COMMUNITY-ORIENTED TECHNOLOGY ASSESSMENT

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ABSTRACT

Technology assessment approaches have traditionally occupied organizational informatics and policy-making areas. Approaches tailored to the unique characteristics of and concerns within community-based projects are lacking. Formal technology assessment processes can provide a critical bridge between observational community informatics research and technology design and development processes. This paper presents a framework adapted to community-based technology assessment processes. A survey of the field is given with discussion of adaptations required for community contexts. Performing technology assessments in partnership with communities is also discussed.

INTRODUCTION

This work is part of a broader effort to adapt quantitative and qualitative social science methodologies as inputs into systems analysis and design processes for community-based information and communication technologies. Social science research methods, both quantitative and qualitative, along with policy studies are now seen within social and community informatics as being necessary, if not always used, components of responsible design and engineering processes. The examination of social and policy issues as a strategic activity in technology development has come to be called “technology assessment” in many spheres.

Technology assessments are necessary as a distinct phase within an observational community informatics process if the results of observational research are to enable solutions in the form of policy or technology development. We include all manner of quantitative and qualitative research methods under the term “observational research” here.

Technology assessment emerged as a distinct area of policy studies before the multi-disciplinary fields of social or community informatics coalesced. The emphasis in technology assessments has historically been placed on organizational, sectoral, and national contexts. Lacking have been approaches suitably adapted to community contexts, particularly the involvement of communities as partners (see Sclove 1994). The goal here is to synthesize an adaptive approach to performing assessments that is particularly suited to community-based situations. This paper presents the results of our initial efforts.

The next section of the paper provides an overview of the development of technology assessment. The third section discusses the need for community partnerships in technology assessment. The fourth section contains a presentation of our community-oriented technology assessment process framework.

BACKGROUND

Goodman (1998) identifies "technology assessment" as a concept that arose out of policy-making discourse in the U.S. Congress in 1965. It is recognized here that researchers of many types and policy makers have been performing technology assessments long before the phrase was coined and they continue to do so under other labels.[1] Nevertheless, it can be argued that an area of policy studies and specific methodologies emerged during this time and that they occupy a distinct space between the observation of technological impacts and subsequent design and development of technology. This is evidenced by recognition and institutional support. In the U.S., this included the formation of the Office of Technology Assessment and programs within the National Science Foundation that lead to the development of formal methodologies (see Armstrong & Harman 1980; Goodman 2004).

The primary goals of technology assessments are to inform either design or policy-making processes of the impacts of technology within some social or engineering context. Assessments may be performed retrospectively, seeking to analyse existing systems. Alternatively, they may have a prospective viewpoint, seeking to project the potential impacts of either existing technologies in the context of a design process or emerging technologies. The functional roles of technology assessments include: processes designed to gain an understanding of existing or potential impacts of technologies (Armstrong & Harman, 1980); and processes that encourage the development of emerging technologies (Schot & Rip, 1997). The former type of processes are referred to here as *analytical technology assessment*; while the latter is referred to as *constructive technology assessment*.

Armstrong and Harman (1980) presented a survey and evaluation of some of the major analytical technology assessment methods that evolved in the 1970s. In the end, they synthesized their own methodology based on the common strengths they observed among the different approaches as well as an attempt to fill what they considered to be gaps in those other methods.

Analytical technology assessment evolved as mostly linear processes that were divided into elements or steps. Each step defined a focused set of activities with specific goals. At a high level, the methodologies covered by Harman and Armstrong shared a general set of activities: (1) defining the nature and scope of the assessment, (2) data collection, (3) analysis of technological impacts according to a specified set of dimensions, and (4) production of conclusions and recommendations.

Later methods introduced iteration into the process and consideration of alternative outcomes. In introducing iteration, it was expected that individual steps or sets of steps would be repeated to correct earlier outputs and to gain new insights based on the cumulative perspective not possible without a previous run-through. Later approaches also introduced activities that span the entire sequence of steps. These so-called “cross-cutting” elements sought to focus attention on concerns, such as social values, that cannot be constrained to a single step. Such concerns persist across two or more steps and were of such importance that they were seen as deserving a structural place within the assessment process.

