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Making an Issue out of a Standard: Storytelling Practices in a Scientific Community

Florence Millerand[1], David Ribes[2], Karen S. Baker[3], and Geoffrey C. Bowker[4]

Abstract

The article focuses on stories and storytelling practices as explanatory resources in standardization processes. It draws upon an ethnographic study of the development of a technical standard for data sharing in an ecological research community, where participants struggle to articulate the difficulties encountered in implementing the standard. Building from C. Wright Mills' classic distinction between private troubles and public issues, the authors follow the development of a story as it comes to assist in transforming *individual troubles* in standard implementation into an *institutional issue* for the

[1] Département de communication sociale et publique, Université du Québec à Montréal (UQAM), Montréal, Canada
[2] Georgetown University, Washington, DC, USA
[3] School of Library and Information Science, University of Illinois Urbana-Champaign, IL, USA
[4] University of Pittsburgh, Pittsburgh, PA, USA

Corresponding Author:
Florence Millerand, Département de communication sociale et publique, Université du Québec à Montréal, PO Box 8888, Station Centre-ville, Montreal, Quebec H3C 3P8, Canada.
Email: millerand.florence@uqam.ca

ecological scientific community. The authors present the "hands-on" social science collaboration in this study as an example of a mechanism for supporting institutionalization of issues. Finally, the authors argue that narratives can serve as effective organizing principles within institutional settings, thereby providing an approach to understand the practical, substantive difficulties that occur in work with data in the sciences.

Keywords
stories, sensemaking, standards, intervention, trouble, issue

> Nasreddin sat on a river bank when someone shouted to him from the opposite side:
> "Hey! how do I get across?"
> "You are across!" Nasreddin shouted back.

Between 1997 and 2001, a team of information technologists at the National Center for Ecological Analysis and Synthesis (NCEAS) initiated and carried through the first stages of development for the Ecological Metadata Language (EML). The introduction of the standard would serve as a groundbreaking event in ecology, promising to facilitate the interdisciplinary sharing of data sets and new avenues for large-scale collaborations in ecological research. As a "universal" language by which standardized descriptions of ecological data could be produced, data would circulate and be shared across disciplinary fields and laboratories. In 2001, the standard was officially adopted by one of the largest research communities in ecology. This adoption marked the high point in a "*success story*" of data-standard development in the sciences.

However, individual research sites within the Network had difficulty using the standard when tagging actual ecological data. In particular, information managers, who were tasked with the responsibility of the majority of the work in implementation began to report troubles. It was found that contrary to an idealized image of a "universal" language, individual research sites have their own ways of naming, classifying, and organizing their data, making use of specific terminologies and measurement units that were not accommodated by the new standard.

Over time, a new story of the standard and the standardization process has begun to emerge within the Network. In this story, the standard is *not yet a success*, substantial work in implementation remains, and doing this work requires changes to the standard itself, along with renewed access to human resources and time. *We ask: What happened in this process of implementation of a standard that led a group of actors to formulate another history of the standard?* A story, already recounted and recorded as a success story, was retold as a partial success promising that the greatest gains were to come.

We adapt the work of sociologist C. Wright Mills to understand this transition, a shift from private troubles to public issues (Mills 1961), and we draw from the storytelling and sensemaking literatures to trace the story-building and storytelling work of participants involved in the implementation process (e.g., Czarniawska 1998; Weick 1979; Weick, Sutcliffe, and Obstfeld 2005). The new story which we call "success-to-come" extends more broadly than the "success-already" story. While the first story (success-already) points to the development of the technical standard itself and its official adoption by the Network, the second (success-to-come) extends more broadly, also including the work of implementation and redevelopment by information managers as they seek to make the standard work in practice.

Drawing from ethnography and grounded theory methods, we follow the development of this second story, as an explanatory resource, as participants seek to make sense of their troubles in implementing the standard—highlighting connections between troubles and issues and the shift from individual difficulties or troubles to a story of a collective issue. The authors of this article were observers *and* participants in this process. We actively intervened in the sensemaking process, helping to shape the success-to-come story. We reflect upon this participatory role and note how recent discussions of "intervention" within Science & Technology Studies (STS) do not adequately account for and describe such "everyday" and "on the ground" forms of interventions.

Private Troubles and Public Issues

C. Wright Mills first articulated the now classic sociological distinction between *private troubles* and *public issues*. *Troubles* are the experiences of individuals, variously blamed on irresponsible action and poor planning or explained away as unfortunate contingencies: "they have to do with the self and with those limited areas of social life of which he [sic] is directly and personally aware" (Mills 1961, 8). In contrast, *issues* are recognized as collective phenomena: many individuals are swept along in changes that could not be planned for and to whom no responsibility can be laid, "they have to do with ways in which various milieu overlap and interpenetrate to form the larger structure" (1961, 8). The difference between a trouble and an issue is largely a matter of casting the story in a different light, and assembling information in ways that render individual problems as part of a collective phenomenon.

Mills uses examples, such as "being without a job." Within the United States, joblessness is commonly framed as the private personal trouble of an individual and their family—a situation to be resolved by action on the part of that individual, such as finding work. However, in the face of an acknowledged crisis, such as a recession or environmental disaster, a private trouble can be recast as a public issue—"being without a job" becomes "unemployment"—a matter of national or international concern, to be resolved by actions of the state, nongovernmental organizations, and/or foreign aid.

An issue is often more difficult to articulate than a trouble because its manifestations are not immediately available to everyday experience. A "high unemployment rate" is the product of collecting and assembling multiple national statistics from various private and public agencies. New information must be generated and brought to bear on the trouble in order to recast it as an issue. Making an issue out of troubles is also interpretive and argumentative work, difficult for those awash in individual everyday activities. In short, it becomes a case of collective sensemaking. Mills believes that a full formulation of the problem requires understanding "biography and history," "man and society," "self and world"; or in other words, that a problem is most revealing when troubles and issues are cast simultaneously across multiple frames and/or scales. A national issue of unemployment cannot be addressed without grasping the particular mechanisms and experiences of individual troubles in addition to the broad sweep of history and social change. A sophisticated modeling of a problem draws connective strings between the troubles of individuals and historical and structural transformations.

Mills emphasizes the public role of the sociologist in helping to broaden the horizons of "ordinary men" who "do not possess the quality of mind essential to grasp the interplay of man and society, of biography and history, of self and world" (1961, 4). It is in this respect that we depart from Mills' analysis, greatly tempering the sociological hubris of his arguments. While Mills treats the transition from seeing troubles to understanding an issue as a matter of "the sociological imagination," or bringing to bear a professionally positioned perspective to the question, we treat the transition as a matter of participants' sensemaking, storytelling, and practical work—driven, in our case, primarily by the participants themselves.

Beyond Accounting for Success and Failure: The Work of Sensemaking and Storytelling in the Ongoing Activity of Standardization

While Mills posits that "ordinary men" "cannot cope with their personal troubles in such ways as to control the structural transformation that usually lie behind them" (1961, 4), our field research revealed precisely the opposite. We saw on a daily basis that participants themselves told stories that drew together their individual troubles and began recasting them as collective issues. We take a storybuilding perspective on member's organizational work as the participants seek to make sense of ongoing difficulties in standardization.

