publications by STS researchers that reflect upon or serve as making and doing practices.

The gatherings and distinctions we outline below attend first to what we call the "elements" of STS making and doing practices that establish their directionalities, or valenced pathways of travel, recognizing that many of the consequences of STS scholarship are beyond the scholar's control.[3] We then turn to dimensions of the "ecologies," or dynamic relations in the fields of study, that they envision, encounter, and produce.[4] This dual focus on elements and ecological dimensions calls attention to how scholarly projects in STS making and doing build on practices of engagement and reflexive learning to enact their two-way or multiple-way flows of knowledge production and expression. Accordingly, this chapter repeatedly poses the following questions: What sorts of elements constitute distinguishable practices of STS making and doing? How do practices of STS making and doing envision and learn from the ecologies of knowledge-making and world-making that they join or help create?

After spelling out elements and ecological dimensions, we investigate how these may appear in, and sometimes infuse, distinguishable clusters of STS making and doing. We identify three such clusters: (1) boundary-crossing STS claims, (2) meta-activism, and (3) experiments in participation. By organizing this array of work into three clusters, we seek to be generative rather than exhaustive in content.

Elements

In order for STS claims to become relevant for others beyond the field, STS scholars must build the elements necessary for those claims to travel into new settings and gain position and status within them. Such elements pertain to what STS scholars judge to be the key analytical issues at stake, as well as to the concrete activities they undertake to address those issues within the settings.

One: Frictions and Alternate Images Like much STS research for scholarly publication, practices of STS making and doing position themselves by identifying some dominant or otherwise problematic images of science and/or technology and their analogs in medicine, engineering, and so on. The term *dominant images* refers here to ideas or meanings whose acceptance has traveled sufficiently across some population and terrain to become given, or true—for that population and across that space (Downey 2009, 60). Dominant images of science in the singular, for example, tend to highlight creative discovery that produces Truth. Dominant images of technology in the singular tend to posit autonomous developments that become external forces. STS scholars who "get involved" with science and technology encounter and try to learn from versions of dominant images that are localized and, hence, diverse.

A common first step is to identify "frictions" within the field (Kember 2003)—places where dominant images lose their smoothness and become multiple. All images make some things visible while hiding others. Much STS scholarship published for academic audiences makes visible for those readers the frictions that dominant images of science and technology hide. A key element of STS making and doing involves making frictions visible for audiences within the field.

Two: Techniques, Devices, and Infrastructures Projects of STS making and doing draw on learning to develop and situate specific, localized techniques and devices to contribute to the field. These may be such discursive forms as policy analyses, op-ed articles, (participation in) public debates, focus-group reports, and so on. They may include such materializations as modified information communication technology (ICT) systems, art installations, or market devices. Techniques, devices, and, sometimes, infrastructures for activating them tend to be tangible and carry both the pleasures of construction and demands of maintenance. To identify them as elements of STS making and doing, it is important to question their directionalities. Where are they headed—for what or for whom, and with what expected bandwidths of influence or effect? In which unexpected places do they end up?

Three: STS Expertise and Identities Who an STS scholar is sometimes figures in specifying the pathways across which making and doing practices can or cannot travel. It can matter, for example, whether one's scholarly formation included education in the sciences, engineering, medicine, and so on, in addition to STS. Also, STS scholars may adopt, resist, or even attempt to transform the expert positions they encounter in the field in order to involve themselves deeply. In what ways do STS scholars adopt, resist, or transform expert positions ascribed by actors in the field? What dimensions of

the STS scholar *qua* person and agent are relevant in how her or his scholarship relates to its fields? In what ways does subject-matter expertise inflect the positioning of the work? How do such positions shift over time, and what possibilities do different stances open up or close down?

Ecological Dimensions

STS scholars must take account of the ecologies (Star 1995) within which they situate the work of making and doing. The important notion of ecologies highlights the agencies of learning, webs of influence, and hierarchical and dynamic orderings that the scholarship and scholars both encounter and enact across the locations and settings of their work.

Four: Audiences, Partners, and Engaged Practitioners Instances of STS making and doing are performed for specific audiences and often include partners or engaged practitioners as the work aims to produce learners who benefit and necessarily accept the risks of producing victims. Which audiences or collaborators do scholars build into their techniques and devices, and who become actual audiences or implied practitioners? How do practices of making and doing learn from and handle differences encountered? The interest here includes the identities and statuses of audiences, partners, and others as active agents in the STS project at hand. How and in which directions do STS scholars expect their practices of making and doing to travel? What are the geographies of their consequences? Who learns, with what benefits and what costs?

Five: STS Sensibilities Out There STS sensibilities about the making of sciences and technologies, as well as their travels and lives, are by no means the exclusive domain of STS scholars. Encountering such sensibilities among so-called research subjects is rather common. After all, STS scholars learn, or acquire, sensibilities from closely studying the work of actors in empirical fields. Furthermore, some educational programs for engineers, health care professionals, and business managers are heavily infused with STS work. This leads to interesting empirical puzzles: how do STS sensibilities in the wild relate to STS making and doing practices?

