

Toward a Framework for Research on Geographic Information-Supported Participatory Decision-Making

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Abstract: This article offers a framework for evaluating geographic information technology applied in the context of participatory problem solving and decision-making. The framework consists of constructs and detailed aspects describing significant issues of participatory decision-making. Constructs reflect the structure, while aspects address the content of participatory decision-making. Aspects are tied through premises, which present fundamental statements about the nature of convening, process, and outcome phases of decision-making. The power of the framework lies in linking premises with research questions and testable hypotheses, which can be formulated on the bases of research questions. Empirically based testing of hypotheses leads in turn to verification of theoretical framework and to design guidelines for future uses of geographic information technology in participatory decision-making.

Introduction

At a workshop on Access and Participatory Approaches in Using Geographic Information organized by the U.S. National Science Foundation and the European Science Foundation in Spoleto, Italy, in December 2001, the development of place-based methodologies and methods for more inclusive community participation in spatial decision-making was recognized as one of six core research areas in the context of geographic information system (GIS) and society (Weiner et al. 2001). The plea for the development of methodologies implies some shortcomings in the current state of knowledge on participatory decision-making and begs the question: "What are the main obstacles to successful implementations of participatory decision-making supported by geographic information technology?"

Many examples of community development projects involving public participation from around the world suggest that cultural and political context rather than hardware and software are the main obstacles to successful public participation in decision-making (Craig et al. 2002). This may be true for participatory decision-making situations employing relatively simple information tools. Yet there are many other spatial decision situations where the success of a participatory approach requires both a good understanding of cultural and political context and more efficient, effective, and equitable information and communication tools. In these types of situations, there is a lack of operational knowledge to guide the selection of information tools appropriate for the task at hand. Insufficient knowledge also extends to the influence of culture and political systems on shaping feasible forms of participation. One example of the importance of knowing how different cultural and political contexts influence what works and what does not work in adopting a participatory approach to a decision-making process is work by Renn et al. (1995), which is based on ideas articulated in a National Research Council report entitled *Understanding Risk* (1996). In that study, Renn presented the results of evaluating one specific model of public participation

in environmental decision-making called the "analytic-deliberative process." The model involves three consecutive steps:

- 1) identification and selection of concerns and evaluation criteria;
- 2) identification and measurement of impacts and consequences related to different policy options; and
- 3) conducting a discourse with randomly selected citizens as jurors and representation of interest groups as witnesses.

This model was applied with different results in Germany, Switzerland, and the United States. While participants in Germany and Switzerland were grateful for the invitation to participate, U.S. participants distrusted prefabricated participation models and suspected hidden agendas with such an approach. This underscores the cultural differences that come into play in participatory decision-making. Renn concluded that the success of public involvement in the U.S. would depend on securing approval of the process by the affected communities before that process is put into play. Based on multiple empirical studies in Europe and North America, Renn also concluded that discursive/participatory processes needed a structure that assures the integration of technical expertise, regulatory requirements, and public values. Other authors (for example, Pickles 1995) postulated that participatory decision-making should become a tool of political discourse challenging the instrumental logic of the existing practice of decision-making. This, according to Pickles, may require using a different logic than a normative approach to the decision-making process. Shiffer (1995) saw the promise of Internet-based participatory decision-making, but at same time admits potential difficulties arising from involving computer-technology challenged people and differential understanding of information presented through virtual images and map-based representations. Weiner et al. (2001:13) expressed belief in potential contributions of public participation geographic information systems (PPGIS) stating that "Future PPGIS academic research can thus contribute