Stories are deeply implicated in every aspect of organizational life. By turning to storytelling as a sensemaking activity, the ongoing aspect of organizational action can become the object of analysis: "A focus on stories leads naturally to a concern with themes ranging from fictionality, plurivocity and reflexivity to temporality, intertextuality and voice, all of which are suffused with power" (Brown, Gabriel, and Gherardi 2009, 324). Stories are "the basic unit" of narrative (Fincham 2002, 5) and can be understood as the local activities of sensemaking associated with particular situations, instances, or past events. At its most fundamental level, a story defines a history, a current state of affairs, and then outlines a future direction for the circumstances. More than rhetorical framing devices, Julian Orr (1996) notes that stories are tools for local sensemaking and can become resources for action within institutional settings.

Time itself can be framed in the explanation of the object of a story, "The time of innovations depends on the geometry of the actors, not on the calendar" (Latour 1996, 88). Timelines, such as the ever-present "planning and deployment stages" of technology life cycles are themselves "changeable" through narrative formation. The evolution of a project of technological development is understood not according to an inflexible linear time frame (for instance, according to stages of emergence, ripening, decaying, etc., in an evolutionist perspective), but rather, according to the temporalities framed by different actors in the project, which are held and reshaped collectively in stories. For example, the stories of standardization we explore in this article reshape the time frame of when the deployed standard may be considered a success. While initially success is a matter of formal adoption of the standard within the research community studied, we show how storybuilding and storytelling practices come to tie together the work of technological development to its adoption in the definition of success.

Through storytelling, a complete success in standardization becomes part of the future of a data standard, something that can only be claimed after user adoption.

The storybuilding perspective can be contrasted with a more "objectively" oriented approach that sees only definitive successes or failures. Such rationalist perspectives generate an exclusive focus on outcomes and casts success in stark black and white terms (e.g., in some of the actors' perspectives in the case of the Aramis technology studied by Latour 1996). It fails to capture the lived experience and processual nature of any technological development or standardization process, which is rarely, if ever, simply a matter of success or failure. Most importantly, such perspectives make it difficult to account for the common process by which difficulties in technological implementation and uptake are recast as opportunities for learning (Sauer 1999). Rather than a polarized either/or outcome, this article suggests that attributions of "success" and "failure" are themselves resources for action and implicated in forms of change and innovation in organizations. Thus, there is no "objectively correct account" that serves as the definitive explanation of failure in standardization (Sauer 1993, 24); rather, it is that the process of accounting for failure becomes a matter of organizational work, of sensemaking, and means for launching a renewed set of standardization efforts. To phrase it in an ethnomethodological idiom, formulating a conception of "structure" is an everyday actor's resource in engaging with complex technological and organizational change.

Making an Issue Out of Troubles

In fact, as we will see, no one in our study is telling a story of failure, rather, it is a case of retelling a recognized success as a matter of overcoming difficulties and establishing ongoing commitment. As Fincham notes in his analysis of success and failure narratives in technology adoption, "Rather than being seen as end points (whether a set of causal factors or process), when conceived in narrative terms, success and failure claims form an interactive discourse" (2002, 2). Shades of gray emerge, and success becomes a negotiated marker or a future goal. By making an issue out of their troubles, participants gain a new handle on their difficulties.[1] It is precisely by reframing personal troubles as public issues—as a matter of structural rather than individual concerns—that participants make sense and "cope" with their difficulties.

The move from private trouble to public issue can be understood through the lens of organizational sensemaking.

> Viewed as a significant process of organizing, sensemaking unfolds as a sequence in which people concerned with identity in the social context of other actors engage ongoing circumstances from which they extract cues and make plausible sense retrospectively, while enacting more or less order into those ongoing circumstances. (Weick, Sutcliffe, and Obstfeld 2005, 409)

Stated in a more concise way, sensemaking involves "turning circumstances into a situation that is comprehended explicitly in words and that serves as a springboard into action" (Weick, Sutcliffe, and Obstfeld 2005, 409). Storybuilding is a means by which one makes sense of the world and acts on it.

Coherence is a key modifying adjective in our use of story (Linde 1993, 2001). Stories are not fictions, in that they must sustain a meaningful interpretation of ongoing activity for participants. A coherent story must have both an internal narrative logic—it must make explanatory and causal sense to participants, providing a useful guide to future analysis and/or action—and it must sufficiently frame the facts. As Becker notes:

> The story must first of all "work," be coherent in any of the many ways stories can be of one piece [. . .] The other constraint is that the story must be congruent with the facts [. . .] We don't accept stories that are not borne out by the facts we have available. (1998, 18)

For example, as multiple fragments of the emerging "enacting the standard" story came together, it became necessary for participants to generate various kinds of proofs to backup the emerging story where gathering an understanding of the broader context included: implementing surveys, unearthing historical evidence, conducting interviews, and providing an alternative standard development model. This new evidence simultaneously added robustness to the story while also significantly shaping them. Storybuilding is a matter of fitting. A story cannot be an interpretive resource or serve as a guide for future action if it does not sufficiently align the understandings and expectations of key participants.

Roughly speaking, our empirical case begins at the point where there was a single story (success-already), and in this article, we trace the emergence of a new story (success-to-come) through the storybuilding activities of participants. The two stories are related and continue to unfold side by side, one a precursor not only setting the stage, but prompting emergence of the other. This conjoining of stories highlights the sensemaking aspect, in addition to the persuasive element involved in storybuilding (Fincham 2002). The stories become not individual markers along a path of technological change in an organization, but interacting narratives that prompt discussion and create shared meaning (MacLeod and Davidson 2007).

A Metadata Standard for the Ecological Sciences

We focus on a particular data standard, the EML.[2] In short, the standard provides a shared method for describing data across the ecological sciences in the hope of facilitating data sharing, reuse, and management. The standard was developed at a national ecological center (the NCEAS) and was deployed within an ecological research community (the *Long-Term Ecological Research [LTER] Network*), a US federation of ecological research sites consisting of more than 2,000 members. We will refer to the *NCEAS* as the "national center" or "center," and the *LTER Network* as the "Network" throughout the article.

The social studies of standardization are filled with stories of local resistance and power struggles, of failed plans, and unexpected successes (Lampland and Star 2009). But this case is neither a story of resistance to standardization nor of reluctance to standardize—all parties are committed to effective data sharing via data description. Rather, the activities in our case are a struggle to articulate the difficulties encountered locally in implementing the standard, and how the difficulties are translated from individual troubles to collective issues. That is, from a localized trouble to an institutional issue for the Network.

The Network consists of ecological scientists seeking to understand past and present-day ecosystems, as well as anticipating potential futures (Callahan 1984; Magnuson 1990; Hobbie et al. 2003). These ecological scientists are organized around twenty-six research sites across the United States that both work independently at each site or collaborate to develop joint understandings of global ecological processes. Part of the mandate of the Network is to expand the time frames of ecological research to match those of ecological change (i.e., decades or even centuries). Thus, the collection, curation, and especially sharing of data in new ways, enabled by technology, are central features of Network activity. It is to support these goals that the effort to develop the standard was initiated.

The standard defines a fixed set of tagged fields that structure the text describing any given ecological project, data set, and/or collection of data sets together with their related references and personnel. Literally "data about data," metadata consists of a set of labels or tags, tag categories, and their relational structure. Tags such as "title," "location," and "unit" are used to demark text that provides information about a data set into sections more structured for human understanding, as well as more amenable to automated machine searches. Detailed, standardized metadata can facilitate many tasks, such as searching of relevant data (e.g., requesting all data sets that contain the term biomass in the tagged field title), data availability from multiple field sites (requesting the data location from the tagged field URL), and data integration (requesting data sets with measurements in milligrams per meter cubed in the unit tagged field).