Six: Feedback and Reframing Practices of STS making and doing deal quite differently from one another with the return flows of claims, techniques, and devices—the feedback—that their activities generate. Those who position the work as pedagogical pronouncements by informed STS scholars may be interested mostly in strategic alliances with like-minded actors. Those who explicitly search for generative

instantiations of messy knowledge production and expression may find themselves compelled to learn by exploring mutual feedback that changes both the empirical domain and STS understandings of it. How do different approaches to STS making and doing deal with feedback, controversies, and, sometimes, success? Do these become ethnographic moments for reframing the goals of scholarship, strategic moments for finding out who one's allies are or are not, or what?

Clusters of Making and Doing

Having outlined elements and ecologies, we now turn to introduce three clusters of STS making and doing by exploring scholarly publications as well as nineteen projects that were part of the STS Making and Doing Program at the 2015 4S annual meeting in Denver, Colorado. All expand knowledge production, expression, and travel in STS. We offer "cluster" as a heuristic for identifying activities that display similarities in the collections of elements they mobilize and ecological dimensions they encounter in two-way or multiple-way flows of learning. At the same time, each activity within an assigned cluster includes distinctive features, and many projects have activities that span more than one cluster. At this writing, most have websites. We invite you to explore them. After briefly introducing each cluster, we examine more closely its constituent elements and ecological dimensions.

Cluster One: Boundary-Crossing STS Claims

Concerns have long persisted about how the unique dimensions of STS facilitate novel contributions in the arenas that STS researchers study. For example, in his final presentation at the 4S annual meeting in 2002, David Edge cautioned that popular debates and discussions about science and technology tended to "make ... no reference whatsoever to the STS literature[s] ... on [those] topics ..." (Edge 2003, 162). "It is hard to start any sort of conversation," Edge pointedly continued, "when your conversation partner believes, in all sincerity, that your aim is to silence them" (ibid., 167).

One way in which the scholarship of making and doing in STS seeks involvement in shaping the worlds it enters is by building practices that aim to help STS claims travel across the boundaries of the field into those worlds. What counts as the relevant boundary around the field depends on how the specific making and doing project positions itself in relation to its empirical area of work. Boundary-crossing STS claims appear *inter alia* in blogs, op-ed articles and columns, expert testimony, and policy reports, with both individual and organizational authors frequently adopting the figure of the public intellectual (Bijker 2003; Society for Social Studies of Science 2014).

Boundary-crossing STS practices infuse pedagogies, artistic creations, and a range of experiences designed for learners beyond the field.

One: Frictions and Alternate Images Making and doing scholarship in this cluster tends to portray the areas of technoscience it encounters as instrumental and in need of reflective awareness and reflexive practices. Social dimensions and implications of these technical fields appear to their practitioners as marginalized, subordinated, or otherwise backgrounded in relation to narrowly defined, yet privileged, knowledge or technical contents.

Boundary-crossing STS claims and practices tend to highlight the benefits of apprehending deep interrelations among science, technology, and society, typically evidenced in a specific case or cases at hand. Such can mean making science and technology "subject to political debate" or "[expanding] the information needed to make sound policy," including "intertwined expert knowledge about the biological, material and social worlds" (Jasanoff 2011, 622). It can also mean developing boundary-crossing pedagogies. An STS department runs an interdisciplinary set of degree programs in design, innovation, and society that "bring ... STS to the worlds of engineering, computer science, business management, and communications—all via design" (Nieusma et al. 2015). Developers of these degree programs found the technical fields to perform narrow conceptions of problem solving and design that are out of step with the complex, collaborative design problems graduates will encounter on the job, producing an interesting friction within engineering practice to which STS sensibilities could speak. In this case, an extensive set of design practices spans a four-year curriculum. The goal is to "*frame* our students' entire educational experience … within a more expansive vision of technology-in-society" than what those students routinely encounter (Nieusma et al. 2015). Included in the alternate vision it enacts are skill sets to prepare graduates for leadership positions in worlds with multiple "design cultures" (Department of Science and Technology Studies, Rensselaer Polytechnic Institute 2015).

Two: Techniques, Devices, and Infrastructures Some discursive techniques and devices that STS scholars have used to transport STS questions and insights to learners beyond the field include writing opinion pieces in journalistic publications (Shapin 2006), public lectures for diverse audiences (e.g., Harvard's Science and Democracy Lecture Series 2015), broadcasting provocative short takes on issues of public concern (STS blogs), sharing maps of STS practices and practitioners for public consumption (Pfaffenberger and Hunsinger 2015) (http://www.stswiki.org), organizing public debates to democratize technology development (Sclove 1995), and training STS scholars

to "participate more effectively in decision processes and public affairs" (Jasanoff, Wellerstein, and Rabinowich 2015).

The Critical Futures Lab (http://criticalfutureslab.org/) uses a game to enter the worlds of labor activists and entice them to collaborate with scholars, designers, and technologies to imagine the future of work. The classic scholarly insight that "it could be different" (Boas 1940; Hughes 1970; Lévi-Strauss 1966) is materialized in the infrastructural move of a limited, one-day participatory design workshop. The game challenges participating activists to "explore historical and present technologies, socio-economic conditions and labor realities in order to open up discussions around the way in which technologies shaped and were shaped by social, economic, political and cultural contexts" (Forlano and Halpern 2015). After opening up these discussions, the game helps participants create "counterfactual histories that might allow for alternate relationships, outcomes and possibilities that might benefit workers" (ibid.). They come to play, imagine, and, it is hoped, learn ways of repositioning themselves (ibid.).

