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Who are the users? Who are the developers? Webs of users and developers in the development process of a technical standard

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Abstract. *The paper presents an empirical study of user involvement in developing a technical standard for a scientific community's information system project. The case illustrates how multiple perspectives are involved when considering the user role in practice. The case presents a situation where both developers and users were pre-defined in the design and development phases of the standard as homogeneous groups of actors. Groups of actors changed to become more heterogeneous and 'fluid' in the deployment and implementation phases, thus forming 'webs of developers' and 'webs of users'. Detailed analysis of the process in its entirety shows the blurredness of boundaries between 'developer' and 'user' categories and roles, and reveals challenges at social and organizational levels. Three models pertaining to the system development process are presented in order to illuminate differing perspectives on the user and on the development process itself. The paper draws theoretically from information systems, social informatics, and science and technology studies. The research contributes to a deeper, interdisciplinary understanding of 'the' user, of multiple roles in systems development, and of dynamic sets of user–developer relations.*

Keywords: user, developer, enactment, design, ethnography study, standards

INTRODUCTION

The user is a central actor in information systems development processes and as such is subject to extensive study in theory and in practice. The user – often problematic in getting involved in the design process as well as in fitting into a pre-defined role – is of great importance to system development. We argue that the user concept itself is underdeveloped in theory. This is similar to underdevelopment of other key terms and phrases in scientific research (News, 2008). For example, the phrase 'system usage' is an accepted part of the lexicon, but only recently have researchers granted it theoretical scrutiny (Burton-Jones & Straub, 2006; Burton-Jones & Gallivan, 2007).

Common understandings of complex concepts such as information systems, standards and users often rely on the idea of mutually exclusive categories or simplifying black box models. From a stereotyped yet widespread user's point of view, the development and implementation of technical standards associated with information systems are traditionally viewed as painful processes largely because the processes and the standards themselves are frequently more complex than anticipated. From a simple technology-driven point of view, users have a characteristic reluctance attributed to dislike of change; users often are seen to suffer from a lack of training as well as a lack of sufficient interest. There are design approaches and information system methodologies that offer strategies on how to involve users at various phases of the development process taking into account users as holding various roles such as hands-on user, social actor and sociopolitical actor. Considering these views concurrently leads to a deeper understanding of the user concept and the multiplicity of roles that users play in practice as well as to a reconsideration of the distinction between users and developers.

We aim to demonstrate the value of joining different yet complementary views of the user. Our interdisciplinary research team used a qualitative research approach within an action research framework to observe and analyze the development and implementation of a technical standard in a scientific research community working on development of an information system. From this empirical case, we suggest a new conceptualization of 'the' user and of the multiple roles in systems development in terms of 'webs of users and developers'. From Kling & Scacchi's (1982) 'web of computing' concept, we define a 'web of users and developers' as dynamic ensembles of interrelations between users and developers in system development processes. The web construct contrasts with the analytic simplicity of a discrete entity model that takes computer resources as independent and socially neutral tools. Introducing such a dynamic highlights the translation, negotiation and mediation processes occurring throughout information systems development processes.

We elaborate on the various roles that users play in practice – including co-developer – and we stress how these roles change depending upon the system development model at hand and in mind. We draw from the definition of role in organization theory that allows an actor to have several roles at the same time. Users and contexts of use are hard to identify; most of the time, both are 'discovered' during the system development process. A theoretical understanding of the user concept as well as of users and developers interrelations provides the context for a deeper understanding of information systems development and implementation processes both in theory and in practice.

A contribution of this paper is presentation of an empirical case that illustrates the dynamics of user roles' during development of an information system. The second contribution of the paper is a theoretical account of the multiplicity of user roles and the complexity of user–developer interactions developed from a combination of different theoretical perspectives. The third contribution is a fuller understanding of the complexity of the standard development process summarized in three models of system development emerging from ethnographic study.

In the background section of the paper, we present a literature review of user categories and conceptualizations, and user–developer relations from three distinct perspectives. Our research setting and methods follow with a description of the empirical case. We then present a detailed analysis of the case. Finally, we discuss implications for user involvement in system development and outline several research threads for enrichment of both theory and practice of systems development.

BACKGROUND: UNPACKING 'THE' USER

Involving users in systems development may be viewed as a way of taking into account social and organizational contexts of systems development and use. In considering the interplay of technology users, information systems and organizational contexts, we draw from information systems, social informatics and science and technology studies literatures where social informatics can be seen as a research field that crosses multiple research domains including information systems and science and technology studies. Each takes into consideration the user from a different perspective, and each contributes to an understanding of user relations.

The term 'user' carries with it an intuitive simplicity when defined and used in the sense of an imagined representation. A simple conception of users as part of a two-category set of groups – developers and users – suggests distinct, separated stages of work, i.e. developing the system and then using the system. From this perspective, an emphasis on 'the' user emerges even when this user is not a homogenous group.

Once the user is let out of a two-category box model, a variety of user roles emerge. The user is intertwined in multiple relations, existing in relation to objects (that which is being designed and that which is to be used), actions (that which is presented and that which exists) and settings (at the design table and in practice). Friedman (1989) developed various categorization schemes, such as a six-category typology of patrons, clients, design inter-actors, end-users, maintenance inter-actors and secondary users that spans an information system development cycle. Information system development approaches have taken into account a full cycle appearance of the user. For instance, Mackay *et al.* (2000) with Rapid Application Development considers three user roles – visionary, ambassador and advisor – and points out the 'fluidity' of the boundary between user and developer. From the early 1980s, end-user computing implied blurring the roles of users and developers when users develop applications themselves (Nardi, 1993). When re-conceptualized as a 'social actor' (Lamb & Kling, 2003), the user appears in new ways throughout the information system building process. Participatory design views users as co-designers (Schuler & Namiok, 1993). Contemporary design styles in practice across multiple domains emphasize the action of co-design, e.g. practice-based design, ecological design, contextual design, design-in-use, collaborative design and performativity (Beyer & Holzblatt, 1998; Orr, 2002; Suchman, 2002; Bratteteig, 2003; Jackson & Baker, 2004; Jensen, 2004). The system user may be cast into the role of 'co-designer' just as system observers may be moved into roles of 'co-participant'. The concept of users has morphed from less-than-competent-system-users to holders-of-local-knowledge and validators-of-system-usefulness, who hold potential as local innovators able to negotiate and arrange realignment and use of standards, applications and systems. Whereas the user has been 'envisioned' (Bardini & Hovarth, 1995), 'projected' (Akrich, 1992), 'managed' (Agre, 1995), 'prescribed' (Latour, 1992) and 'configured' (Woolgar, 1991), we expand the concept of the user by exploring and articulating a multiplicity of user roles.