Two often ignored aspects of field practices that create difficulties for data sharing are their situatedness and the manner in which data are moved beyond the sites of their production. First, the understanding of scientific field data is closely bound to the local venue or data-collector (e.g., Goodwin 1995). Second, the production of history and context for scientific data is increasingly erased as it moves away from the site of its production, eventually becoming almost invisible as a story completes with frame, interpretation, and limitations upon publication of an article (what Latour and Woolgar 1986 have called the deletion of modalities).

The context within which issues of standardization play out has been described from the perspective of the ecological sciences as a growing awareness of the social and technical dynamics associated with synthetic efforts in both basic and applied science (Sidlauskas et al. 2010; Carpenter et al. 2009; Hackett et al. 2008) as well as an expression of the continuing movement from "wet" to "dry" ecology of the same type that occurred in molecular biology (Penders, Horstman, and Vos 2008). Ecological data specifically involves highly complex tasks of collection and categorization that are inherent to the domain of environmental sciences (Roth and Bowen 1999, 2001; Zimmerman 2007, 2008).

While journal publication is part of a well-established scientific process of public community review, publication of data sets and their associated metadata is novel within the ecological sciences, involving new types of work not yet integrated into conventions of existing work and accreditation. It is precisely this gap that the standard seeks to fill, a method of documenting data in ways that capture key features of its collection and methods of production. With rich metadata, data are contextualized in support of both wider reuse and legacy use. That is, the use of data is extended to include others who may be addressing questions beyond the original scientific questions that led to the collection of data (data reuse) and/or recall of the data for use at later times.

A Brief History of the Standard

The EML was developed by a team of information technologists located at a national center between 1997 and 2001. In 2001, it was adopted as the official metadata standard of the Network. The problems we investigate in this article focus on the implementation of that data standard within the Network. These problems manifested principally at the divide between those who developed the standard (information technologists at the national center) and those who were tasked to implement the standard by describing existing data sets using the new standard (information managers within the Network).[3]

A first version of the standard saw the light in 1997 at the national center. It was the product of a small team of information technologists trained in computer science and ecological research. The standard fit within the core mission of the center, which is the support of cross-disciplinary research that uses existing data to address major scientific challenges in ecology.[4] The information technologists working at the center were engaged in various technological projects, developing tools and techniques for the environmental science community. We will refer to them as the "developers" of the standard throughout the article.

Information management is a formal body within the Network. Each of the twenty-six research sites has an information manager, tasked with carrying out data and information management. Notably, at the Network level (of all twenty-six sites), there is an Information Management Committee with one member from each site. Thus, the information managers are responsible for managing data and a data repository at the site level and also for collectively planning data curation and integration at the Network level (Baker et al. 2000; Karasti and Baker 2004). We will refer to them as the "information managers" throughout the article.

The recasting of the standard's implementation as a matter of success-to-come was largely reasoned and articulated by participants of the Network itself, primarily by information managers. It was their hands-on experience in attempting to implement the standard, and the continuing interaction among themselves as an organized subunit of the Network that provided the raw materials for reinterpreting their troubles as issues.

Research Design and Methods

Our methods are informed by ethnography and grounded theory (Strauss and Corbin 1998). Data and observations were collected by participant observation, interviews, and document analysis. Data collection spanned 2004-2006 for the interviews and direct observations (e.g., face-to-face meetings), while document analysis was pursued a few years later. Our investigation of the standard, as well as our engagement with the research field is ongoing—still continuing more than six years after its inception. However, within this article, we focus on the period where the second narrative (success-to-come) emerged and took form, essentially between 2004 and 2006. We participated in more than 200 events relating to work with the Network over the period of the study. Specifically relating to the standard topic, we conducted ten interviews, participated in nine conference call discussions and six working meetings, and attended several design sessions.[5] Interviews were with representatives from the main groups of actors involved (i.e., information managers, developers, and scientists), some of them we interviewed repeatedly. All the interviews and selected sections of conference calls, working meetings, and design sessions were transcribed and coded with a qualitative data analysis software (NVivo). Data analysis followed grounded theory methodology, from coding to categorizing to theorizing, developing from memo writing informed by participant observations notes. The quotes presented in this article are marked as information manager (IM), developer (D), and scientist (S). Document analysis was carried out longitudinally, and included standard documentation, e-mails, information managers' publications, and Network reports and publications. Being physically present at the research site, in this case at two sites (Palmer Station and California Current Ecosystem) located at Scripps Institution of Oceanography in San Diego, CA, allowed for two authors of the article (Millerand and Baker) to engage in participant observation almost on a daily basis. One of the authors of this article (Baker) is the information manager for the two sites; also trained in STS, she brought to bear a "sociological imagination" to the troubles in implementation.

The authors of this article were observers and participants in the process of storybuilding and storytelling around the enactment of the standard. We actively contributed in the sensemaking process, in particular helping to shape the success-to-come narrative. But we, as social scientists, by no means credit ourselves with the bulk of building the emergent interpretive narrative. We were not privileged actors "unveiling" the truth of an issue to those mired in a situated view of their troubles; rather, we were one kind of participant in a highly diverse, largely expert mix of participants seeking to enact a standard. We were a sounding board, providing context and language, prompting dialogue, and participating in joint reflection. Within STS, such forms of participation by the researcher in the shaping of the object of study are known as "interventions" (i.e., the social researcher partaking in the unfolding of the research object). Of late, much has been written on the topic of STS scholars intervening within policy or legal spheres (Jasanoff 2004; Lynch and Cole 2005; Webster 2007). However, these recent discussions do not account for and describe such "on the ground" forms of collaboration, a blend of participation and intervention. The kind of "hands-on" participation we depict in this article is more the exception than the rule at this particular time in the history of social science, although it is becoming increasingly common within information technology design, development, and deployment work. We will return to a more expansive discussion of this in later parts of the article.

Telling Stories: Making an Issue Out of Standardization

Our empirical study begins at the point where a new story (success-to-come) was developed, thus challenging the dominance of the previous one (success-already) in its attempt to account for the standardization process. The two stories share a factual understanding of the point of adoption of the standard and of the importance of this moment, but the interpretation of the significance has come to differ substantially. Is adoption the end point in the story of standardization, now considered a success, or is adoption an important milestone toward a final goal of data practices standardization in the Network?

The success-to-come story differs in three distinct ways from success-already. First, the success-to-come story emphasizes the difficulties that arise in implementing the standard—requiring additional resources and expertise. In contrast, the success-already story demarcates a transition point in which the standard has been successfully developed and which "merely" leaves the task of implementation ahead: the greatest investment of resources, expertise, and time had come and gone. Second, it is expected within the success-to-come story that some difficulties in implementation are insurmountable without changing the standard itself, thus, calling for some redesign of the standard or of its use by the information managers. Third, following the previous two points, the success-to-come story emphasizes that the process of the standard's enactment and the solutions to related problems requiring significant work and innovation are beyond the reach of a single individual site but are within the scope of the Network or even the domain of ecology.

The two narratives frame differently the particulars of the problem[6] of standardization, and thus, suggest different kinds of individual and collective action. We begin with the framing of the problem associated with the success-already story, which casts the story in terms of private troubles.

