Stakeholders at a Distance: User Participation in the Development of Cyberinfrastructure

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ABSTRACT
In this study we explored scientific collaborations that were created to develop cyberinfrastructure, which includes data, tools, and technologies for use by their larger scientific communities. It is widely believed that involving intended users in design and development will improve the quality, use, and sustainability of these resources. User-centered design and participatory design are traditional means of engaging stakeholders in cyberinfrastructure development, but were used on a limited basis in the collaborations we studied. We believe this is because the intended users are numerous, widely distributed, and heterogeneous in terms of culture, skills, knowledge, computing platforms, and other factors.

Categories and Subject Descriptors
K.4.3 [**Organizational Impacts**]: Computer-supported collaborative work

General Terms
Management, Design, Human Factors

Keywords
Cyberinfrastructure, scientific collaboration, user participation, stakeholder theory

1. INTRODUCTION
The complex nature of societal problems and the expertise, data, and technologies needed to address them mean that scientific research will be increasingly collaborative, interdisciplinary, and distributed across space and time. A key goal of cyberinfrastructure is to bring together distributed resources such as computational tools and services, instruments, data, and people to create virtual environments that will accelerate the pace of scientific and engineering discoveries by reducing constraints of distance and time [2]

Cyberinfrastructure has the potential to dramatically change the way that thousands of scientists conduct their work. However, past experiences with large-scale information infrastructures show that achieving such goals is not easy. In order for users to adopt new systems, they must offer advantages over current practices, positively change the way work can be performed, and be easy to implement and straightforward to use [9]. Partly in recognition of these facts, the 2003 report of the National Science Foundation's (NSF) Blue-Ribbon Panel on Cyberinfrastructure recommended that "individual disciplines must take the lead in defining specialized software and hardware environments for their fields..." [2]. Even before this report was released a number of scientific fields had begun to do just that. For instance, in several cases, domain scientists joined forces with computer scientists to develop aspects of the cyberinfrastructure to meet the needs of the discipline's members [4]. In another example, researchers from multiple biological science disciplines have come together to generate large amounts of data for the wider research community to use in solving complex biomedical problems [1].

Scientific collaborations created to design and develop cyberinfrastructure that benefits their larger scientific communities are relevant to CSCW researchers for two reasons. First, these collaborations bring together participants from multiple institutions and disciplinary backgrounds who must find ways to work together over a distance. Second, the objective of scientific collaborations is different from traditional research partnerships in which scientists work together to produce data and publications. The goal of these collaborations is to serve the larger community of scientists by developing cyberinfrastructure that will make it possible to conduct science in new ways. However, the challenge in doing so is that the users of such systems are numerous (potentially thousands), widely distributed, and heterogeneous in terms of culture, skills, knowledge, computing platforms, and other factors, all of which make it difficult to engage them in design activities [10]. It is these issues that concern us in this paper. Specifically, we report the results of an exploratory study whose goal was to determine the mechanisms these projects used to gain the participation of intended users. We employed a typology to categorize stakeholder participation as informative, consultative, or decisional. The results of our investigation show that collaborations focused on the development of cyberinfrastructure rely on a limited range of stakeholder participation activities. User-centered design and participatory design were used, but on a limited basis. This may be due to the nature of the projects we studied and a lack of expertise by project personnel. Based on our results, we conclude that future research would do well to study these environments to determine what activities to use to involve stakeholders, when to use the activities, and how to implement them.

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2. STAKEHOLDER THEORY

It is widely believed that allowing key stakeholders, particularly the intended users, to participate in design and development is likely to improve the quality, use and sustainability of such resources. For example, stakeholder participation is a fundamental tenet of user-centered design and participatory design [5, 7]. However, techniques from user-centered design and participatory design are often employed when designing and developing small-scale, standalone systems under conditions in which users' work is relatively stable [6]. Moreover, the stakeholders are generally known and limited in number. In contrast, the scientific collaborations we examined are designing for user communities that are large, distributed, and varied on many dimensions. In addition, since the goal of these projects is to transform how scientific research is conducted, by definition the work practices are unknown and unstable. Given these difficult challenges, we were interested to investigate how these projects facilitated stakeholder participation and the extent to which approaches such as user-centered design and participatory design played a role.