Diverse representations of the user are the subject of ongoing investigation and parallel work in the field of information systems development where linear approaches such as the waterfall model have been replaced by notions of prototyping, iterative and spiral design, and systemic approaches (Friedman, 1989; Bell & Wood-Harper, 2003). These approaches recognize systems as holistic and dynamic; they underscore the interdependence of design, development and use. Though a life cycle may be presented as ordered stages that appear to create one-pass linear systems, the life cycle concept may be broadened to represent a multi-pass or iterative process full of eddies and backflows that reflects the fluidity of design in practice. This interpretation draws from an appreciation of the reductionistic-systemistic continuum (Sinn, 1998) and the extension of technological facets of work that place an information system within its organizational, social, communicative or pedogical context (Lyytinen, 1987; Iivari, 1991; Iivari *et al.*, 1998; Friedman & Miles, 2006). In contrast to a positivist approach, alternative research perspectives focus on the ways by which technologies and users shape each other, in a constructivist epistemological framework (Bijker & Law, 1992; Star & Ruhleder, 1996; Lindsay, 2003; Oudshoorn & Pinch, 2003; Haddon *et al.*, 2005).

The need for an improved understanding of users, user involvement (e.g. Olson & Ives, 1981; Cavaye, 1995; Flynn & Jazi, 1998; Howcroft & Wilson, 2003) and developer–user relations (e.g. Beath & Orlikowski, 1994; Jirotka & Goguen, 1994; Coughlan & Macredie, 2002; Gallivan & Keil, 2003) is well recognized in the field of information systems development where research on approaches and methodologies suited to effective user involvement is a priority (Avison & Fitzgerald, 2003). For instance, the ETHICS method based on the socio-technical systems theory (Mumford, 1983) constitutes the foundation of current user-centred methods, where social requirements and users' participation in information systems processes are emphasized. Soft systems methodology (Checkland, 1981; Checkland & Poulter, 2006) and participatory design (Greenbaum & Kyng, 1991; Schuler & Namiok, 1993) provide further understandings of users' roles with the introduction of key concepts – such as human activity systems and multiple perspectives – and a greater attention to work situations. A review of user definitions in the information systems development field shows their diversity and evolution over time with methodologies moving from basic technical problem solving approaches to approaches incorporating multi-methodological techniques and use-related activities. From an activity theory perspective, recent work by Barki *et al.* (2007) distinguish three use-related behaviours – technology interaction behaviours, task-technology adaptation behaviours and individual adaptation behaviours – where task-technology adaptation may entail modifying or 'reinventing' the system by users. Thus, the user may be seen as an evaluator of design decisions (e.g. prototyping approaches), as a social actor (e.g. ETHICS method), as a social, cultural and political actor (e.g. soft systems methodology), and a domain expert (e.g. participatory design). However, Isomäki & Pekkola (2005) point out that user-oriented methods still are not well connected with information systems development processes. Guidelines are lacking, partly caused by a lack of dialogue between scholarly work in systems methods and systems use. Further, the need for theory and practice to inform and thereby co-constitute each other continues to emerge within the literature (McGrath, 2005).

We consider three views of the 'user' pertinent to our empirical case:

1 Hands-on user: the user who interacts 'hands-on' with an information system. This view regards the user as engaging in definition and development of the system.
2 Social actor: the user as an actor who generates, exchanges and consumes information mediated by the information system in multiple social contexts and among a variety of working activities. This view focuses less on the user of the system and more on the user of the information mediated by the system.
3 Sociopolitical actor: the user as an actor whose social role, organizational position, and political capacity within an organizational and political 'web' of interactions is impacted and mediated by the information system. This view focuses more on the interactions among the actors rather than on the actors per se. This perspective highlights the negotiation and mediation processes occurring among the actors involved in information system development processes. The user view as a sociopolitical actor echoes back to the notion of stakeholder as usually interpreted in the literature (see: Bruga & Varvasovzky, 2000) where a stakeholder's interest is normally based on the fact that the information system impacts him or her.

The focus on the social actor in the social informatics literature and the sociopolitical actor in the science and technology studies literature is complemented by development of the user concept in the information systems literature beyond a simple user–developer, technology-led perspective. In working with multiple views of the user, a dynamic set of user–developer relations emerges.

RESEARCH SETTING AND METHODS

We examine the development and enactment of a technical standard called the Ecological Metadata Language (EML) in an ecological science research community, the Long-Term Ecological Research Network (LTER; Hobbie *et al.*, 2003). Standards have been described as complex socio-technical systems (Hanseth *et al.*, 2006) and as critical to interoperability in Lyytinen & King (2006). They represent one aspect of the technical development of a network information system that brings together local data sets and facilitates data exchange across the LTER research community.

Using a qualitative research approach, we focus on user involvement and user–developer relations throughout the development process of a standard. Our research is part of a larger multi-year project involving comparative study of scientific communities concerned with major information infrastructure efforts (Baker *et al.*, 2005; Ribes *et al.*, 2005; Baker & Millerand, 2007).

Empirical case

As a scientific research community, the LTER network constitutes a highly distributed, heterogeneous, and multi-disciplinary network of more than 2300 participants conducting environmental science spread across 26 sites or research stations located in the continental North America, in Antarctica and on islands in the Caribbean and the Pacific (LTER: http://www.lternet.edu/). With a research focus on long-term ecological phenomena such as decadal patterns and global warming, the need to work collaboratively to share and to exchange scientific data sets across the network constitutes a key challenge. Sites in the network take responsibility for the management of research data produced locally, each having its own data collections, information systems and data management strategies. An information manager working closely with the scientists is charged with the capture, storage and access of data as well as the development and maintenance of local information systems and attendant infrastructures. Across the network data are stored autonomously by the different sites – an arrangement that renders the search for and access to data relatively complex (Baker *et al.*, 2000; Karasti *et al.*, 2007). Accordingly, a networked infrastructure permitting the federation of local data sets or data systems in order to enhance data exchange across the network was initiated in 1996. Efforts to develop the networked information infrastructure crystallized in 2001 with the endorsement of EML as a community metadata standard project. In short, EML aims to provide a specification for the generation of metadata in the specific domain of the sciences of the environment (Jones *et al.*, 2001; 2006). In an ideal world, metadata contain all the details necessary for all possible users of a data set including a wide variety of users not directly familiar with the measurements at their origin (Lytras & Sicilia, 2007). These include detailed information such as the data collector name, data provider name, title of sponsoring project, project summary, key words, type of biome under study, sampling techniques and so forth. The possibility of data reuse will depend upon the quality of the metadata as well as the data.