Having Troubles in Implementing the Standard

As soon as implementation started at the research sites within the Network, problems emerged. When difficulties in implementing a standard are cast as troubles, they are perceived as unique and exceptional circumstances (i.e., a problem for an individual information manager at a site to be addressed and solved locally). Immediately following the adoption of the standard, both developers and information managers accepted this formulation of the situation. Below, we outline in detail an instance of an implementation problem, cast as a trouble. Because such troubles were not completely unexpected by the developers, in the next section, we illustrate the individually targeted solutions that they planned, and in this case, a set of workshops for the information managers.

Being in Trouble

In order to characterize the nature of a trouble, we outline a single instance of a problem, as articulated by an information manager describing biochemical data using the standard. This event, and the interview selections that are based on it, occurred shortly after the official adoption of the standard as the implementation phase began. Jane is an information manager working at one of the twenty-six LTER sites in charge of managing the data collected by scientists at her site. The site is a biome with research focusing on the impact of human development on the quality and quantity of water. Jane is attempting to describe an existing measurement within a nutrient data set using the newly adopted standard. For her site's ecosystem, nutrients are any of the organic and inorganic substances that serve as nourishment for plants; these are commonly composed of, for example, phosphates, silicates, nitrites, or nitrates. They are a crucial component of any ecosystem and can be a limiting factor for a biological system.

A common unit for the measurement of phosphates is microMoles; a unit used in chemistry for the amount of a substance. In applying the standard to her data, Jane finds that microMoles are not included as a metric in the standard. Instead, Jane uses a naming convention that provides a guide for capitalization and ordering of the parts of the name at hand (capital M on moles):

> I was getting nutrient data, and my units came in as micromoles with the micron symbol and capital M, microMoles. When I started having to go into

> EML [the standard], which does not have that unit, I had to figure out, well, what actually is this unit? (IM)

Jane runs into two troubles: the standard does not provide guidance on biochemical units and, when she does research the unit name on her own, she finds that the measure used at the site is a "custom" unit that the site's scientists use as a shorthand convention. Here, "custom" means that it is a locally used unit, rather than one common to the Network or to ecology more broadly:

> And in digging deeper and going to our lab that processed these data, I found out it's not microMoles, it's microMoles/liter. And I am not a chemist so it just didn't mean anything to me. You know, I am just organizing and posting this type of data, and so it really opened my eyes that I have a bigger issue here than I thought, you know, because here we've got people reporting things as microMoles, which is not proper. But that is just the way the work is done, and shared, and no one ever questioned it. (IM)

Jane realizes that the shorthand convention used at her site lacks the completeness required to be understood by those outside the site, a key goal for metadata. The naming convention sufficed for use at her site, but the full formal name including the "per liter"' (that makes explicit that this is a measure of density, an amount per volume, and not simply an amount) was missing. While the shorthand is not "wrong" per se, that is, it is sufficient for the needs of scientists at the local site, for the purposes of the metadata standard, this specification is inaccurate or as Jane says: "not proper."[7] In other words, the unit is not proper for communicating the data to the broader Network.

Jane began to compile a list of the units used at her site that could be reviewed by scientists and made available to site researchers. Like Jane, most of the information managers perceived their difficulties with the standard implementation as unique and exceptional occurrences, or rather, as individual troubles they needed to address and solve on their own. As we show in the following section, the developers of the standard also perceived emerging difficulties as private troubles experienced individually at each site.

Targeting Solutions Individually

That there would be troubles in implementing the standard was not in itself a surprise for the developers. They were familiar with the heterogeneity of the sites and the data in the Network as well as the differences in the backgrounds of individual information managers. However, they perceived these problems as troubles, that is, as difficulties to be addressed through individually targeted actions at each site. Below we describe their solution: tutorials and training sessions for information managers. This solution, targeting information managers' deficiencies, would train individuals at sites in how to implement the standard.

Developers related difficulties and lag in the implementation of the standard across the Network directly to the variation in the sites' information systems. Only a few of the "ideal" sites were able to implement the standard quickly because their data were stored in highly structured databases. Other sites used "semistructured" files and a lot of the sites had files with very little structure. As a developer describes:

> The LTER [Network] sites have a lot of variation in their systems. Some of them have very advanced relational database systems and for those sites I think it was relatively easy to implement and convert to the EML standard [. . .]. There was another set of sites that maybe had text documents, those sites had a bit more, quite more, a lot more difficulty than the relational database sites [. . .]. And then there were some sites that had very unstructured metadata, those were definitely the hardest, many of those sites I think had to either re-type their information into EML or develop a database system. (D)

For the developers, the heterogeneity of the information systems, the dominance of homemade systems and site-specific metadata practices contributed to a framing of the problem in terms of individual sites. One of the criteria for good organization is having flexibility to work with metadata in a structured manner, for instance by "having relational databases," those that did not have such organization could be cast by the developers as being behind the technological curve, with information managers that they believed were using outdated approaches.

Information managers' lack of expertise is taken by developers as another critical obstacle. In practice, information managers have a mixed bag of programming abilities and training in ecological data management; while some are trained in computer science, others are drawn from the environmental sciences. They do not share a common trajectory of training, each arriving at their profession through circuitous routes. Perhaps, the most accurate characterization is to say that information managers learn by doing, in practice and on the job. Faced with implementing a brand new metadata standard using "cutting-edge technology" and representing "the state of the art" of metadata language (in the developers' words), many found themselves unskilled. The developers anticipated this lack of expertise and, therefore, quickly set out tutorials and outreach activities targeting the information managers very soon after the Network adopted the standard:

> We did a number of tutorials and different outreach activities to try and familiarize the information managers, much less the scientists, but familiarize the information managers with the technologies that we were proposing to use. And so I would say in the first half of the development of EML, the biggest barrier was that none of them had the expertise to even begin addressing the problems that we were dealing with. (D)

The developers held two workshops in 2001 and 2002 in Phoenix, Arizona, with the goal of training the information managers. They also developed a tutorial on Extended Mark-up Language, the computer language in which the metadata standard is written.

These training sessions are examples of individually targeted solutions to individual troubles; while the classes themselves were targeting the collective of information managers, the knowledge imparted in these sessions was intended to train-up individuals rather than an attempt to change the organization or the standard. Being ill trained is, in this case, defined as a personnel deficiency that each information manager had to overcome. Such troubles stirred up distress that frequently manifested as a matter of personal responsibility, and thereby as a failing that involved individual faultfinding. There was an implicitly accepted obligation to correct the situation, and information managers were expected to get the resources they were missing, whether these resources were tools or expertise. The need was for the information managers to meet or adapt to the existing technical arrangement to which they had agreed to commit, that is to say, to get trained by attending the training sessions or to do so on their own.

Making an Issue Out of the Standard

As more and more difficulties arose in the implementation of the standard, information managers began articulating a new story for what had become a standardization process. Implementation of the standard was redefined from a private trouble experienced individually at each site to an issue for the whole Network. But such a reconceptualization required work, what we call storybuilding and "making an issue" out of the standardization process. These were sensemaking activities that slowly and collectively carved out the new success-to-come story.

First, a software tool developed to help implementation at a single site was found to be useful at many sites. The creation of this tool hinted at a collective problem regarding the standard and opened a window for discussion among information managers experiencing similar difficulties. Second, an increasingly apparent lag in deployment led to an alliance of developers and information managers as they sought to investigate the source of these problems. The first formulations of the success-to-come story emerged from a workshop organized by this team. Finally, as the narrative solidified, surveys were deployed in order to more formally capture and represent the collective difficulties of the community. Together, these activities all helped build and strengthen the success-to-come story that constituted difficulties in implementation as a collective issue.