Stakeholder participation is generally defined as a "ladder of participation" [3]. We used a three-level stakeholder typology to explore the different kinds of stakeholder participation that these scientific collaborations employed [3]. The typology's three levels – informative, consultative, decisional – represent increasing levels of risk and commitment. Informative participation is used to educate stakeholders. Communication is one-way. Stakeholders only receive information, so participation is considered passive. With consultative participation, advice is solicited from stakeholders, however, it is not necessarily acted upon. In decisional participation, stakeholders are involved in the decision-making process. It represents the highest level of commitment and risk because organizations no longer have full control over how things are done. Despite the loss of control, giving stakeholders a voice in the decisions being made might translate to buy-in and thus better rates of adoption.

3. RESEARCH METHODS

3.1 Scientific Collaborations

Six scientific collaborations were examined for this study. Three collaborations were funded by Program A (pseudonym) and three were funded by Program B (pseudonym). All of the projects are currently active. We chose collaborations from these two programs because the programs had similarities and differences that we thought might influence levels of stakeholder participation. The major objective for Program A and Program B was to initiate long-term (5-10 years), innovative research directed toward challenging problems. However, Program A funded scientific collaborations that emphasized basic and applied research in information technology. In contrast, Program B supported scientific collaborations that brought together researchers who could share and integrate knowledge and resources to solve complex biological problems. Program B projects concentrated on the creation of data, methods, and tools, whereas Program A built technology. Another difference is that Program B was explicit about the need for stakeholder participation. All Program B funded collaborations were required to propose measures to consider and respond to concerns of the scientific community working in their particular areas.

3.2 Data and Analysis

Data for this study was collected as part of the Science of Collaboratories (SOC) project [8]. SOC was a 5-year study funded by the NSF to study large-scale academic research projects across many science and engineering disciplines.

Our goal in this exploratory study was to investigate and classify the different stakeholder participation activities that the collaborations used. We were interested in examining whether different approaches were being used across the different collaboration projects and funding programs. We categorized the data according to the typology of stakeholder participation described earlier, which includes informational, consultative, and decisional participation activities.

4. RESULTS

Although we found evidence of each type of stakeholder participation activity, informative activities were most prevalent. This is consistent with prior research [3]. Given that Program B required projects to consider and respond to the concerns of their larger scientific communities, we expected that Program B collaborations would rely more heavily on consultative or decisional stakeholder participation activities. Although a collaboration in Program B was the only one to use decisional activities, in general, we did not find differences in stakeholder participation activities between the two funding programs.

4.1 Informative Participation Activities

The informative stakeholder participation activities were similar across the funding programs. Many of the collaborations used their websites to inform stakeholders. Within this, a wide variety of approaches were used from basic to sophisticated. It was common for projects to provide access to promotional materials, presentations, and tutorials through their web sites. One project developed an elaborate online instructional tour of their web site that included audio and video. In addition, some collaborations provided more internal project information than others. For example, a Program A project made notes from internal working group meetings available and provided access to their web-based project management system.

4.2 Consultative Participation Activities

The types of consultative stakeholder participation activities used varied across the funding programs. Program A collaborations employed evaluation and user need workshops, whereas the Program B funded collaborations did not. This makes sense in light of the fact that Program A collaborations created software applications and prototypes, and Program B collaborations tended to produce data. One of the Program B collaborations conducted a survey to assess stakeholder needs and included stakeholders in project working groups. In this case, we classified these activities as consultative because the stakeholders offered advice that the project was free to accept or not. An interesting difference we found among projects was that some reported back to the stakeholders whether and how they implemented the advice and others did not.

4.3 Decisional Participation Activities

We observed only one example of decisional participation. One of the Program B collaborations included stakeholders on their steering committee, which was responsible for setting project direction and determining how funds were spent.

4.4 Summary of Results

In sum, we found that the scientific collaborations we examined used activities that could be classified as informative, consultative, or decisional participation. Even though the collaborations employed activities from the three categories they relied on a very narrow set. Most of the participation activities we found were categorized as informative, followed by consultative. Decisional participation was rare. We also found some consultative participation activities "closed the loop", by explaining to stakeholders what had been done with the advice they received. Lastly, we found these collaborations did employ technology as a means to engage stakeholders in participation activities. However, in most cases when technology was used, the interaction between the members of the collaboration and the external stakeholders was one-way or asynchronous. Face-to-face communication was used for more traditional means of stakeholder participation such as workshops to address user needs and evaluate prototypes, which tended to be more consultative by nature.