Three: STS Expertise and Identities In accepting the challenges of transporting STS insights to the publics of technoscience, STS scholars must develop and display unique expertise in producing the claims and practices they offer. Expertise on blurring the social and the technical claims relevance, sophistication, and, sometimes, superiority by providing intellectually distinct, revealing, and socially significant angles on topics at hand.

Cleverly accepting the widespread claim that the "innovation process" stands "at the heart of reimagining Europe," seven STS scholars explicitly activate lessons from STS scholarship in a Science Policy Briefing designed to persuade the European Science Foundation (ESF) that both science and society are fluid entities whose innovations are in "continuous co-evolution" (Felt et al. 2013, 3). Their thirty-page report forcefully asserts that the "often narrow evaluation criteria used in research, innovation and education policy" are sorely at odds with the "broader value systems employed by [diverse] societal actors to assess science as a public good." The strategy is to nominate a "science *in* society" model to replace the reactionary, yet dominant, "science *and* society" model in formal ESF policy making. Such authorizes what they call a "logic of care" in what should be seen as the "governance" of science in society. It grounds ambitious initiatives to grant scientists "more time and space for reflexive work within research" (Felt et al. 2013, 3–4).

In such instances, while claiming to be of central importance to debates and deliberations over science and technology, the arrival of STS expertise in boundary-crossing moves may be seen by others as coming out of left field. While challenging the notions

embodied in established practices of technoscience, the risks can be high that such expertise will be misunderstood, will be judged to be threatening, or will not resonate sufficiently with the concerns of actors involved. Those risks are clearly high, so the necessary STS expertise must be enacted strongly.

Four: Audiences, Partners, and Engaged Practitioners The STS work in producing, expressing, and transporting boundary-crossing claims typically aims to expand audiences and multiply pathways for reaching them. The expectation is that the learning that results will help expand distributions of benefits and reduce distributions of costs. Bijker's (2003) call for public-intellectual work, for example, seeks not only to reach "politicians, engineers, scientists, and the general public" with the STS insight that "science and technology are value laden." It also aspires to elevate the public profile of technoscience by making clear that "all aspects of modern culture are infused with science and technology, that science and technology do play key roles in keeping society together, and that they are equally central in all events that threaten its stability" (ibid., 444). Accordingly, the transport of STS findings and claims in this cluster typically construes audiences as external to the field and the pathways for reaching them as multiple and overlapping. The cluster tends to define success as transforming external audiences into apprentices for STS learning and STS-grounded action.

Seeking "public learning" of "STS ideas," for example, the Nano and Society project reaches millions of people across the United States each year (Ostman, Bennett, and Wetmore 2015). Through science museums, exhibits for rent or purchase, free videos, print media, public forums, theater and stage presentations, and programming for more than a week of NanoDays, the seven regional hubs of Nano and Society create mazes of pathways for transporting STS-informed questions and accounts to non-STS audiences (NISE Network 2015). Built around the core question in one exhibit, "Nanotechnology: What's the big deal?," this self-styled initiative in "informal science education" connects research to museums to wrestle with the "complexity and abstract nature of nano, the ubiquity of its applications in society, and the relative lack of knowledge about the ethics and the impacts on health, environment and society of these applications" (Lundh, Stanford, and Shear 2014, 5). Expanding attention to the social dimensions of nano beyond the narrow early conception of "ethical, legal, and social implications," Nano and Society endeavors to build a public geography for this technological emergence that is informed about its social and ethical dimensions and hungry for further insights.

Five: STS Sensibilities Out There Audiences of STS claims may have strong appreciation for frictions that their particular positions produce, for example, for the politics of knowledge or for self-limiting practices of technical fields. Such does not, however, equal or necessarily lead to developing and displaying an STS understanding of those frictions. Within this cluster, boundary-crossing STS claims are ascribed something of a privileged status in terms of conceptualizations, understandings, and contributions, tending to portray others as more the recipients than the bearers of STS insights. To the extent practitioners in the fields of study become agents of STS sensibilities or analysis, they typically enact it implicitly. Anything more explicit becomes a successful travel of STS insights.

Crafting Digital Selves is one such project. It asks if preservice science teachers can become agents of STS sensibilities and scholarship. Through the infrastructure of a required course for preservice science teachers (an accomplishment in itself), STS scholars help the teachers acquire "sustainability literacy" so they can, in turn, become agents of its pedagogy (Warren et al. 2015). The prior knowledge that teachers tend to bring to the course predisposes them to expect, for example, that solutions to the problem of sustainable water supply depend primarily, if not solely, upon large technical infrastructures. But then they encounter a ten-minute "digital story" that highlights how infrastructural solutions in the past have helped to produce the problems of the present. Technical infrastructures gain social dimensions and futures become multiple, subject to the choices of the present. Instructors seeking to achieve a "more inclusive form of STS" produce such stories and then use them in homework assignments as well as in both face-to-face and asynchronous online discussions (Warren et al. 2015). To persuade teachers to help produce "globally-minded and knowledgeable citizens who are able to analyze sustainability challenges and work toward solutions," the STS-informed instructors must find acceptable ways to interpolate sustainability literacy into the identities and directionalities—the selves—that the preservice learners are already building as prospective science teachers (Biodesign Institute 2015).