Circulating a Collective Solution

If a problem is individual, then it is largely up to that individual to address the trouble. But what if there is a single solution, a tool, which can help many people with their troubles? To the extent that a single solution can solve many problems then that problem begins to appear collective. This was the case with a simple conversion program developed by an information manager at a site to address a local trouble; the tool turned out to be helpful to information managers at other sites. The circulation of that tool across many sites became an opportunity for storybuilding, helping to reframe troubles as issues.

As the work of implementing the standard turned out to be complex and problematic, information managers sought out ad hoc solutions, work-arounds, as well as help and advice from other information managers to facilitate the integration of the new standard into their local infrastructures and data practices. Tools, such as spreadsheets and conversion programs to translate local site metadata to standardized metadata, were developed and started to circulate within the information managers' community, across multiple sites. These tools were "ad hoc" in the sense that they were not part of the toolset provided by the standard developers, they were work-arounds (Pollock 2005; Gasser 1986; Star 1995) developed to manage local troubles. Working-around is not a form of resistance per se, rather it is about building an understanding of how something could be better used given local constraints and needs. Work-arounds seek to continue the overarching activity by cleverly assembling resources at hand.

In the quote below, Maria, an information manager, describes how a tool developed at one site traveled to other sites.

> [Scott] [information manager at one site] had made an excel template that had these same content standards that were recommended (. . .) and Paul [information manager at another biome site] came to my site actually twice, and he was looking at this template that Scott and I put together in trying to figure out a way to convert it into EML. (. . .) And a little more time went by and, actually I had Wanda [information manager at a third biome site] [. . .] using my metadata template at her site. (. . .) So we were in this together, and there were some others that were interested in this format. (IM)

The tool Maria and Scott created converted a templated file in Microsoft Excel—a spreadsheet format commonly used within ecological sciences—to a format compliant with the metadata standard. The tool circulated among the information managers and became used more widely. It was demonstrated at the annual Network information managers' meeting in 2004 and became the topic of an article in the information management newsletter.

Along with the tool, through the sharing itself, came stories about the difficulty of fitting homemade measurement units into standardized data descriptions, essentially another example of the problem Jane encountered with a local measurement unit that could not be described in the standard (see section *Being in Trouble*).

> IM1: [At my site] they are collecting plants, one of my units is something like, 'leaves per short shoot'. I'm like, what is that.
> IM2: Wait, per short shoot?
> IM1: Shoot yes, then I asked my office partner here who knows plant physiology, is a short shoot something that is on every plant? Can we call it something else that is more general? Because how am I going to describe this in EML? And I still don't know the answer to that one because a short shoot is, its part of like a sea grass, and it's not common to other plants. So it's a custom unit, but it's just really hard.
> IM2: Yeah we ran into that. I mean if you look at our sheet we have "egg to lost date."
> IM1: Yes, so you see that's funny.

The tool that was produced and passed to other information managers was part of a larger process of story sharing and of collective sensemaking. The lack of existing templates and tools together with lack of authoritative guides for description of data measurement units became an occasion for collective discussion. If difficulties identified at one site were mirrored at other sites, the problem was more wide spread than originally understood. If work-around solutions and site-developed tools that were used at one site, could also address the problems of another, then it seemed there was something more to these problems than the success-already narrative might suggest.

Moments of Storybuilding

The conversion tool and the discussions that surrounded its dissemination set the stage for questioning the success-already narrative. Discordant voices started emerging within the information managers' community, calling into question both the standard itself (in terms of its appropriateness for the community) and the standardization process (in terms of its planning, the resource allocation, and its general understanding). However, as we mentioned, all parties were still interested in the promises of the data standard (i.e., describing data and sharing across the various sites). Wholly rejecting the standard was not under consideration. What remained was a desire to develop a new narrative that would help explain the various problems at the sites, and possibly how to address them.

Difficulties became even more noticeable as plans for the rollout of the standard fell behind schedule. In order to track the success of the standard deployment effort, each site was required to submit reports on how many (and to what extent) data sets were in compliance with the standard. In 2003, only a third of the sites had succeeded in implementing the standard.[8] Such statistics revealed that two years after official adoption of the standard, the number of data sets that had been logged as "standardized" (i.e., properly described) still lagged at most of the sites, despite local efforts. In order to address this, in combination with mounting reports of troubles, developers and information managers came together for the first time and organized a working group on the topic entitled "Community process of standard implementation." The title of this working group reveals an increasing sense of a collective issue. This working group eventually decided to host a workshop for the Network information managers at the 2005 annual meeting. In the workshop's call for participation, the working group organizers stated that they hoped the discussion would "inform upcoming EML revisions and future network projects," and that "products of the working group include the accumulation of experiences of the participants with standards, distillation from these experiences of some principles and critical questions to guide the LTER IM community and its partners in future projects."[9]

The working group included the majority of the Network's twenty-six information managers, a handful of standard developers and some representatives from the Network Office, an office established to manage the

Network and its communications. It was at this meeting that we can begin to identify the emergence of the alternative narrative we call success-to-come. Discordant voices could be heard and a new "framing" of the standardization process started emerging. Common difficulties were recognized, such as timing issues, lack of suitable tools, lack of resources in terms of both expertise and funding—all recognized as coming under the community level more than under the site level. It was also pointed out that the standard itself had intrinsic limitations. For instance, the standard was claimed to be "poorly suited to working with legacy data [long term data]" (in a participant's words)—thus strongly constraining its use within a research community carrying out long-term ecological studies. The lag in the standard implementation started to be framed then as a community issue, and not just as an information manager's troubles. Deployment started becoming an issue.

A synthesis of the working group activities was presented in a publication in the Network Information Management Newsletter, a publicly available online publication.[10] The publication's authors included two information managers, a developer and a social scientist (see last sections of this article for an extensive discussion of social science intervention). The new framing of the standardization process present in the publication was cast in terms of "lessons learned," acknowledging that the standard is considered as "a successful experience" but that critical problems still need to be solved at the community level—such as (participants' words) "inappropriate support environment," "lack of community involvement," and so on. In going public, this new framing reached beyond the information managers' community and even beyond the Network to the domain of ecology more broadly, contributing to the transition from the standard implementation defined as "individual troubles" to be defined as "community issue."

Knowing the Issue

The emerging stories that cast troubles in deploying the standard as an issue are a starting point, but they do not reveal the content of that issue. In other words, while the success-to-come story identified troubles as collective, the developers and information managers still needed to define and articulate those troubles. The use of surveys, for example, was crucial in making collective issues knowable and credible. While individuals can speak of their troubles, communities cannot. Communities require representation or spokespersons. The results of surveys make visible collectives as "findings," they transform hidden and distributed phenomena into hard numbers, charts, and diagrams. Surveys are visibility mechanisms, constituting community as they study it (Igo 2007). Within technology development projects the *meaning and constitution of community* "is debated, researched and ultimately constituted by representatives who seek to mobilize its identify as the they go about the work of planning" (Ribes and Finholt 2008, 107). Surveys of the Network revealed systematic difficulties in deploying the standard, these difficulties were recognized as "of the community" rather than of individuals, and as such, served to add credence to the success-to-come narrative.