Our study examined development and implementation processes of the standard. EML development started in 1997 at an ecological research centre [National Center for Ecological Analysis and Synthesis (NCEAS)] following an open development model based on voluntary participation from the broad community of environmental scientists. A few information managers from the LTER community worked closely with the developer team initially composed of informatics specialists from NCEAS experienced with technology application and familiar with ecological science. When released in 2001, implementation of the standard began in the LTER research community. Six years later, an initial enactment of EML is almost complete but proved to be a harder and longer process than anticipated. The difficulties and delays encountered acted as one of the triggers for this study. There are three principle groups of actors:

1 Informatics specialists, associated with the research centre, are funded to design and develop EML together with associated tools to be used as elements of ecological community information management. In a two-category developer–user view, these are 'the developers' who create applications and work on metadata specifications.
2 Ecological scientists, members of the scientific network, are going to use the information system as well as the data sets produced by the information system (the final product). From the developer–user view, these may be seen as users of the standard or as beneficiaries of the standard.
3 Information managers, members of the scientific network, are responsible for curating the data and implementing the standard at each site so that scientific data sets can be produced and shared across the network in an agreed upon manner.

Our analysis will show how the evolution of roles requires making a distinction between information system usage and standard usage.

Data collection

The study uses qualitative research methods drawing from grounded theory building and making use of ethnographic techniques (Strauss, 1987; Strauss & Corbin, 1990; Reason & Bradbury, 2001). From a qualitative research perspective, we want to understand the processes of systems development and enactment through a detailed description of the case, its characteristics and setting. We take an empirical, multi-perspective and interpretative approach (Orlikowski & Baroudi, 1991; Hindmarsh *et al.*, 2000; Chen & Hirschheim, 2004), investigating the meanings and interpretations of the participants to understand the why and how of what we observe in terms of decision making processes and behavioural patterns. We inscribe our research in an action research framework that partners practitioners with an interdisciplinary research team (Whyte, 1991; Reason & Bradbury, 2001). A longitudinal study and multi-year partnership began in 2002 (Karasti & Baker, 2004) and continues today. The work reported here is formulated by a team comprised of a researcher from science and technology studies and a participant of the scientific community experienced with information management and science studies. Our focus is on the ongoing improvement of practice by the participants themselves. We explore the community workings through discussion of fieldwork studying standards-making – the process of moving from a set of rules in theory to standards-in-practice and vice versa. The framework provides a unique opportunity to bridge theory with practice, allowing 'real-world' problem solving at the same time contributing to the production of new understandings (Lau, 1999).

Data collection techniques include participant observation, structured and unstructured interviews, document analysis as well as interventions and collaborations taking the form of working group organization, oral presentations, co-design activities and joint publications. The research occurred over a 2-year period (2004–2006) and was conducted largely from one of the 26 sites of the LTER scientific community. We conducted 15 interviews – including nine interviews with information managers from seven different sites, two interviews with other

LTER members and four interviews with standards developers at the research centre. We participated as participant observers in periodic conference calls over a 6-month period with working groups dedicated to the EML standard implementation and other related topics. For the annual LTER information managers meeting in August 2005, we co-organized a joint working group meeting in the form of a workshop titled ‘Community Process and Standard Implementation’ involving developers and information managers. We used a survey instrument to elicit information before and after the workshop, and we reported the results with a joint publication in a community newsletter (Millerand *et al.*, 2005).

This empirical case is concerned with technical issues, organizational elements and social ramifications. In investigating and describing development and enactment of a standard, we find that the roles of user and of developer emerge as dynamic webs of users and developers within the development process of a standard. Objects and settings are frequently local so have a specificity defined by circumstances of organization, time, political arrangements, etc.

ANALYSIS

Development process model

In this section, we analyze the observed development process of the standard in terms of a model that we describe as a development model together with an associated local implementation model that adds detail to the implementation phase of development. We observed a shift in focus during implementation as the standard was implemented first at the research community level and then at the individual sites. A joint understanding of the development process as four phases (Figure 1a) was documented prior to the joint workshop; the implementation phase emerged in greater detail as an implementation process including local design, development, deployment and enactment phases (Figure 1b). Looking closely at implementation brings the mediation and negotiation processes associated with local enactment to the foreground, making them more visible and understandable. These models have implications for the distribution of roles and responsibilities in system development and for user–developer relations.

The EML standard development process was cast from a developer-manager perspective in terms of a traditional sequential four-phase process (Figure 1a) where design implies devising and designing the standard, development implies building it, deployment refers to its release and spread across the scientific community, and implementation entails making the standard functional in practice. This development model consists of two main categories of actors with well identified roles: developers, acting at the design and development phases; and information managers – localized at the sites in the scientific community, acting as ‘implementers’ of the standard so that standardized data sets were available to ecological scientists.