Most technology assessment methods require consideration of technological impacts along several dimensions. These usually include the broad categories of economic, social, political, environmental, and legal impacts. Subdimensions of these might include efficiency, resource flows, and physical and social organization involved in the management of technology. Later approaches, such as the framework of Agarwal and Tanniru (1992), call for the examination of the combinatorial possibilities between local, global, direct, and induced (or indirect) impacts.

Technology assessment methodologies have been adapted to specific domains. The most notable is the area of health technology assessment. Here, the dimension of physical safety, along with costs and efficacy, is key. See Lehouz and Blume (2000) and Goodman (2004) for detailed surveys of health technology assessment methodologies.

In contrast to analytical technology assessment methods, those of the constructive type are concerned primarily with the production of technology, including policy making that might be necessary in this context. Shot and Arie (1997) present a survey of constructive technology assessment. They cite three types: (1) technology forcing, (2) strategic niche management, and (3) technology stimulation. Technology forcing is a form of policy making where some authority, usually the state, dictates a goal. An example here is the area of environmental regulation, where goals are linked closely to technological development. Strategic niche management is an activity whereby some authority manages a design process. This is often seen within standards bodies or coalitions within industrial sectors that foster the development of a new technology. Technology stimulation is an activity short of niche management where some authority creates the environment and linkages necessary to encourage the development of a technology. Examples here include governmental organizations that have as their mandate the support of basic research of technologies seen as strategically important to the state.

Shortcomings of the technology assessment methodologies we have surveyed exist due to the role of assessment as an endeavour distinct from the processes required to design develop technology. Ideally, design and development are informed by technology assessment, among other inputs, such as quantitative and qualitative research about the deployment environment. Other shortcomings include a failure to address sustainability, both technical and economic. This is an impact area that is critical in community-based projects, where financial and human resources are often limited. As technology assessments have evolved, the impact criteria they include have become more holistic; however, the other major shortcoming that remains is the lack of attention to impact criteria specific to communities. These include impacts to environment, accessibility, language, and sustainability with respect to both financial and human resources.

A participatory approach is seen as a necessary condition for conducting technology assessments pertaining to communities. In the next section, we discuss community-oriented technology assessment as a partnership process.

TECHNOLOGY ASSESSMENT AS A COMMUNITY PARTNERSHIP PROCESS

Communities present a context sufficiently unique from the organizational settings for which traditional software engineering and management information systems have been developed that a tailored technology assessment process is warranted. Community-based processes must prioritize consideration of social, economic and cultural factors involved in the design and use of technologies within the target community (see Rudolph 2002; Margonelli 2002). Communities are often geographically situated, which can raise significant design and use issues. Communities often face tighter financial constraints than business or governmental organizations in attempting to address their problems in terms of the costs of implementation and long-term maintenance. The development process must, therefore, devote greater attention than in corporate settings to issues such as the training needs and the capacity of communities to provide technical support and respond to changes in system requirements. Finally, community-based processes must ensure that the widest range of citizens can enjoy the benefits of ICT, including those with disabilities (see Glinert and York 1992).

It is widely recognized that to adequately address the unique characteristics of communities, design and development processes must be user-centred throughout (see Landauer 1995 and Norman 1998). We argue that this is also necessary for technology assessments, as they may provide inputs into a design process. This is particularly the case in performing technology projection, scoping of assessments, and collection of requirements for a follow-on technology design and development process. It is imperative, therefore, for technology assessment processes to establish and maintain community partnerships from inception to completion to facilitate a user-centred approach.

The general history of technological development in organizations and for the consumer market is replete with cases of failures. Most are attributable to poor design practices. Systems analysis and design, software engineering, usability engineering and the other related disciplines that make up the constellation of generally recognized best practices all demand people with special training and experience. Communities without a proper educational framework and knowledge base are not likely to have access to such people. Based on the history of ICT development in an organizational context, it can also be argued that communities are not likely to arrive at nor apply best practices on their own. Thus, special community-level training in these skills is needed. The processes involved, as traditionally practised, can be costly.