Six: Feedback and Reframing Given the status of an STS insight as frequently drawing on experiences of a given setting, the expectation of feedback, pushback, and other responses can certainly affect or reframe the STS scholar's understanding of that setting. At the same time, however, given that the boundary-crossing claims also draw on insights from what is now an established academic field, they may be resistant to substantial reformulation once offered or implemented. STS learning and reframing may hone in on better ways to transport risky messages to their audiences. Moments of

learning can also congregate around reformulating alternate images, to increase their chances of traveling sufficiently to become new realities.

The Energy Walk produces learning about one's experiences of renewable wave energy in the sea. Wave, wind, geothermal, solar, and other renewable energy technologies can feel like alien objects. Energy is supposed to come powerfully, but invisibly, through wires or pipelines in the ground, from distant sources. Renewable energy objects can be big, in one's face, and, hence difficult to understand or accept (Winthereik et al. 2015). The Energy Walk puts in people's hands a digital walking stick with an audio player activated by radio frequency ID tags, similar to those used to tag pets. It invites the walker to experience the landscapes of a wave energy center and its environs. In an energy center, where the invisibility of power generation and distribution is given, the experience produced by the walk could well generate resistance, pushback, or rejection. But The Energy Walk happens at the "energy edge," especially island settings whose residents cannot assume the existence of reliable, invisible energy supply (Watts and Winthereik 2015). Perhaps places where "people see the end" are particularly fertile sites for boundary-crossing learnings to generate alternate images and experiences (Ford 2015). The walking stick is designed to help researchers learn how "green energy creates and reconfigures relations between humans, technologies, and nature at particular project sites" (Winthereik et al. 2015).

In summary, this cluster of making and doing activities specializes in rendering visible STS insights to new audiences, providing them with fresh, more sensitive perspectives on or experience of the connections among science, technology, and society. As a consequence, elements of making and doing in this cluster tend to be strongly developed, whereas the ecological dimensions may prove to be less formative or consequential. To the extent these activities remain occasional for STS scholars and position their audiences mainly as recipients of STS knowledge, this cluster of STS scholarship and its practitioners may not become integral parts of the ecologies in which the audiences operate. Indeed, the ecology may become first and foremost an object of study. When the boundary-crossing project is successful, it may afford new opportunities for strategic alliances with those who are receptive to STS insights. To the extent activities of boundary crossing expand or become persistent, features more characteristic of the second or third cluster could emerge and come to predominate.

Cluster Two: Meta-Activism

We call the second, related, cluster of practices through which STS gets involved in making and doing the worlds it inhabits "meta-activism."[5] With this term, we refer to the activities deployed by STS scholars to assist or support actors who may already be

resisting, challenging, or seeking alternatives to dominant images in their fields. While such scholarly practices draw upon insights from STS research to enhance repertoires of resistance, challenge, or the formulation of alternates, they are "meta" in the sense that they still largely delegate the contents and work of advocacy itself to actors in the field.

One: Frictions and Alternate Images Meta-activist projects of making and doing tend to highlight the political contents and power dimensions of the frictions that dominant images of science and technology produce and perform. They frequently make the case that subordinated or marginalized positions and silenced voices deserve both visibility and strength. They find actors who are part of or represent the subaltern or the silenced and contribute to their initiatives by formulating, expressing, and transporting alternate images aimed at facilitating empowerment.

The Scientific Legislation project (Comisso, Maciel, and Roberts 2015b), for example, aims to "empower several disciplinary undergrad students with law creation techniques, knowledge about science & technology in contemporary controversies and policy analysis in the frontier of STS to elaborate innovative and transdisciplinary proposals in scientific law for Chile." Through a curriculum for undergrad students, including law-development workshops with participatory methods, and a session presenting the results to senators and members of congress, the aim is to "construct legal projects that are consistent and pertinent for Chilean legislation concerning matters of science and technology, in a collective manner, using suitable learning elements for the appropriate legal, scientific/technological, and social interpretation of the phenomenon" (Comisso, Maciel, and Roberts 2015a, 2).[6] In this manner, students of specific technoscientific issues mobilize frictions to provide alternate images of innovative "civilian-academic" and citizen-led laws, without providing subject-matter expertise on the specific phenomena for which those laws are made (Comisso, Maciel, and Roberts 2015b).

Drawing attention to power relations can help contest the subordination of selves as well as that of positions or groups. The Department of Play project creates temporary play zones through which the initiators "explore the potential of play" to tease out experiences of public, urban spaces that "neat, authoritative urban visions" tend to hide (Balug and Vidart-Delgado, 2015; Vidart-Delgado and Balug 2015a). Play supports resistance to frictions as it invites participants to "envision alternate futures, share life experiences and different kinds of knowledge, collaboratively create artifacts, and negotiate different ways of relating to each other beyond established norms" (Vidart-Delgado and Balug 2015a). Without offering or imposing alternate images themselves, the initiators explore how diversely designed playdates can contribute to "forging a

common vocabulary among diverse actors" and potentially "facilitate ... the pursuit of pluralistic visioning" (Vidart-Delgado and Balug 2015b).