Although some information managers began the work of implementing the standard relatively quickly, most ran into significant issues that required attention. Information managers became not only ‘local implementers’ of the standard but also ‘local developers’ of tools and

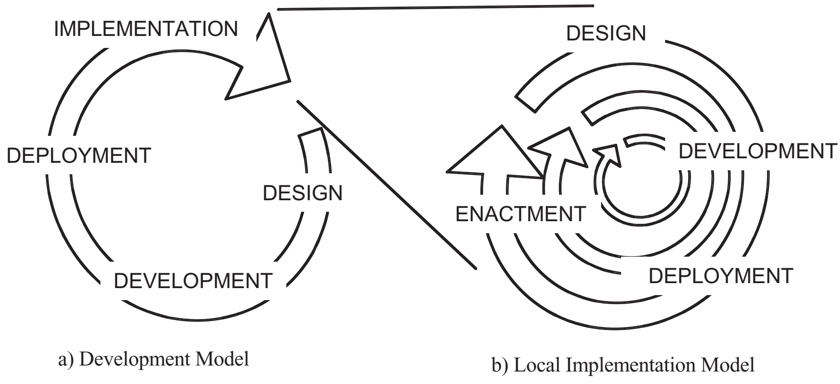

Figure 1. Models describing the development process: (a) Development Model with four phases: design; development; deployment; and implementation, and (b) Local Implementation Model with four phases: design; development; deployment; and enactment. The implementation phase of the Development Model is expanded into an iterative process described in the Local Implementation Model. The two processes represented – a broader-scale development cycle and a local-site implementation cycle – may occur sequentially in the short-term but from a longer-term perspective may be seen to co-occur.

techniques as well as of new local systems and data practices required in order for the standard to be implemented. For instance, the technical tools provided by the development team to facilitate the standard's implementation proved largely unusable when there were difficulties aligning and/or blending with existing information systems and practices. Local implementation work became much more than developing the details necessary to make the standard work; it implied redesign and redevelopment activities, such as tool development and best practice formulation. Further, there was readjustment of pre-existing practices, such as adoption of new conventions for metadata work. Amidst ongoing refocusing, reorganizing and recoding, we suggested the local mediation be given the name 'enactment' in order to identify the implementation phase as a process that accounts for the multidimensional local work involved that was technical and organizational as well as social and political. Enactment identifies the specifics of use in practice within the context of local arrangements (Orlikowski, 1996; 2000). From a local user perspective, the implementation phase of the EML development process (Figure 1a) opened up to include a distinct iterative four-phase local implementation process (Figure 1b) with activities occurring locally over time, iteratively and sometimes simultaneously; the 'multi-pass system' is represented by multiple arrows. Technically, information managers provided feed-back about the standard to its developers and also worked together within working groups facilitated by their community-of-practice communication infrastructure to redesign and redevelop elements relating to the standard including extensions to make it more usable and useful locally. Organizationally, information managers worked and negotiated among themselves and with the scientists regarding resource allocation and implementation strategies. Socially and politically, information managers and developers negotiated when reports and stories about the whole EML project started to circulate, whether in terms of a ‘success story’ (from a developer’s point of view) or in terms of a ‘success to come’ (from an implementer’s point of view) (Millerand & Bowker, 2008).

Development of the local implementation model was prompted by a dialogue we initiated with the developer and information management communities in order to explore the work of creating a community standard (Millerand *et al.*, 2005). Consistent with our action research framework, we co-organized a working group on ‘Community Process and Standard Implementation’ at the information managers August 2005 annual meeting where we introduced the enactment concept from organizational theory (Weick, 1979; Orlikowski, 1996; 2000; Fountain, 2001). The term enactment was found to account effectively for the work performed beyond common ‘implementation’ tasks and to be valuable as a shared community concept of development (Millerand *et al.*, 2005).

The EML standard is complex: its organizational flexibility includes a well-defined data set structure with a nested hierarchy of metadata description that allows for multiple starting points in organizing collections of data sets by project, study and instrument platform; its interpretive flexibility includes a lack of specificity for elements such as ‘methods’. The generality left room for subsequent discovery of specifics but also made it difficult to understand and enact in its entirety early on by the information managers. There existed differing ramifications of enactment depending upon decisions made with respect to fitting to existing local practices vs. planning for future community uses. Differing types of enactment have been distinguished, i.e. inertial (when the new system is used to retain pre-existing way of doing things), application (when it is used to augment or refine pre-existing practices) and change (when it is used to substantially alter pre-existing practices) (Orlikowski, 2000). In this case, although the standard was supposed to improve pre-existing practices (application type of enactment), it required in practice substantial changes at a number of sites, as information managers recognized the need for a complete redesign of their data management structures and practices.

The whole process, starting from the standard’s first design to its enactment across the scientific community, provides an interesting situation where users and developers moved from a homogenous, isolated group of participants to an assemblage of reformulated groups.

Webs of developers and users

When the proposal to develop EML as the metadata standard for the ecological sciences was submitted to the funding agency in 1997, the concerned actors and their roles were easily identifiable. The standard was to be developed as a specification by a group of informatics specialists at an ecological research centre experienced with technology application and familiar with ecological science. Users of systems that used the standard were envisioned as the ecological scientists from the broader community of environmental sciences. Two years after version 1 of the standard was developed, native limitations were identified and a new version planned within an open development framework based on voluntary participation from the broader community. In particular, some targeted user communities were more clearly envisaged, including the scientists of the LTER network. The open development model informed and influenced LTER Information Manager community discussions and attracted