In the period of time that is of interest for this article, four surveys were conducted: two by the information managers in December 2003 and August 2005, and two by the coordination site of the Network in August 2005 and July 2007. The first survey results were that "7 of the 21 sites responded that they had implemented EML, although only three stated that all of their datasets have at least basic EML."[11] In other words, two years after the inception of the implementation process, less than 15 percent of the sites had succeeded in producing standardized metadata. The second survey, a qualitative survey highlighted some of the main implementation frustrations and barriers: the developers expressed their frustration as "mainly due to people's unwillingness to take the time to contribute metadata," while information manager's frustrations included the lack of suitable tools, time, communication, and community involvement in the development process of the standard.[12] However, this survey did show some progress as "half the information managers reported successful experiences in terms of a 'full implementation' of EML so that EML metadata can be generated at the sites."[13] Nevertheless, despite this progress, 50 percent of the sites were still struggling to implement the standard four years after its adoption.

The third and fourth surveys showed more progress: 90 percent of the sites at the end of 2005 and then 100 percent in 2007 "had implemented the EML standard." However, it is important to consider that "having implemented" meant that each site needed to show at least one of its data set converted to the standard. The 2007 survey report added some nuanced interpretation of its results: "Do not be fooled. Reaching a milestone does not mean that the metadata work is finished."[14] Indeed, both surveys masked large inequities in terms of levels of completeness of standard implementation. Still, as of 2007, only half of the sites offered "rich metadata content" (i.e., detailed descriptions of the data structure and content for allowing machine reading and interpretation of the data). The other half of the sites still had not "fully" implemented the standard.

What the surveys were showing, over the years, was that the lag (or slow pace) in the standard implementation was not an isolated trouble (a problem only a few sites were experiencing) but a collective issue that the whole Network faced.

Institutionalizing the Issue

The distinction between troubles and issues informs the treatment of how responsibility is assigned, and how solutions are formulated. The responsibility and resolution of a trouble is seen to lie within the scope of a given individual's possible range of action. Even if a trouble is known to be widespread, it is still not an issue as long as responsibility and resolution are understood to lie within the purview of an individual. Issues are collective crises, explained by structural transformations or historical events. Everyday individuals cannot address an issue singlehandedly; issues are the responsibility of groups, communities, or organizations. We call "institutionalization of the issue" the recognition of troubles in standardization by the Network as a whole, coupled with a redistribution of resources and new roles for organizational members that are formally codified (such as the best practices document we examine below).

The Network is a (relatively) large organization and information managers are only a small part of it—well regarded but with a relatively low status (especially in comparison with scientists, who are the focus of the organization and are the principal investigators of the funding awards).[15] Along with the technicians and research staff, the information managers are seen as providing a service to the scientists (Baker and Karasti 2004). They are a type of infrastructural workers whose voices and messages often remain unheard (Star and Ruhleder 1996). Thus, that information managers had come to consider the implementation of the standard as an issue is necessary but not sufficient to begin systematically addressing the problem.

A narrative defines much more than a state of affairs and a future direction, it also marks a set of relevant actors and their roles, along with a particular framing of past, present, and future activities. Fincham's work regarding narratives is interesting when considering the movement between troubles and issues: "narratives like success and failure in particular can be seen as persuasive rhetoric used in legitimizing particular courses of action" (2002, 1). The success-already narrative identifies the most significant actors as the developers. They are the ones who conceived of, framed, and launched the standard project. The proposal they wrote for developing the standard was funded, thus validating their role as standard-makers and technological representatives able to act in support of ecological scientists. Adoption of the standard marked a successful end of the project. In this narrative, all other roles are secondary: information managers are in charge of implementing the standard, and scientists are the end users of the standardized data sets in the information system. In the success-to-come narrative, information managers become far more significant actors: they will make the standard work so that scientists can ultimately access standardized data sets. The success-to-come narrative not only redefines the moment when the project could be seen as a successful enterprise, it also facilitates the process of recognition and legitimization of the role information managers play as active contributors to the development of the standard.

This new role is articulated in the success-to-come narrative in two ways: first, the narrative points to the idea that the deployment phase is just as much a part of the standardization process as the design and development phases—the current standard requires partial redesign and redevelopment as it is deployed. Second, that the key actors in this fitting process between standard and data are the information managers.

In 2005, the developers came to recognize the information managers as being codevelopers of the standard and included them as active participants in the ongoing definition and revision of the standard. Codification of this new role appeared in documents relating to the standard, such as the official Web site of the standard:

> EML is defined and revised through an on-going community effort, particularly involving the participation of ecological research station information managers, and other interested parties. (EcoInformatics Web page, 2005)

As a consequence, the information managers' role in the development of the standard was recognized outside of the Network and reached the domain of Ecological Informatics—a domain that the developers were so far representing alone. In practice such a recognition did not change the day-to-day work of the information managers, but it gave them a legitimate status as participants in the development of what was supposed to be *the* metadata standard for ecology.

The first story established that success had been attained and merely implementation remained. More than rhetorical effects, this also had consequences in resource distribution. Informed by the success-already story, only a few additional funds have been allocated for the "mere task" of implementation. Making information managers' troubles into the Network's issues would mean significant transformations in the distribution of human, financial, and technical resources, as well as in the distribution of responsibility and credits. Codification activities, such as defining organizational roles and division of labor, and formal documentation of processes, such as establishing of guidelines and rules, are means by which things get institutionalized. Below we focus on the establishment of a new process for the production of metadata at the sites formalized in a best practices document.

Formalizing New Processes

Written documents are useful tools by which rules and processes get formalized and referred to. Best practices are common documents among information professionals that describe "the best way" of accomplishing a task.[16] They usually describe explicitly and in great detail a set of working methods or processes that are accepted collectively as being the best to use and to follow under particular circumstances.

In the mid of their troubles implementing the standard, information managers initiated the writing of a best practices document. The document represented a community activity until a stable version was released in 2004. One of the document's main objectives was to "provide guidance to sites in their initial implementation of EML, and a roadmap for improving their implementation to achieve higher functionality."[17] It detailed recommendations and example codes. Information managers came to use the document extensively.

The document formalized a set of methods regarding implementation of the standard as a five-stage process. These best practices were ultimately adopted as formal processes to be followed by all sites within the Network. For instance, these best practices came to be used in the funding reviews of the sites where each had to demonstrate that the site "conformed to current best practices for critical design features such as data and metadata encoding."[18] Best practices had become the criteria of excellence and a marker of successful standard implementation.

Unlike troubles, which can often be articulated clearly (I don't have a job or I can't produce standardized metadata), the existence, cause, and treatment of issues are ambiguous and often the site of debate; for this reason, an issue frequently involves a crisis of institutional arrangements. The two facets of institutionalization we have recounted here did not lead to a significant transformation in terms of redistributing human, financial, and technical resources (i.e., information managers did not receive additional resources for community-level work), but it did redistribute responsibility and crediting of work done. The recognition of a new role—"codevelopers"—for information managers meant that they too were evaluated in efforts to implement the data standard. Similarly, the adoption of the best practices process in the Network shifted the responsibility of successfully implementing the standard to the site (scientists and other members of the Network) rather than to the information manager alone.