Evidence suggests that the viability of technological designs for communities is more sensitive to the use of best design practices in general and attention to economic, cultural and social dimensions of appropriateness in particular. Potential adopters of technologies in communities may be less able to withstand the economic and social impacts of poor designs. The costs of failure in ICT-based projects are on average high relative to the size of an organization. Communities are probably least able to withstand such impacts. For example, a number of studies have documented high benefit to cost ratios in performing usability engineering to ensure that good designs are produced (Myers et al. 1996). In contrast, the costs incurred by poor designs can be very high and, thus, potentially crippling for community-based projects. Meyers et. al report on studies by Nielsen and Landauer published in 1993 showing, by implication, that medium size projects during the period under study risked on average over $600,000 (USD), depending on the thoroughness with which usability engineering was used. Other costs for failure must be considered. For example, the cost of fixing a problem once a system has been deployed has been reported to be from 40 to 100 times the cost of fixing it while the system is in development (Landauer 1995, p. 320).

Social and cultural norms about the appropriateness of various facets of a given technology may differ significantly between communities and thereby impact the viability of a system. The case of the Approtec's successful design of a human-powered irrigation pump provides a good example. Engineers in the non-profit organization first considered an existing design, but because the treadles were positioned too high, they caused what was considered provocative hip swaying. It was, therefore, determined that the existing design would not be appropriate for the primary users -- women (See Margonelli 2002).

A major reason for poor designs is a failure to adequately involve the target user community in the design process (see Landauer 1995; Norman 1998). It is reasonable to assume that formal technology assessment processes for communities must be community-centred. Without proper training or partnerships, it is likely that communities would fail to employ user-centred processes when it is common for IT experts to fail to do so. Jakob Nielsen and others have shown, for example, that technical experts are on average less likely to identify or be sensitive to usability problems in a system (see Landauer 1995, pp. 314-320).

The operational and economical sustainability of ICT are critical criteria for the impact analysis and technology projection activities of community-oriented technology assessment. Impact analyses must address the significant deficits in investment capital, infrastructure and experience that communities often face. The economics of a community will often preclude individualized solutions that are the norm in corporations, more affluent communities or developed nations as a whole. Instead, technology projections must include consideration of group-based solutions. Geographic factors may preclude certain modalities of communication in a community. Thus, novel approaches to using existing technologies will be necessary.

Beyond technology assessments, community informatics in general must be open to using alternate design and implementation approaches. These include the use of free and open source software, the creative appropriation and adaptation of existing technologies of infrastructure, and use of traditional ICTs (e.g. print and radio). In addition, the use of open technologies -- as opposed to custom commercial or commercial off-the-shelf (COTS) solutions -- requires people in the community who have sufficient expertise to develop, operate and maintain systems. This is an added challenge for developing communities, where such expertise may be even more difficult to find and afford.

A community-oriented technology assessment process must, therefore, establish a partnership that empowers communities to build the capacity and knowledge to participate in requirements analysis, technology projection, and impact analysis. Communities that are to be properly involved in such a process must develop an educational process to help their members participate. This should be built into a partnership.

In summary, the need for formal community-oriented technology assessment processes exists in stark contrast to the domains of management information systems and science and engineering design and development for which large bodies of knowledge and good practices exist. These practices generally assume an abundance of resources and expertise. The characteristics and needs of communities are significantly different from those of business and technical organizations and, thus, require different approaches to assessment, design, development, deployment, and operation.

A COMMUNITY-ORIENTED TECHNOLOGY ASSESSMENT PROCESS

The approach that we propose integrates the general functional areas and elements described in Armstrong and Harman (1981), the Coates 10-Step Technology Assessment Model (1976), and the Mitre/Jones 7-Step Technology Assessment Methodology (see Armstrong & Harman 1981, pp. 5-15). In addition, we use Agarwal and Tanniru's four dimensional impact analysis space in examining each impact criterion (1992, pp. 626-643). We cast the resulting methodology in the model of the Unified Process (UP), known primarily in the discipline of software engineering (see

Rational Corporation 2001). The UP is well-suited to our purposes because it is inherently iterative, mirrors the phase/activity structure of existing assessment models, allows for the modeling of cross-cutting activities, and it provides a process consistent with a UP-based follow-on design and development process.

Our community-oriented technology assessment process (COTAP) has three phases:

(p0) Technology Description;

(p1) Impact Assessment; and

(p2) Policy Analysis.

The COTAP is depicted in Table 1 below, where a shaded cell indicates a phase during which an activity is performed. The technology description phase is concerned with collecting data necessary to perform the assessment, projecting technological trends that may be relevant to the analysis of future impacts, determining the scope of the assessment, and selecting the criteria by which the impact analysis is to be performed. The impact assessment phase is concerned primarily with the analysis of existing and potential technological trends according to the criteria selected in the previous phase. The policy analysis phase is both normative and constructive, being concerned with policy making regarding the technology and, if warranted, initiating the design and development of a new technology. Examples here would be the creation of accessibility or linguistic regulations for user interfaces.