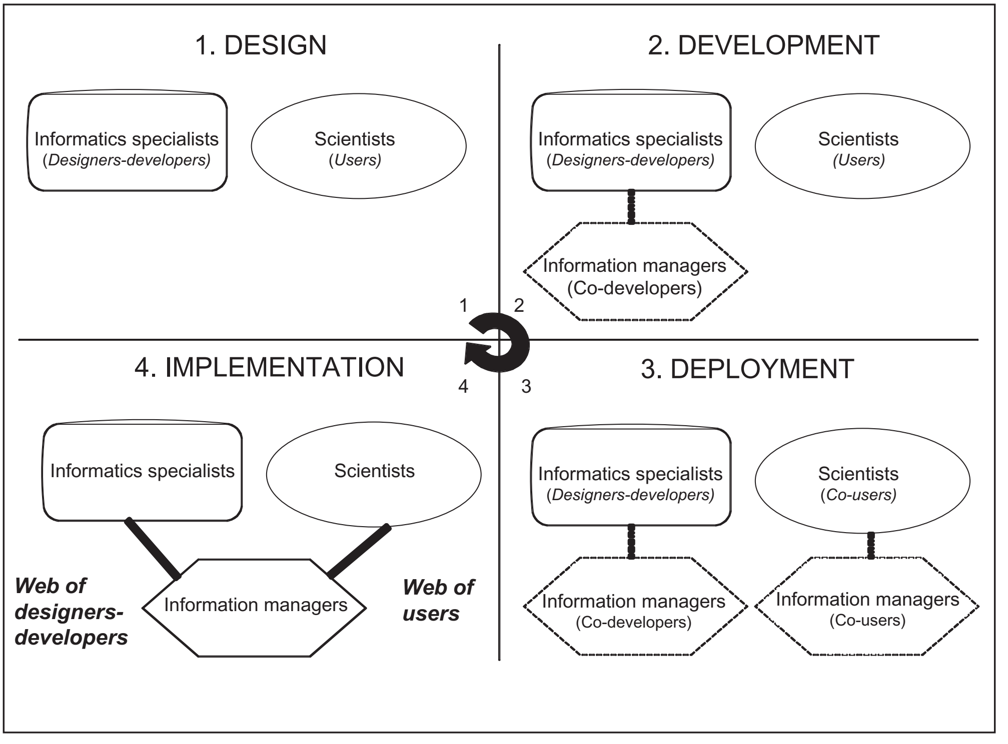

Figure 2. From users and developers to 'web of users' and 'web of developers'. The dashed lines represent an emergent role.

additional developers, including – for the first time – a separately but synergistically funded information manager from the LTER community. The developer team moved from being collocated individuals with comparable backgrounds (the informatics specialists from the research centre) to a more diverse and distributed team working through a collaborative platform in the form of an informatics organization developed as a forum and as a representation of the development community (http://ecoinformatics.org). In 2001, the developer team considered version 2 of EML stable enough to present to the LTER information managers, a community actively in quest of tools and strategies to tackle data interoperability issues across the network. EML was adopted and endorsed by the community, leading to its deployment at the sites. From that moment, who were the users and who were the developers became less and less clear as regrouping occurred in development and deployment (Figure 2).

Users were thought to consist of the scientists in the design and development phases of the standard but ultimately included information managers in the deployment phase as co-users. In a similar manner, the team of developers became a more extensive co-developers team – including informatics specialists and information managers.

Web of developers

We present two examples of initiatives by which the information managers and the developers joined to form a web of developers: the development of a best practices community document; and the prototyping of an approach to facilitate implementation of the standard (a unit registry and dictionary).

The information managers looked for help with enactment within the community; two workshops devoted to implementation of the EML standard were organized. These led to the production of a synthetic ‘best practices’ document by the information managers for implementation of the standard in the LTER community. An ‘EML manual’ provided by the developers existed already, but its universal nature together with the inherent flexibility built into the standard created a lack of specificity or guidance at the local level. The LTER EML Best Practices document had a material impact on enactment at a number of sites. For instance, it provided specific community examples to guide-mapping of local information to standardized metadata tags. At the working group meeting, the two approaches to an EML manual emerged and were brought forward for discussion. On one hand, the information managers took pride in having developed a document that had been found useful in facilitating enactment of the standard. On the other hand, the developers, having in mind the scope of implementing the standard throughout the ecological community, suggested the LTER information managers consider creating a less community-specific document. An important subtext to this story is that neither had planned or was supported specifically to create such a document; it was not part of a requirements specification. This difference of views – one emphasizing the benefits of universality that encompasses a larger scope and the other focusing on the need for specificity in guidelines in order to represent local situations – frequently surfaces as a tension between theory and practice or between the general and the particular but may most productively be recognized as a dichotomy inherent to many situations including knowledge production. Bratteteig (2003) presents dichotomies as inseparable from design processes, as requiring discursive work and active negotiation so that choices and their ramifications are generally identified, understood and supported rather than dismissed. In this empirical case developers could see the scientific community as provincial and too narrowly focused whereas the community could see the developers as too vague and disconnected from the realities of their daily work practices and needs. At this point differing values may be recognized in the process; that is, the design process is not value-free.

Subsequent to the development of the best practices document, a subgroup of information managers initiated a working group dedicated to the production of a process to facilitate the standard’s enactment at the sites, a dictionary of measurement units (Baker *et al.*, 2006). One of the principal difficulties facing information managers was tied to the complexity of the work of complying with the standard, that is, of translating existing metadata into this standardized language – notably with respect to one kind of metadata: measurement units. On the one hand, a dictionary of measurement units incorporated in the standard essentially catalogued measurement units of ecological phenomena – largely physical units though most of the community sites were using biological and ecological measurement units. On the other hand, it is extremely difficult to describe a specialized biological measurement unit in a standardized language. These personalized units are sometimes part of the scientific process, developed for some targeted purpose in a research project and only making sense in the context of that project. Faced with such difficulties, some information managers began to exchange lists of measurement units (including local ones) used at their site, creating a comparative process for their respective translations in order to identify both inconsistencies in naming conventions as well as differences in methods or meanings. This quickly evolved into an informal project to transform these lists into a community-wide catalog of units. The plan was to produce a dynamic, online prototype tool. The team, which until then had been made up solely of information managers, expanded specifically to include a member of the LTER network developers' team. As such, the dictionary effort was both an implementation aid for the standard and an example of an effective collaboration between information managers and developers. Technically, the dictionary process and associated tools would provide the information managers access to definitions of measurement units in the standardized language (including some specialized units). However, it did considerably more than facilitate conversion from one format to the next. It was also a coordination mechanism among the information managers themselves as well as between the information managers and the developers, both of them forming then a co-developers team.

Five years later, the work of local enactment of the standard and its use continues. In brief, as often tends to happen, the standard that the developer team delivered had to be partially re-factored in order to be usable in practice. But putting this standard into practice required not only the traditionally understood implementation work – which is developing the details necessary to make the standard work – it required enactment work, which is engaging in redesign and redevelopment activities to make the standard useful and usable locally as well as engaging in restructuring work to adapt pre-existent infrastructures and practices. Both the production of the best practices document and the units' tool initiative are examples of redesign, redevelopment and restructuring activities. Thus information managers in the scientific community, the 'implementers' of the standard became an extended developer team, part of a web of developers.