5. DISCUSSION

User centered design and participatory design were used on a limited basis. Although these projects might benefit from using these activities to a greater degree, the nature of the projects we studied suggest that stakeholder participation activities should go beyond these traditional means of engagement. For example, future research should consider how user-centered design and participatory design activities can be conducted in environments where there are a large number of intended users and they are widely distributed from the designers as well as from each other. Future research in CSCW might consider how technologies can support stakeholder participation under these conditions.

The typology was useful in categorizing the kinds of stakeholder participation activities being implemented in these collaborations, but it also highlights what was missing for our purposes. For example, the typology does not describe how stakeholder participation might change over time as the projects evolve. Future research might consider how the different kinds of stakeholder participation activities can be used over the lifecycle of the project. Are there patterns of stakeholder participation that occur over the lifecycle of a project that are more likely to lead to success than others? For the projects we studied, it may be that user-centered design and participatory design are critical at some stages of the lifecycle, but not others.

Another concern for these projects, their intended users, and the funding agencies that support them is the sustainability of the cyberinfrastructure that these collaborations have developed. At some point, the responsibility for the cyberinfrastructure might have to shift from the funding agencies and the members of the project to the larger community of stakeholders. For this transition to occur, the intended users must fully buy into and adopt the cyberinfrastructure. Therefore, future research should consider how stakeholders perceive the effectiveness of the different participation activities used. What kind of stakeholder participation activity or combination of stakeholder participation activities is most likely to impact stakeholder satisfaction, buy-in, commitment, and adoption rates?

The typology does not discuss how to plan and implement stakeholder participation. For example, we found that activities could be put in more than on category depending on these factors. It also does not outline a portfolio of stakeholder participation activities according to the activity's goal, risk, reward, and expected outcome. Doing so may lead to better understanding of the planning and implementation of the activities. Future research should consider whether informative and consultative approaches are sufficient to build, evolve, and sustain cyberinfrastructure. Are there other kinds of stakeholder participation activities that we have not uncovered that projects should consider? Will educating project personnel about a wider range of stakeholder participation activities and their trade-offs lead to a better portfolio of activities that balance risk and reward?

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] Abbott, A. Alliance for Cellular Signaling: Into unknown territory. *Nature* 420 (2002), 600-601

[2] Atkins, D., et al. *Revolutionizing Science and Engineering Through Cyberinfrastructure: Report of the National Science Foundation Blue-Ribbon Panel on Cyberinfrastructure.* National Science Foundation, Washington, DC, 2003.

[3] Green, A. O., and Hunton-Clarke, L. A typology of stakeholder participation for company environmental decision-making. *Business Strategy and the Environment* 12 (2003), 292-299.

[4] Keller, G. R. GEON (GEOscience Network): A first step in creating a cyberinfrastructure for the geosciences. *Electronic Seismologist* July/August (2004).

[5] Norman, D. A. and Draper, S. W., eds. *User Centered System Design: New Perspectives on Human-Computer Interaction*. Lawrence Erlbaum, Hillsdale, NJ, 1986.

[6] Oostveen, A. and van den Besselaar, P. From small scale to large scale user participation: A case study of participatory design in e-government systems. In *Proceedings Participatory Design Conference 2004*, ACM Press, New York, 173-182.

[7] Schuler, D. and Namioka, A. *Participatory Design: Principles and Practices*. Lawrence Erlbaum, Hillsdale, NJ, 1993.

[8] Science of Collaboratories www.scienceofcollaboratories.org

[9] Star, S. L. and Ruhleder, K. Steps toward an ecology of infrastructure: Complex problems in design and access for large-scale collaborative systems. *Proceedings CSCW 1994*, ACM Press, New York, 253-264.

[10] Zimmerman, A. and Nardi, B. A. Whither or whether HCI: Requirements analysis for multi-sited, multi-user cyberinfrastructures. *Proceedings CHI 2006*, ACM Press, New York.