A COTAP must be iterative in the sense that activities such as assessment scoping and criteria selection may be revisited more than once after they are first performed. Thus, the table depicts some activities as spanning more than one phase. The most critical activity here is that of initiating and maintaining a community partnership for performing the assessment. This is seen as spanning the entire process.

We propose also that a COTAP can implement the community partnership process by adapting an appropriate participatory action research (PAR) methodology. Some PAR methodologies have been designed, in part, for establishing community partnerships and have been shown to be quite effective (see Ramirez & Richardson 2005). The primary objective in using participatory action research in a COTAP would be to address the capacity building and sustainability issues discussed in the previous section.

Phases p0 through p2 are shown in the table as activities that are integrated with a preceding research process, phases p-n through p-1, and a follow-on design and development process, phases p3 through pm (where m > 3). The outputs of the preceding research process should be designed to provide most of the data required to perform a COTAP. The follow-on technology design and development processes are optional. They would be initiated according to the inception phase of the standard UP.

	Assessment Phases				
Assessment Activities	**(p-n ... p-1) Pre-assessment phases**	**(p0) Technology description**	**(p1) Impact assessment**	**(p2) Policy analysis**	**(p3 ... pm) Post-assessment phases**
Identity and adapt a participatory action research methodology (PAR)					
Establish and maintain community partnership (using the PAR)					
data collection					
assessment scoping					
technology projection					
impact criteria selection					
requirements analysis					
process and data flow analysis					
impact analysis					
policy recommendation					
technology construction					
design and development					

Table 1. Technology Assessment Process

Minimal criteria by which technological impacts are assessed are showing in Table 2. It is expected that within the criteria selection and assessment scoping activities that criteria specific to the community context will be added. Each criterion should also be assessed in relation to Agarwal and Tanniru's four-dimensional impact space: (1) direct local impacts, (2) direct global impacts, (3) indirect or induced local impacts, and (4) indirect or induced global impacts. The term “local” in this context refers to the community involved in the assessment. The term “global” in this contexts refers to impacts that span beyond the community of focus.

Impact Category	**Criteria**

Impact Category	Criteria
Social & cultural	• Accessibility issues • Actors involved in using the technology • Linguistic impacts • Cultural issues that may arise in using the technology • Safety risks • Privacy risks
Knowledge & Skills	• Knowledge and skills required to use and maintain the technology • Feasibility of the community sustaining the technology on a technical level • Training requirements to use and maintain the technology
Economic	• Efficiencies enable by the technology (e.g. per unit time) • Error rates • Feasibility of the community sustaining the technology financially
Political	• Power relations involving the technology
Technical	• Impacts to existing hardware and software infrastructure • Security risks • Existing technological resources
Environmental	• Flow of resources required to sustain the technology • Energy requirements • By-products produced by using the technology
Legal & regulatory	• Regulatory requirements in using the technology (e.g. Licensing) • Existing and potential legal challenges in using the technology • Copyright issues • Intellectual property issues

Table 2. Criteria used to assess technological impacts.

CONCLUSIONS

We have presented a framework for formal community-oriented technology assessment processes (COTAP). This framework has been derived from the four decade evolution of formal technology assessment models. Such models are seen as distinct from (1) quantitative and qualitative observational research and (2) technology design and development processes. Formal technology assessment processes are seen as a bridge between the former and latter types of processes.

A COTAP attempts to address the unique issues that community settings bring to assessment processes in contrast to the corporate contexts in which they have traditionally been applied. These include the need for closer attention to: social and cultural concerns; accessibility and universal design requirements; and the sustainability of ICT solutions with respect to the financial and human resources available to a community.

Our research is currently focused on evaluating the COTAP framework. This is being done using the outputs of survey and qualitative research involving information needs and uses in community organizations. We are also planning an in-depth survey of participatory action research methods to determine how they might be best adapted to COTAPs.

ADDITIONAL NOTES

1 See, for example, Lewis Mumford's classic text from 1934 Technics and Civilization or Harold Innis' equally-influential The Bias of Communication from 1964.

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