Web of users

The scientists – as intended users – encountered the complexity of the standard and its associated new constraints when already in the deployment phase. The significant investment of time required learning first about using the standard and second to make use of it effectively proved to be off-putting. Just talking in terms of quantity, standardized metadata could represent the double of the data they described. That is to say, using the standard itself implies the dedication of a significant amount of time especially for scientists not familiar with systematic and structured metadata generation. Further, incentives were not clear or strong enough to enroll them in this effort. Most of them relied on information managers' collaboration and help. Thus, use of the standard was largely delegated to information managers who became part of an extended user team: the ecological scientists as users of the standardized data sets and the information managers as the users of the standard. Scientists were supposed to make data accessible to the research community through an information system but also to make use of the information system (filled with well-described data). This contributor role was part of the user role that was assigned to them. At the same time, the information managers moved from being implementers of the standard to being users of the standard, as they used it to describe and deliver local scientific data. Thus the information managers, who were seen as ‘implementers’ from a developer’s point of view, became ‘enactors’ in practice, that is, actors in a local implementation cycle who represented together with the scientists an extended user team, forming a web of users.

What does this focus on developers and users moving groups – which appears to be a frequent phenomena in practice – tell us about systems development processes and users involvement practices? First, such a focus helps in identifying critical social and organizational challenges associated with information systems development such as resource allocation and division of labour. Second, it creates sensitivity to the multiple changing roles in which involved actors must invest in practice – that are often quite different from what is originally planned. This approach enriches our understanding of system development processes both in theory and in practice, and suggests insights that may enable resource planning in the future that better reflects the work involved.

Social and organizational challenges

Throughout the development process of the standard, new definitions of developer and user groups as well as crossovers from one group to the other emerged in parallel with critical social and organizational challenges. In particular, *ad hoc* rearrangements of developer and user groups reflected larger unresolved and/or unexpected issues in the standard development process in terms of, for example, implementation process understandings and planning, resources allocations, coordination work within distributed communities, division of labour, professional recognition, actors’ learning curves and so on.

The development of the role of an information manager at local sites as part of the LTER vision for network science is an interesting aspect of this empirical case. In the original vision of the standard that prevailed during the design phase of the development process, little mention was made of roles for the information managers. A developer team was to design and develop a metadata specification as a new standard for the community of scientists to – hopefully – adopt and use so to foster data sharing and collaborative research projects. At this stage, the work of the information managers is invisible in the sense described by Star & Strauss (1999). This work is invisible in the same way as the standard local enactment work is unseen. What is ignored – or taken for granted – is the labourious adjustment work necessary to make the standard fit with local singularities (such as disciplinary data) and a legacy of infrastructures, and at the same time, the restructuring work of pre-existent practices such that new ones emerge (Star & Ruhleder, 1996). All these tasks were in addition to the regular day-to-day workload.

In practice, when information managers make visible and explicit the inherent difficulties of enacting the standard, they accomplish a number of things important to systems development endeavors. First, they perform a redefinition of the previous division of labour in terms of a developer team on one side and a user group on the other by adding new conceptualizations: a web of developers and a web of users. In so doing, they sparked discussions and negotiations regarding resources and responsibility allocation as well as regarding their organizational position and professional recognition. The information managers' contribution in improving the standard through re-design and re-development activities, together with their new expertise with standard usage challenged their pre-existing social and organizational positions and status.

Second, the information managers contribute to an elaboration of the standards development process by highlighting an unplanned local enactment phase. This holds potential benefit for other research communities dealing with standards and information system development (at a practical level) and contributes to a better understanding and planning of such processes (at a theoretical level).

Third, they contribute to the conceptual development and articulation of a key issue in establishing a scientific community standard: its maintenance and development over time. A working EML standard implies a maintaining of itself as a community-wide structure as well as an adaptation of itself (to fit diverse local needs including existing and future information systems) and of information managers' pre-existing work practices (to comply with new data management processes). The viability of a working standard involves at least three phases: endorsement, adoption, and finally its continuing use in association with negotiated changes over time. That is, the EML standard could not operate as a standard per se within the LTER community without ongoing mutual adjustments and without the recognition of the various roles played by the actors in practice. The relative importance of endorsement for planning in the implementation phase and of adoption for the local enactment phase is an aspect of the development process that would benefit from further consideration.

In this case, delays in the standard's deployment throughout the scientific community are interpreted as revealing neither the capacity of resistance of the users (information managers plus scientists) facing enactment of a community standard nor the limits of EML itself as a shared standard. Rather, delays and unexpected challenges may perhaps be better understood as symptoms of collaborative work being in early phases of development and of misunderstandings with respect to the development process of standards, of the new and multiple roles of actors, and of the distribution of resources. Clearly, delays in the deployment of the standard across the LTER community reflected a mismatch between 'de jure' (anticipated) developers and users vs. 'de facto' (effective) developers and users. Further, the implicit negotiations about who were the users and who were the developers that occurred throughout the standard development process, from its design to its local enactment, reveal the permeability of the boundaries between the two groups in practice.

DISCUSSION: USERS–DEVELOPERS RELATIONSHIPS IN PRACTICE AND IN THEORY

Users are being given increasing attention in information system development, both in theory and in practice. We have moved from considering 'the' user as a monolithic, well-defined

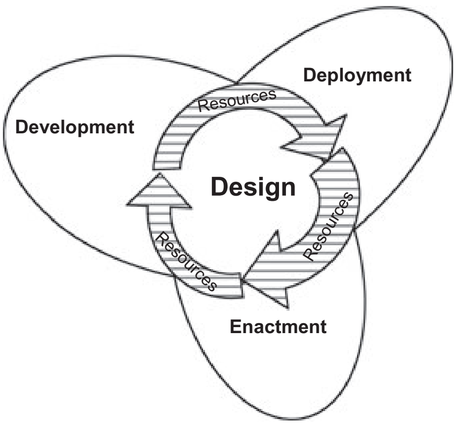

Figure 3. Integrative Design Model: the cycle of standards development is shown as a three-phase model (development, deployment and local enactment) where design activities occur throughout all three phases.

group, to a more complex and fragmented one (Mackay *et al.*, 2000). The empirical case presents a situation where both users and developers moved throughout the development process. In practice, users and developers evolved to include and represent different types of actors. In theory, users and developers moved from a relatively simple and stable group to a more complex and unstable one. Users presented originally in the design and development phases of the standard as a homogeneous and well-defined group of actors (scientists) changed to a heterogeneous and much more 'fluid' group of actors (scientists plus information managers) in the deployment and enactment phases, where ecological scientists and information managers acted as links in a web of users. In the same way, developers moved from a stable and homogeneous group to a more diverse and changing one.