Two: Techniques, Devices, and Infrastructures Meta-activism mobilizes diverse arrays of techniques, devices, and infrastructures. A common technique is to provide strategy advice to activists, informed by academic STS scholarship. An exceptional example, Martin's *The Controversy Manual* (2014, back cover) informs its readers that it does "not tak[e] sides on individual controversies." Rather, as a meta-activist device, it "offer[s] practical advice for campaigners ... provid[ing] information for understanding controversies, arguing against opponents, getting your message out, and defending against attack." Made available by Irene Publishing, it contributes to an infrastructure designed to help effect "peace through peaceful means." The Civic Laboratory: Plastics project (Liboiron 2015), by contrast, addresses a specific issue. Microplastics "are ingested by marine life, their associated chemicals bioaccumulate in animals and biomagnify up the food chain," making them "an environmental justice issue." Civic Laboratory tools seek to make the problem "visible and actionable" through citizen science projects that create feminist technologies to monitor" even microscopic plastics. The project makes available "open source, affordable, hackable, do-it-with-others (DIWO) devices" such as the Plastic Eating Device for Rocky Ocean Coasts (P.E.D.R.O.C.). With fairly detailed building instructions, this wooden/metal device, anchored on rocky coastlines, can collect plastic over time. With two sieves and a flag, it mobilizes a heterogeneous infrastructure that includes both rocky coastlines and passers-by.

Three: STS Expertise and Identities Similar to the first cluster, meta-activist projects tend to position the STS researcher as expert, in this case on political patterns within technoscience. The relevant expertise can consist of both analytical understandings of technopolitics and power relations and strategic sensibilities about how to act in the midst of technopolitical complexities. Whether by enacting advice to the subaltern, building new organizations, or producing devices to expand participation, meta-activist making and doing tends to proactively position STS expertise as strategy that others can bring to bear to transform the experience of frictions into more overt action. In this sense there is a division of labor, in which STS scholars serve as experts on certain sensibilities so others can rethink and revise technopolitical positions and strategies.

As the STS+ With Practitioners initiative puts it (de la Torre et al. 2015), participants aim to help medical students in post-Fukushima Japan and both K–12 and engineering students in the United States animate environmental thinking within formal pedagogies that all-too-often exclude them. Rather than straightforwardly teaching STS

findings, the project "cultivate[s] the 'thought styles' of STS" in students being trained otherwise. Its practices involve building "scaffolding," or "light structure," to facilitate reading, listening, and observing "with STS sensibilities," to enhance students' capacities to analyze, evaluate, and creatively intervene in key exclusions.

Four: Audiences, Partners, and Engaged Practitioners Audiences of meta-activism consist, in the first instance, of those bearing the costs of dominant images of science and technology. Such audiences can therefore be quite large and heterogeneously populated, and the pathways for reaching them quite diverse. In addition to work that seeks to empower marginalized positions and perspectives, as both the *Controversy Manual* and the Scientific Legislation project expect, some meta-activist making and doing focuses its attention on the means through which dominant images of sciences and technologies produce subordination and silences in the first place. Favorite sites for such work are the performative operations of technoscience institutions, which can produce diverse, even surprising, arrays of potential audiences and partners for meta-activist scholarship.

The "War on Science" by the Harper administration in Canada included "cancellation of over 100 federal research programs; the closure and destruction of libraries and archives; the firing of thousands of federal scientists; and … government policies that constrain federal scientists' freedom to speak to the public." The Write2Know project challenges both explicit and implicit silencing of evidence-based decision making via large-scale letter campaigns (Myers et al. 2015). Demanding that undone science be both done and revealed, Write2Know offers a "platform" that those who have stakes in such science can use to "pose questions to federal scientists and ministers on matters of public and environmental health and safety." Addressing research on topics including "endocrine disruption, uranium mining, and lead toxicity" (Myers and Liboiron 2015), it provides STS-informed templates that highlight "gaps between research and government policy" and make visible issues of social and environmental justice, including the "impacts of resource extraction, oil sands pollution, [and] marine plastics." The project also "foreground[s] colonial contexts in Canada, which render aboriginal communities especially vulnerable" (Myers et al. 2015). In addition to facilitating the generation of more than 4,000 individually signed letters on eleven topics, Write2Know also offers the option to ask a new question via a stepped approach, a sample email, and an overview of federal ministers and their critics in the political opposition. While not necessarily problematizing the politics of evidence, the project directly problematizes the power relations in its production. Its audiences and partners therefore evolve with the performative operations of the institutions that command its attention.

Five: STS Sensibilities Out There Rather than starting from more definitive STS notions about a certain topic, meta-activist projects typically begin with problem statements advanced by marginalized actors in the field. The STS work then involves reconceptualizing those problem statements in STS terms to open up new repertoires of action. STS sensibilities about the creation, materialization, travel, and utilization of facts and artifacts may be largely latent until activated by meta-activist scholarship, and need not even be identified as such, or at least not prominently. The key point is that marginalized actors in the field are likely experiencing problems to which STS sensibilities can speak or relate.

Although many meta-activist projects of making and doing position others to be, or become, bearers or agents of STS knowledge and expertise, some projects do not. In the *Controversy Manual*, STS scholarship on controversies appears in an appendix, while the Write2Know project links to an STS scholarly endeavor in the "Who we are" section of the project website. Yet other initiatives, such as the STS+ With Practitioners project, expect practitioners precisely to become well versed in those sensibilities as STS sensibilities.