Community understanding of a problem occurs when from amid troubles, there is a joint recognition of an issue. There were some efforts to raise awareness of this phenomenon as an issue, but at the moment of publishing this article, the story is still ongoing. Further, solutions do not arrive along with the identification of an issue. Once identified, there are a number of possible responses—both reactive and proactive. Institutional response may remain an individually targeted solution (for instance, unemployment is recognized as an issue but still, solutions are mostly individual in the United States). That is, even with the standard implementation recognized as an issue, a number of institutional responses are possible: support discussion forums that enable sensemaking and emergent solutions, create new site-level directives, initiate a community-wide undertaking, or initiate another domain-wide undertaking. Resources could be made available at the site or community-level, where the issue is first identified, or at the domain level. Such decisions are still ongoing as the standardization process continues. Eventually when early responses and communications about troubles may be considered collectively, retrospectively, they may be recognized by developers as an issue that can become the focus of the next phase of what is today called "iterative design," a multiphase development approach in software engineering.

Intervention in Support of Institutionalization

Social scientists, and in particular ethnographers, have carved themselves a unique position within the design, implementation, and evaluation of information systems. Such interventions have sometimes been of a "theoretical" nature, occasionally even changing disciplinary worldviews within the computer and information sciences (e.g., Suchman 1987). Interventions between ethnographers and systems developers have also been common in the design and evaluation of novel tools, for example, in the field of Computer Supported Cooperative Work. In addition, a more everyday role for social scientific methods has emerged in the gathering of user requirements or in evaluating systems following their deployment (e.g., Goguen and Jirotka 1994). Today large-scale system development in science, such as with cyberinfrastructure, quite often includes social scientists as participants in the formulation of the work; cases of such partnering opens up the possibilities for social scientists to play diverse roles in addition to conducting studies (Ribes and Baker 2007; Waterton 2010).

We explore below the ways our orientation toward practice and the role of representation in shaping everyday activity came to "intervene" in the emergence of the second narrative about the development of the standard (the success-to-come narrative), and we call this form of participation for STS scholars an "on the ground" intervention.

Participating in the Construction of an Alternative Narrative

In the broadest conception of the term, participant observation is always a form of intervention. Having a social scientist present during the process of standard deployment stimulates forms of reflexivity among participants that may not occur otherwise, but this is not the focus of this section. Some of our interventions were direct and intentional in that we came to be everyday participants in the deployment of the metadata standard. Over the years, we collaborated with our respondents on many activities: we coorganized a workshop with information managers, engaged in debates over best ways to proceed, cowrote reports and papers directed at the Network and the broader ecological sciences, drew up and circulated diagrams to information managers, conducted surveys of the community, and so on. In doing so, we contributed to communication among the participants by providing an arena for discussions and exchanges. We provided assistance in narrative building through document writing and poster presentation.

Capturing and discussing the implications of these activities is beyond the scope of this article; instead, we consider a single instance of intervention, highly relevant to understanding the emergence of the success-to-come narrative, and of particular relevance to the STS community because it draws on some of the key theoretical insights of our field.

By 2005, four years after the official adoption of the standard, our research was revealing that almost all sites were struggling with the standard implementation. As mentioned earlier, we decided to help by organizing a working group on this particular topic at the annual Network information management meeting, that year in Montreal, Canada. In preparation for the working group, we developed two diagrams representing the process of standard implementation. The initial diagram represented the process in three phases: design, development, and community deployment—where design and development happened at the developers' center, and deployment within the Network (Figure 1a). The second diagram

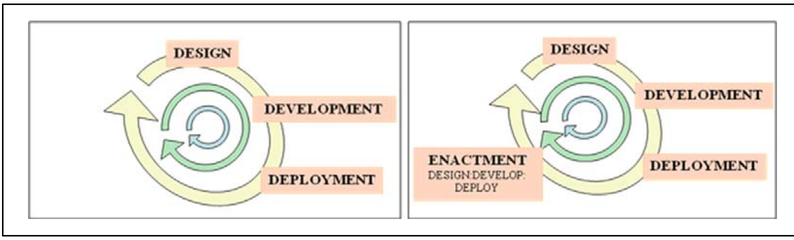

Figure 1. Envisioning information infrastructure: (a) the implementation cycle and (b) the implementation cycle inclusive of enactment.

(Figure 1b) added implementation at the local site, naming it "enactment" and representing it as a nested phase of standard redevelopment within the first diagram.

Implementation can be described as the process of taking a completed set of information tools and making them work for local use; it comes close to the common sense understanding of the term "installing," such as with software on your computer. Our direct intervention here was the introduction in the second diagram of "enactment" to what was an otherwise conventional "stage theory" model of software implementation. Fountain (2001) distinguishes between an "objective" technology, that is to say, a set of technical, material, and computing components (such as the Internet), and an "enacted" technology, that is to say, the technology on the ground as it is perceived, conceived, and used in practice in a particular context. Following this distinction, we suggested the concept of "enactment" to identify a type of work that the information managers were engaged in but that could not be summarized by the term implementation. "Enactment" is defined as the last phase in a multiphase implementation life cycle (design, develop, deploy, and enact) of a resource. The enactment phase requires work to integrate a new resource into local practices as well as into existing organizational and technical configurations. A new cycle is added involving redevelopment of the local work practices as well as the metadata standard itself (Figure 1b). The information managers were not simply "applying or installing" the standard to their existing data, rather they were reworking the standard as they went about the task of implementing it. More subtly, they were reshaping the local practices at each site: how would data and metadata be collected, recorded, and organized in such a way as to facilitate data set description in a standardized manner. Our research focus, and the theoretical sensitivity afforded (Glaser 1978) by STS and practice-centered studies, enabled us to the see these transformations and to articulate them. At this workshop, we explained that the concept of enactment as an augmented approach to understanding the implementation process of a standard.

This diagram (Figure 1b) came to be discussed extensively at the meeting, becoming the focal point of many discussions. The term enactment was understood by the information managers and appealed to them because it gave language to the broad swath of activities with which they were engaged—activities far more ambitious, arduous, and time consuming than is suggested by the term "implementation." Following the meeting, several versions of the diagram were created and circulated among the four coorganizers. At a later meeting, we presented the evolution of the diagrams to the working group because the series captured changes in understanding of the process.

Intervening "on the Ground" in Information Infrastructure Development

Though STS practitioners have reflected on the role of intervention within, for example, the US court system (Jasanoff 2004; Lynch and Cole 2005) or the realm of policy (Webster 2007), the "on the ground" and more "hands-on" roles that researchers may play has not been properly considered. Bowker et al. (1997) called for new forms of collaboration to bridge the "great divide" between social sciences and computer science/information systems. Recent attempts to "unpack" STS interventions emphasize the need to further problematize distinctions between description and action and to explore the different forms interventions can take in both action-oriented research projects and in research carried out under other conditions (Zuiderent-Jerak and Jensen 2007). Ribes and Baker (2007) suggested that the organization of technology projects could come to structure and shape the contribution of social scientists, thus calling for several "modes of social science engagement" (e.g., providing feedback on social issues, participating in propagation of social science findings, contributing to planning and design decisions).

We are far from claiming to be the chief architects in the building of the new narrative. More modestly, we were a single set of participants in a large expert milieu, contributing to the coconstruction of the success-to-come narrative. By taking this approach of participation, we came to learn as much as the participants although with different goals and outcomes. This then provides an example of interdisciplinary bidirectional dialogue and mutual learning to the benefit of all participants.