Users and developers are not stable entities; they tend to adopt multiple roles that are constantly evolving throughout information system development processes. Although invisible in the original standard's design–development–implementation planning, information managers vested with different roles. They acted as: (a) user representatives – first when difficulties in the standard's development called for a user representation with the developers, second when difficulties in the standard's usage called for information managers' help and expertise; (b) co-developers – when engaged in tool production such as best practices and dictionary prototyping to facilitate and adapt the standard to fit local needs; and (c) co-users – when the ecological scientists' participation in the standard's enactment required their collaboration and help.

We suggest an integrative design model (Figure 3) as an alternate understanding of the initial local implementation process (Figure 1b). As a result of our analysis of the empirical case after the August 2005 joint workshop, we identified design activities occurring at all phases of the local implementation process. Figure 3 shows a continuing three-phase process – development, deployment and enactment – with design and attendant dialogue placed at the centre.

There are ensembles of participants at all phases engaged in and joined together both by the overarching conceptual undertaking of the task at hand and by the design work in practice. This reconceptualization shows a design hub that is ever-present. In this model (re)design activities occur continuously at each of the three phases. A continuing cycle replaces the multiple arrows that represented iteration in Figure 1b. This model makes explicit an enactment phase that encompasses more diverse and complex tasks than traditionally expected or planned for in implementation work, tasks such as design activities carried out by information managers at geographically distributed sites. It also makes explicit that resources – and negotiation processes for their allocation – are a critical enabling factor, with growing resources required as the design team increases from the original developers team to local participation and interface. In this empirical case, resources were obtained for the development process as a whole (Figure 1a) but not for the local implementation part of the implementation phase in particular (Figure 1b). Some small additional resources in the form of supplements were available on a one-time basis to a limited number of sites in the scientific community. There was a general call for more resources but there was also a lack of conceptual detail and 'articulation readiness' in terms of describing local enactment. The formulation of the local requirements lacked specificity so that explicit packaging of 'enactment' tasks for support remained elusive. Also, depending upon the organizational positions of information managers at the local sites, some voices were more heard than others.

From a theoretical viewpoint, we revisit the user views drawn from the information systems, social informatics, and science and technology studies literatures to underscore how users roles evolved throughout the standard development process depending upon model perspective (Table 1). We return to the three views of users introduced earlier: hands-on user; social actor; and sociopolitical actor.

Table 1 summarizes the user roles for scientists and information managers in each of the three models. The Development Model guided the actual development and implementation of the standard. The Local Implementation Model was developed for the joint workshop. The Integrative Design Model represents a post-workshop understanding of the roles – multiple and evolving – that the actors played in practice.

In the Development Model, we find two main views of users: hands-on user and social actor. Although the scientists and the information managers are seen as hands-on users in the

Table 1. Users' roles in system development process across three model types. Roles are defined for scientists and information managers in each of the models' four phases: (a) hands-on user; (b) social actor; and (c) sociopolitical actor

	Development model		Local implementation model		Integrative design model	
	Scientists	Information managers	Scientists	Information managers	Scientists	Information managers
Design	a	–	a	–	a, b, c	a, b, c
Development	a	a	a	a, b	a, b, c	a, b, c
Deployment	a, b	a, b	a, b	a, b	a, b, c	a, b, c
Implementation	a, b	a, b	a, b	a, b, c	a, b, c	a, b, c

development phase, they are seen as social actors in the deployment and implementation phases. As the standard is deployed and implemented, the variety of usage settings calls for a more complex view of the user as being immersed in diverse contexts of use of the standard, the system and the data so involved in many other working activities. In the Local Implementation Model, we find the same two main user views along with a third user's view, sociopolitical actor, for the information managers in the implementation phase. As the standard is enacted, the information managers' organizational position is challenged with requests for more resources and professional recognition. In the Integrative Design Model, we find all three views for both the scientists and the information managers at each of the phases.

How are such multiple and evolving views of users to be taken into account in information systems development processes? We argue for recognition of all three views at all phases and for a negotiation during design task formulation as to the development model and roles required so that a suite of roles and role configurations can be considered. A failure to recognize the full range of participants and activities involved results in a project that lacks realistic scoping in that: (a) a mismatch exists between planned and expected use; and (b) resources are not allocated across the set of activities and roles that may occur in practice. The Integrative Design Model introduces a new perspective that holds potential for informing problem formulations and for creating more points of engagement in the development process as detailed in Table 1.

The empirical case may be exemplary in representing a fairly typical scenario in practice from which general lessons can be drawn. Iterative design methodologies such as user-centred, participatory design and agile development provide useful guidelines and protocols that support the adaptability of interdependent, dynamic systems, actors and settings. We present some recommendations aiming first to facilitate translation of our observations into action, and second to prompt reflection upon them.

At a conceptual level, we argue for a new ideation of 'the' user in terms of a dynamic 'web of users' rather than a fixed and pre-existing single user or single group of users when planning for information systems enactment. A standard like the EML standard entails 'group cooperative work' or 'community cooperative work'. In the CSCW field, Schmidt & Bannon (1992) have noted that replacing the term 'cooperative work' with that of 'group work' or defining the former by the latter does not bring clarity to the scope of the field. To the contrary, it entails a host of problems of its own. The term 'group' is quite vague. Lee *et al.* (2006) highlight fluid, fuzzy groups and organizational memberships as ecologically beneficial for interactions in a scientific network. We use the concept 'web of users' in recognition of such blurriness, fuzziness and fluidity. Moreover, we argue for recognition of and even planning for the fuzziness and permeability of user and developer group boundaries. In our view, a critical issue for information systems development and enactment is the recognition of the active relationships between the two, i.e. their dynamic nature rather than a priori knowledge of the right category (user or developer) for the right group of actors. Suchman (2002) speaks of 'artful integration' and 'redrawing boundaries and lines of interaction in such a way that identities of technology designer and user, and the relations between them, are transformed'. A boundary denotes a division and a need for 'boundary-crossings' whereas networks invoke notions of alignment, overlap and webs of multiplicity of connections (Suchman, 1994; MacKay *et al.*, 2000).