Six: Feedback and Reframing Feedback within meta-activism is likely to appear as overt troubles. Instances of pushback could prove to be confirming signs of the political conservatism and power hierarchies performed and effected by dominant technoscientific practices. As support for activists seeking to expand frictions into opportunities to reframe or replace the performers of dominant images, meta-activism can prompt rebuttal, reassertion, retribution, and reprisal.

Such feedback does promote learning. For meta-activist scholars advising participants in controversies, pushback could increase the sophistication of *The Controversy Manual* and other similarly positioned techniques and devices. For policy-oriented meta-activism, feedback and critique could lead to better understandings of how to advise effectively. The possibility of obstruction or impediments also raises the question of which dominant images of sciences and technologies, or which aspects of locally dominant images, meta-activist projects leave intact while contesting another image or aspect of an image, and why. For example, in fighting a technopolitics designed to create ignorance, the Politics of Evidence Working Group in the Write2Know project aims at supporting a "right to know about the health and wellbeing of our bodies, communities, and environments" (2015). This is a laudable aim and courageous attempt to address undone science that affects the lives of many. And such a focus on undone science probably stands the best chance if it brackets—in some settings and for some audiences—how the politics of evidence is at other times understood in STS, namely,

as the politics *of* evidence rather than of its *absence* (see Ottinger, Barandarián, and Kimura, chapter 35 this volume).

Collaborative learning within meta-activist scholarship may thus involve finding out what sorts of outcomes are achievable or potentially workable and selecting among diverse potential pathways, with distinct gains and losses. No project contests all images. Indeed, reflexively learning from initiatives to identify and promote undone science may challenge STS scholars to interrogate and postpone, or even undo, some of their own knowledges in order to facilitate specific meta-activist projects.

In summary, the second cluster of STS making and doing projects specializes in finding strategic routes into dominant settings and practices. When successful, scholars articulate STS insights for audiences that have experiential sensibilities of the politics and power implications of dominant images and practices but may be locked into the frames and hierarchies those images and practices enact. Meta-activist scholarship travels through interactions with those implicated in scientific and technical controversies, as well as by engaging professionals or those who may not even realize that their experiences are relevant and subordinated. It can also travel through new publication formats, such as the strategy guide or foundation report, as well as through procedural innovations in legislative practices and even the creation of temporary play zones. Collaborative learning develops further understanding about both the technopolitics and the power relations in the setting and the feasibility of additional meta-activist initiatives.

Cluster Three: Experiments in Participation

Drawing on our linked interests in "sociological experiments" (Zuiderent-Jerak 2015b) and "critical participation" (Downey 2009), we call this cluster of projects "experiments in participation" (see Lezaun, Marres, and Tironi, chapter 7 this volume). Projects in this cluster formulate, enact, and reflexively learn from novel, STS-inspired practices within their fields of study. Both posing and performing alternates to dominant images of sciences and technologies, participatory experiments actively blur boundaries between the project and the field. Some projects seek to open up new possibilities for action and interpretation by emphasizing and mobilizing the "improvised, surprising, generative side[s]" of existing settings (Zuiderent-Jerak 2015, 20). Some seek to facilitate the travels of STS scholarship within the field by materializing new pathways and settings for its formulation and expression (Downey 2009, 63–66). All generate guideposts, or "fingerposts" (Hacking 1983, 249), to point subsequent learning in both or multiple directions.

One: Frictions and Alternate Images Experiments in participation involve STS scholars deeply with both the existing frictions they identify and the new frictions they produce. Approaching technoscience through an understanding of the "'increasable complication' of practice" (Strathern 1991, xiv), participatory experiments actively mobilize the localized complexities in technoscientific practices that dominant images and practices hide or ignore. Whereas scholarship in the first cluster mainly envisioned boundaries between empirical fields and STS scholarship, work within this cluster rather emphasizes internal inconsistencies *within* empirical fields. Also, large-scale issues involving the status, power, and authority of technoscience become localized and complicated in specific moments of formulation, enactment, and learning.

The Now(here) project explores "an inverse approach to science education, where [participants] are invited to learn about BPD [Borderline Personality Disorder] diffractively and with attention to the implications in the lives of affected women" (Whynacht and Westby 2015). The project consists of "a participatory, digital installation created with a group of women living with the diagnosis of [BPD]" (ibid.). It explores "materialist feminisms and controversy mapping approaches to science engagement [that] allow for new techniques with which to address 'marks on bodies' (Barad 2007) in ethical ways" (ibid.). Rather than simply resisting, critiquing, or rejecting biomedical and legal experts, experimental involvement involves both "education and engagement with [such] experts" (ibid.).

Two: Techniques, Devices, and Infrastructures The techniques, devices, and infrastructures in participatory experiments typically seek to inflect the settings under study in specific directions, drawing upon prior learning. Their specific contents are crucial to their effects, both expected and unexpected. The array already in use in STS projects is dizzying.

In an experimental collaboration between an STS scholar and care professionals in a high-risk medical ward, the care professionals video themselves engaged in clinical practices that they judge to be significant to patient safety. The outcome is "exnovation" in patient care—challenging a locally dominant image of safety by building new practices upon "overlooked or forgotten" competencies, while also informing STS understandings of patient safety in the process (Mesman 2015). Values in Design, another initiative, mobilizes a wealth of techniques, from design workshops to card games, to challenge the reactionary view of critical theory as tackling technologies once they are in place. Its sociotechnical design experiments both reflexively "build values into design" and seek to learn from the valuations that such design processes produce

(Knobel and Bowker 2011, 2). Further examples include developing new organizational formats in the management of patient trajectories as techniques and devices for learning about standardization in health care (Zuiderent-Jerak 2007). Also, the Engineering as Problem Definition and Solution (PDS) project advances friction-based pedagogical techniques, such as multiple images of engineers and role-playing exercises, as part of an experiment to displace a dominant image of engineering problem solving by juxtaposing alongside it an image of collaborative problem definition (Downey 2008, 2015; Han and Downey 2014).