Conclusion

In this article, we traced the efforts and activities of participants, who in seeking to understand private troubles, transformed the troubles into more public, ultimately institutional issues. They did so through a process of sensemaking and storybuilding. Stories provide an organizational principle for memory to mark out what is worth remembering or forgetting (Douglas 1986). In introducing new groups of actors or rearranging dynamics between the actors already in place, in redistributing resources, roles, and responsibility in organization, a new story may shed light on new types of work and workers, thus assisting in the transformation of *individual troubles* into *institutional issues.*

Infrastructure studies have helped to cast the spotlight on seldom studied phenomena, notably the "invisible" work accomplished in the background by actors whose performance is considered as effective when it remains invisible (Bowker and Star 1999; Star and Bowker 2002; Star and Ruhleder 1996). The work of maintenance and technical support, which becomes manifest only when there are problems, constitutes a luminous example thereof (Shapin 1989). From this perspective, the study of the work as carried out in practice, rather than the study of the actors, makes possible the updating of possible differences between those who accomplish jobs and those who are rewarded for them (Star and Strauss 1999).

This case of an ecological research network developing information infrastructure describes a single issue but provides an example of the very real, substantive difficulties that can be expected in technical work with data and the development of standards. It also provides a detailed account of the diversity of resources and means (stories, surveys, technical tools, diagrams, etc.) that help explain how a local problem, defined as a trouble, is able to move beyond a particular site, gain attention and legitimacy as a substantial issue for others. Notably, this sensemaking and storybuilidng work is not purely a rhetorical activity. Much of the shift from trouble to issue was accomplished through the development of data tools and constructing representative surveys of the community. The integration tool we describe targets the collective that is encountering an issue, rather than individual conceptualized as lacking in skills. The survey data produces an external, objective and accountable representation of "a community" which is also systematically encountering difficulties.

In today's large-scale information system developments in the sciences, such as with, an approach to envisioning local problems not merely as troubles but potentially as issues may provide an alternative to classical institutional responses such as and fault-finding. By choosing to take account of two different perspectives on the process of standardization within a scientific research network, we intentionally tried to contribute to the visibility of a particular point of view, one which was multiple, diffuse, and hardly expressed, and which told a different story.

Our collaborative partnering illustrates the extreme specificity of "on the ground" forms of STS interventions in such cases and how we were in a position to identify resources as they were created or mobilized in this transition: stories and storytelling practices, sensemaking activities and products, work-arounds and actions as well as codification of tools and processes. The transition occurred in two phases: first, from individual stories and understanding to a common understanding; and second, from this common understanding or community narrative to institutional recognition. The success-to-come story served as an interpretive guide for understanding the implementation of the standard as well as serving as a resource for future action—here enacting the standard.

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Notes

1. Mills did not study those institutionalized systems which make accessible individuals and their experiences, or which are able to collate individuals into populations, "making visible" social problems such as unemployment. These systems include sociologists and social workers, along with economists, psychologists, and other participants in modern governance. More recent studies in sociology and history have focused on these particular mechanisms for shifting between such frames: how do private problems become public issues? For example, the historical rise of tools for surveying "economies" or "populations" (Foucault 1991), evaluating the state of the market (Mitchell 2002) or for predicting famine. Closer to the standardizing goals of the standard under study in this article, Bowker and Star (1999) show the development of information systems for keeping track of nurses' work process and activity. Nurses themselves are interested participants in developing and implementing these work classifications systems as part of what we could call a strategy of professionalization. By making the often invisible and undervalued work of nursing something that can be tracked "on-paper," it becomes possible to regulate time and resource allocation: "the fear is that unless nurses can describe their process this way (at the risk of losing the essence of that process in the description), then they will not be described at all" (1999, 272). These are the techniques of survey investigation and statistical analysis which make visible collective phenomena such as nurses' work or, as in Mills, unemployment rates. Although at a significantly different scale than nation-states or continents, the mechanisms by which the individual problems of implementing the technical standard come to be the Network's collective issues are quite similar.
2. In particular, the EML is a "specification" that details technical requirements; a specification is referred to as "a standard" following its adoption and/or use.
3. Both groups are heterogeneous in terms of training and background, and sometimes overlap. For instance, some information managers from the Network participate in projects initiated by information technologists at the center and vice versa. For heuristic purposes, we describe them as distinct in this article.
4. See http://www.nceas.ucsb.edu/.
5. Lengths of the interviews and conference calls were about an hour, while working meetings and design sessions could length up to three hours.
6. We use the word "problem" in a common sense, referring to both "troubles" and "issues."
7. Later on, it was recognized as a limitation built into the standard itself that the list of measurement units that came with the standard essentially cataloged

physical measurement units used commonly in the physical sciences studying nonliving systems (e.g., meteorology, physical oceanography). The Network sites, however, were using a large number of biological and chemical measurement units such as microMoles/liter. For a discussion of this point, see Millerand and Bowker 2008, 2009.

8. In *"EML Implementation Survey—Summary and Analysis"* (e-mail between information managers).
9. In the announcement of the working group that was circulated prior to the meeting (internal document).
10. In: *LTER IM Databits Newsletter, Fall 2005*: http://databits.lternet.edu/issues/161#165.
11. In *"EML Implementation Survey—Summary and Analysis"* (e-mail between information managers).
12. In: *LTER IM Databits Newsletter, Fall 2005*: http://databits.lternet.edu/issues/161#165.
13. Idem, note 10.
14. In *LTER IM Databits Newsletter, Fall 2007: http://databits.lternet.edu/fall-2007*.
15. Issues of power in scientific collaboration can manifest in many different ways other than differences in positions and status (such as between scientists and information managers), for instance in referring to stratification effects in interdisciplinary collaboration (e.g., MacMynowski 2007). We thank the anonymous reviewer for having pointed to this idea.
16. In *Wikipedia* (November 8, 2010), http://en.wikipedia.org/wiki/Best_practices.
17. *EML Best Practices for LTER Sites*,http://intranet.lternet.edu/modules.php?lid=697&name=UpDownload&req=viewdownloaddetails.
18. In *Review Criteria for LTER Information Management Systems (version 1.1 January 26, 2009).*

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Author Biographies

Florence Millerand is an associate professor in the Département de communication sociale et publique at Université du Québec à Montréal (UQAM), and full member of the Centre interuniversitaire de recherche sur la science et la technologie (Interuniversity Research Center on Science and Technology) in Montreal. Her research projects focus on large-scale scientific infrastructure developments in the sciences (cyberinfrastructure, e-Science), collaborative web sites for knowledge production involving experts and ordinary people, on-line discussion forums for health information sharing, social web and participatory culture. More at http://florencemillerand.info

David Ribes is an assistant professor in the Communication, Culture and Technology program (CCT) at Georgetown University. He studies the emerging phenomena of cyberinfrastructure (i.e., networked information technologies in the support of science) and how these are transforming the practice and organization of contemporary knowledge production. A common theme of his research is investigating the sustainability of long-term research organizations. His primary methods are ethnographic and archival. More at http://davidribes.com

Karen S. Baker recently joined the graduate program and the Center for Informatics Research in Science and Scholarship at the Graduate School of Library and Information Science, University of Illinois at Urbana-Champaign (CIRSS/GSLIS) after having worked at Scripps Institution of Oceanography (SIO), University of California San Diego as Co-Director of Ocean Informatics and as the Information Manager for the Long-Term Ecological Research programs at SIO. Her long-term interests are in data practices and learning environments as well as in data stewardship and the growth of information infrastructure.

Geoffrey C. Bowker is a professor in the Department of Informatics, School of Information and Computer Science, University of California at Irvine. He also

directs the Values in Design laboratory there. His research focuses on the development of large scale scientific infrastructures and on emerging configurations of knowledge expression. His most recent book, Memory Practices in the Sciences, was published by MIT Press.