Although innocuous terms prima facie, conceptual categories are important and powerful instruments; they usually convey a division of labour, resources and professional recognition or credit. This contrasts with the notion that ‘developers’ are allotted resources and asked to ‘develop’ a system with the unspoken assumption that ‘users’ will ‘use’ the system. A great deal of negotiation – and in some cases a lot of questioning and learning – takes place in practice related to who are the users and the developers and also related to who is allowed and supported to co-develop and co-use. The permeable boundaries and changing groups call for a need to consider systems life cycles with a diachronic (longitudinal) perspective to better understand evolution of roles, tasks and associated social and organizational challenges.

At the practical level, an important part of cooperative data work and collaborative science requires planning for coordination mechanisms and use-related activities require planning (Schmidt & Simone, 1996; Barki *et al.*, 2007). Activities must be designed, built and supported in order to enable communication and cooperation. Within the information science arena today, complex topics such as classification analysis, community arrangements, semantic relations and repository federation schemas have been identified but their development is at an early stage. Articulation efforts targeting elements of information systems development represent opportunities for designers and users to gain insights independently and/or jointly; targeted work is required to negotiate meeting specific needs and developing local standards while considering both community and universal solutions. That is, coordination mechanisms are a sine qua non in creating both the necessary formats and the local readiness for establishment of distributed networks. This entails development of new understandings of activities and boundaries as well as a range of actor perspectives and roles (see figure 5c, Fleischmann, 2006; Baker & Millerand, 2007). Recognition of the importance of human actors doing the work of problem formulation, translation and integration is needed in order to support the flow of data across boundaries and the (re)design of coordinated systems. Many individuals act as mediators as illustrated in the case by the information managers acting as user representatives for the developers and at the same time as developer representatives for the users. From a design perspective (Figure 3), activities and procedures represent ‘boundary objects’ (Star, 1989) that serve as a focus for critical design and articulation work for all participants at all phases.

CONCLUSION

We have explored the development process of a technical standard in support of a community information system and of user involvement, focusing on an individual case. We have emphasized taking all processes and phases of the processes into account. We developed a local implementation model in order to detail the local implementation process in practice (Figure 1b) but recast this model after a joint workshop and analysis by bringing design to a central position as an ongoing integrative force (Figure 3). Our exploration of the development process provides greater analytic insight in considering developer–user relations, addressing the phases of a working standard (endorsement, adoption and use) and creating the myriad of roles, coordination mechanisms and activities that serve as integrative factors for enabling collaborative work. We conclude the paper with a synthesis of our research main contributions at conceptual, practical and methodological levels. A scientific network with the role of information manager placed organizationally at multiple distributed sites presents a unique information infrastructure configuration that highlights particular types of mediation and has ramifications in terms of local information system development. Our multi-perspective approach to the case studied resulted in distinguishing two models associated with the development process of a standard from which a third view, a design model, emerged. Despite the intrinsic limits of research based on one case, we think that these contributions can benefit information systems development by enriching understanding and planning of development and implementation of standards and local information management.

At a conceptual level, we have suggested a new understanding of the user actor by taking into consideration the multiple roles users play in practice. We have argued for a new ideation of 'the' user in terms of a 'web of users' rather than a pre-existing individual user or group of users, thus recognizing the multifaceted nature of 'use'. We have called into question the traditional category pair 'developer–user' by investigating the hyphen that both ties and distinguishes them. As idealized conceptual categories in theory, 'developers' and 'users' tend to translate into vague, 'imperfect' concepts in practice where boundaries of both developers' and users' groups show their permeability and fluidity, allowing for crossovers and emergent roles in-between.

Implications at the practical level relate to the multiple dimensions of systems development including models available as well as organizational support and community resources. Sensitivity to the user category and the fluid nature of the user actor in systems development contributes to flexibility and change as the system gets designed, developed and enacted. We suggest that planning for all phases of the development process including an implementation phase involving a local implementation process would allow for eventual crossovers between developer and user roles as well as for new roles to emerge, thus taking them into account in terms of resources allocation, credit, coordination mechanisms, timeframes, etc. In addition, better planning of system development processes would benefit from an understanding of the multiple roles actors play in practice, and specially the roles 'in-between'. As the EML standard was developed and implemented, there were multiple facets to the role of local information management. Information managers became sometimes part developers, sometimes part users, and acted as mediators, enactors and innovators. They acted as mediators while undertaking negotiation and translation work between developers and users; they acted as enactors while helping the standard's deployment by fitting it into pre-existing infrastructures and practices while transforming them; they acted as innovators while developing new implementation tools or defining new data management practices that circulated through the scientific community. The role of local mediator in the development process of information systems for geographically distributed communities is a topic for further investigation.

A fluidity of groups and diversity of activities provides a basis for integration of theory and practice as well as for improvement in collaboration mechanisms. The development of theory-practice interfaces requires co-coordinated planning that supports the forming and reforming of groups and their activities depending upon the timeframes and scope of tasks at hand. Thus a historian of science and technology may work with an information systems design team to blend critical, historical and interpretive insight or a strategic design session may bring together a systems administrator with a database programmer and an information manager. An organizational theorist may provide insights into institutional and agency structures and practices that bias toward disciplinary research or create unintended barriers for information infrastructures. From a methodological point of view, an overarching insight of this research is the benefit of interdisciplinary research bridging information systems and social science perspectives in a research action framework. Our research partnership brought together practitioners with the researchers' team in a fruitful learning experience that allowed new conceptual understanding of development as well as reflection on design and development practices in the field. The involvement of an action researcher with expertise in information, communication and technology user studies served as a mechanism for initiating collaborative forums and opportunities for reflection.

Complexities introduced by collaborative elements in the form of webs of users, webs of sites, and webs of data sets raise new challenges in terms of scientific information systems design and user involvement. It will take interdisciplinary scholarship and collaborative care as well as attention to collaborative techniques and development processes in order to adequately sort and understand their highly intertwined social, organizational, technical and political dimensions. Works in science and technology studies, information systems and social informatics open the way for interdisciplinary perspectives on information ecologies, together with bridging of theory and practice. This research incorporates action research and provides a unique opportunity to consider the user and the developer figures, the not-so-clearly distinct roles and interfaces of developers and users as well as the challenges of user involvement in information systems development. Our work forms one part of ongoing efforts that aim at improving understanding and concern with information systems, with a special commitment to arrange and grow fruitful research partnerships suitable for all participants.

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