Three: STS Expertise and Identities A challenge for scholars contributing to this cluster involves accepting both the constraints and opportunities of joining the field under study. With scholars informed by STS sensibilities, introducing techniques and devices into the fields of study becomes a way to learn more, and more collaboratively, about the field, while also inflecting it. Enacting STS expertise may consist of explicit efforts to "keep open" (Jerak-Zuiderent 2015) acquired understandings of practice and "hold the tension" (Star 1991) that such opening affords. Developing attachments within the field also becomes part of the experiment, for, in addition to producing commitments and responsibilities, they may also produce moments of surprise (Jensen 2007). Also, acquiring subject matter expertise can be essential to "becom[ing] interesting enough for practices [in the field] to care about" (Jensen and Lauritsen 2005, 72).

"Interventions," the Experimental Methods project reminds us, "can function as sites where divergent investigative approaches can become visible, actionable, manipulable, and theoretically viable to each other" (Klein and Gluzman 2015). The Experimental Methods project searches for ways of "including" scientists. "While scientists and their daily practices are the objects of our research," its advocates acknowledge, they also ask, "[H]ow might we do the difficult work of including them as interlocutors?" (ibid.). Offering an alternative to the notion of the STS expert, the project deploys "empirical structures (experiments) that involve scientists' participation, as co-designers, subjects, and/or co-interpreters" (ibid.) in order to explore the potential for having scientists as scholarly interlocutors.

Four: Audiences, Partners, and Engaged Practitioners Experiments in participation foreground local audiences in the ecologies they join because the material, organizational outcomes of experiments tend to be highly localized, with travel inherent in the experimental practices themselves. The scholar may also build attachments to still other audiences through published accounts, workshops, demonstrations, and other

locally appropriate pathways of travel. These latter audiences may prove important especially when the audience implied in the initial experiment inhabits only one of many possible sites for the lessons learned. Sometimes, these extensions turn back to fellow STS scholars as well.[7]

Five: STS Sensibilities Out There Although STS scholars acquire sensibilities by studying interesting practices of technoscience, this does not mean that practitioners in the field are able to examine and assess what they do in terms other than those established by dominant images and practices. Taking seriously the pragmatist insight that knowing and acting are deeply intertwined (Dewey [1951] 1998), agents in the field may possess both authority and authoritative knowledge but do not necessarily occupy a more privileged knowledge position. Experiments in participation share with other clusters the expectation that examining and rethinking the boundaries between the social and technical/scientific dimensions of technoscience has performative value. The particular challenges in experimental work lie in simultaneously collaborating with people and things in the field to produce such performances and learning from the often-surprising ways that collaborators formulate, or reformulate, the contents of the experiment itself.

In Mesman's video ethnography, neither the STS analysts nor the care professionals knew prior to the experiments how they might reposition "safe care" or even the problem space of safety. It was actually "one of the NICU-nurses on the video team [who] ... proposed to use the footage as a visual aid to the protocols" (2015, 189). While Mesman was looking for ways to widen the analytical focus from "eliminating causes of error" to "includ[ing] causes of strength" (Mesman 2009, 1705), this nurse taught her what could be seen as an STS lesson about the importance of materializing connections between conceptualization and practice. Bringing STS understandings of risk and safety together with the knowledges and techniques of specialized nurses thereby achieved "artful contamination" (Zuiderent-Jerak 2010) of both simultaneously.

Six: Feedback and Reframing Because this cluster of projects treats frictions as invitations, experiences of pushback, critique, and anger, including the stress these may generate for the STS scholar (Mascarenhas-Keyes 1987), can become ethnographic moments for further learning about the setting and the possible directions of future experiments. Even the potentially evolving politics of the experiment and the scholar can become positioned "as one dimension of theorizing rather than as its foundation" (Downey and Rogers 1995, 272). Keeping the setting open for further experimentation and reframing requires "accepting the risk of greater ambivalence" (ibid., 277)—but

also comes with the attendant benefits that may emerge from the outcomes of the experimental work.

In summary, this cluster of projects in STS making and doing highlights the intertwinement of experimentation, knowledge production, and world making. Contributions often place both their concepts and their politics at risk in embracing participatory practices of collaborative, multiple-way learning. Frictions appear magnetic to scholars who join practitioners in the field to identify with and respond to them. Drawing on critical STS work demonstrating the frictions in knowledge production, expression, and travel in technoscience despite the ecological authority of dominant images and practices, STS experiments in participation make "keeping open" a tool for both STS-informed alternates and ongoing collaborative learning.

Conclusion: Enacting Multiple-Way Travels of Knowledge Production, and Expression

Performing knowledge production, expression, and travel in STS through practices of making and doing offers important opportunities for expanding the contents, the scope, and, at times, the influence of STS scholarship. As we have seen, many STS scholars are turning STS lessons back onto STS work. We identify and outline three distinct clusters of STS making and doing to call greater attention to the relations between STS findings and insights, on the one hand, and the myriad of settings into which these travel, on the other—with reflexive and collaborative learning as the planned, expected, or hoped-for outcome. Also, by detailing the elements and ecological dimensions of individual projects and clusters, we have elaborated how the directionalities of STS making and doing initiatives vary with their precise scholarly contents. A willingness to get involved is essential but provides only a prefatory condition for the high-quality scholarship required.

This survey of scholarly activities in STS making and doing suggests that it is less a new direction for STS as a field or discipline and more an existing array of projects that, when made more visible and prominent, can serve as attractive touchstones for further work. At the same time, analyzing such projects in relation to one another may have something to offer to longtime debates about the directionality of STS as a field. An oft-told story about STS is that it developed through two distinct, contrasting threads of scholarship. The theoretical, academic thread took on dominant images of science and technology through the metaphor of construction. The activist, social movement thread took on power inequalities produced by enacting those very images. Each thread tended to judge the other to be lacking in significant respects. This way of cutting up the field has appeared, for example, in debates over whether the acronym

Table 8.1
Elements and ecologies of clusters of making and doing.

	Elements			Ecological Dimensions		
Clusters of Making and Doing	**Frictions and Alternate Images**	**Techniques, Devices, and Infrastructures**	**STS Expertise and Identities**	**Audiences, Partners, and Engaged Practitioners**	**STS Sensibilities Out There**	**Feedback and Reframing**
Boundary-Crossing STS Claims	Social dimensions are marginalized. Frames deep inter-relations among S, T, and society.	Op-ed articles, statements, expert witnesses, documentaries, blogs, design workshops. Can include pedagogies, games, etc.	STS scholars produce unique insights on blurring social/technical-scientific divide. Expertise must be enacted strongly.	STS scholars share insights with external audiences: politicians, engineers, scientists, general public.	Others are usually recipients. Learners can become practitioners.	Learning from resistance may lead to better ways to reach audiences or better alternates. Realities made through getting insights across.
Meta-Activism	Highlights political contents and power dimensions that dominant images perform. Aims at more dynamic, open, and innovative S&T. Details of alternate images left to other actors.	Strategy support, advice for participation in controversies. Developing infrastructures for distributed activism through devices and STS thought styles.	Specialized analytical understandings of technopolitics and power relations. Subject-matter expertise mostly left to others.	Those facing problems, either as marginalized knowledge producers, general scientists being stuck in a conservative system, or those suffering from undone science.	Others usually not expected to become agents of STS knowledge, but can benefit from STS sensibilities.	Can prompt pushback, confirming power hierarchies. Learning can lead to better understandings of how to advise. Re-framing mostly left to the field. Re-framing STS is risky.
Experiments in Participation	S&T have 'increasable complication.' STS scholars "get involved" with frictions found with dominant images to open up action repertoires.	Building devices, changing organizations, video-reflexivity, art installations, novel curricula, etc.	Accept constraints and opportunities of participation. Focus on "keeping open" acquired understandings. Focused learning from collaborators in the field.	Audiences and pathways implied in the local ecologies of experiments. STS is equally an audience of the experiment.	Agents in the field may possess authority and authoritative knowledge, but not necessarily a more privileged knowledge position. Can be sources of surprise.	Feedback and re-framing as core elements of learning, for opening up the field and for developing STS understandings. Realities are enacted in the experiments.

STS stands for the academic enterprise called Science and Technology Studies or the societally involved project of Science, Technology and Society studies (Rip 1999). It has also appeared in tendencies to treat engagement and reflexivity as mutually exclusive alternatives to theorizing and enacting involvements in STS fields of study.

By contrast, the scholarship of STS making and doing treats practices of engagement and reflexivity as intimately linked and builds on both by calling attention to the two-way, or multiple-way, travels of knowledge production and expression. The scholarship of STS making and doing is about both care and learning. As the examples above repeatedly demonstrate, STS scholars learn by using involvement to problematize our own intentions and actions, even as we justify the value of our work to others.

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Notes

1. Gaining the PhD typically qualifies a learner as a researcher. We take STS practitioners to be those learners and performers of STS knowledge and expertise who neither have sought the PhD nor claim career identities as researchers. STS scholars are now giving more overt attention to the figure of the STS practitioner (Downey et al. 2015). The boundary between STS researcher and STS practitioner is porous and, hopefully, increasingly contested.

2. We acknowledge other members of the 4S Making and Doing Committee—Sulfikar Amir (chair), Joseph Dumit, Nina Wakeford, Chia-Ling Wu, and Sara Wylie, and all contributors to the STS Making and Doing Program.

3. See Downey (2016) for more on directionalities as vectors or valenced pathways of travel for knowledge and people.

4. See Zuiderent-Jerak (2015), particularly the conclusions, for elaboration of the related notion of ecologies of intervention.

5. We thank Ernst Thoutenhoofd for co-developing this notion.

6. Translated by the authors.

7. To name some dedicated collections: Cohen and Galusky 2010; Caswill and Shove 2000; Downey and Dumit 1997; Jespersen et al. 2012; Pors et al. 2002; Woolgar, Coopmans, and Neyland 2009; Zuiderent-Jerak and Jensen 2007.

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