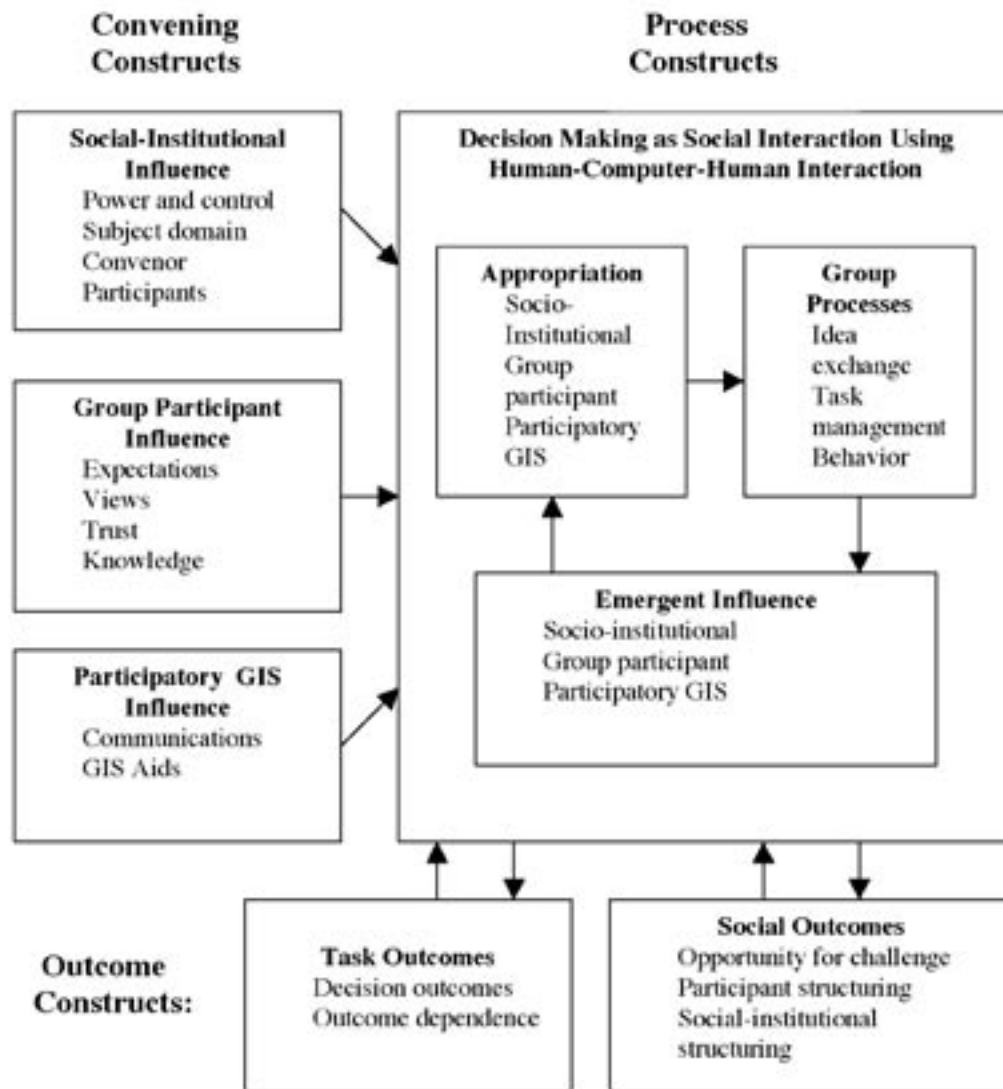


Figure 1. EAST-2 framework consisting of convening, process, and outcome constructs (including example aspects) plus the respective premises provides a conceptual map for understanding a participatory decision process.

significantly to geography and to the social sciences in general.” This statement is somewhat tempered by their earlier concern “...that academics engaged with PPGIS will tire and fall back to their familiar role as researchers. In such cases, PPGIS has the potential to become another form of community exploitation” (Weiner et al. 2001:9). This seeming inconsistency underscores the tension resulting from the interdisciplinary character of inquiries about the access to and the participatory use of geographic information. Applications and research about participatory decision-making are rooted both in social-behavioral sciences and in broadly defined information science and technology. This is a reflection of what geographic information-supported participatory decision-making is about – open and transparent access to spatially enabled data and information handling tools for people interested in place-based problem solving and decision-making in a specific socio-political context. This ad hoc definition demonstrate the complexity of the subject.

The Need for a Framework Characterizing Participatory GIS Use

Any successful implementation of participatory decision-making requires the knowledge of people who are involved in the decision-making process, plus their values and expectations. Implementation requires data and information about the problem at hand – both scientific and non-scientific – representing individual experiences and the collective wisdom of participants. It requires an understanding of socio-political influence on power and control. Last, but not least, implementation requires data processing and communication tools.

The range of tools that may be appropriate in a given decision problem context ranges potentially from push-pin maps to such high-tech structures as virtual reality visualization environments. But how is one to know whether a given problem situation is a

good candidate for a participatory approach and, if so, which information and communication tools are appropriate for the task at hand? There is a clear need for a knowledge base about when, in what context, and how one should apply participatory approaches to spatial decision problems and which information and communication technologies should be employed in support of such participatory approaches.

Developing such a knowledge base requires a systematic approach to empirical studies of participatory approaches to place-based decision-making. Empirical studies are potentially the main source of knowledge guiding further development and applications of participatory decision-making. In order to develop the knowledge base, it is necessary to understand the social-behavioral implications of information and communication technologies applied in a spatial problem-solving context. Unfortunately, anecdotal evidence about the implementations of participatory decision-making supported by geographic information technology, although good for sharing experiences and telling stories, is not sufficient to understand the complexity of information technology intertwined with human perceptions and understandings of spatially represented information in various social-political contexts. Without a systematic knowledge of participatory use of GIS and other information and communication tools based on social-behavioral research, poor designs of geographic information technology-supported public participation are likely to be reproduced again and again and to have (sometimes unintended) social implications for efficiency, effectiveness, and equity. If anything, an approach based on anecdotal evidence rather than on systematic research framework may lead to community exploitation.

Without a systematic approach to researching participatory decision-making, stories and experiences are difficult to integrate; hence we are less likely to accrue “knowledge about use.” Nyerges et al. (2002) proposed one such approach that may be helpful in developing empirical evidence about the use of participatory GIS (PGIS). The approach is based on social-behavioral research on the uses of PGIS consisting of three stages: planning, implementation, and corroboration. Each stage involves a balance among three research domains: substance, theory, and methods. From this approach, a rigorous methodological framework consisting of problem articulation, treatment mode selection, data gathering strategy, data analysis strategy, and reporting strategy can be derived for empirical studies about substantive problems. A theoretical foundation to back up that methodological approach is Enhanced Adaptive Structuration Theory (EAST). The theory provides constructs and premises that help to interpret how people make use of PGIS in a given problem context and elucidates the elements involved in structuring human-computer-human interaction.

Enhanced Adaptive Structuration Theory (EAST)

The most recent version of the framework, called EAST-2, consists of a set of eight constructs detailed in terms of 25 aspects (the elements of the conceptual domain) that describe significant

issues for characterizing group decision-making (Jankowski and Nyerges 2001a). The seven premises of EAST-2 describe the relations among the eight constructs (Figure 1; the seven premises are numbered from P1 through P7 and the eight constructs are depicted in the respective eight boxes). The structuration process of what/who influences what/who is the embedding context for EAST-2. Neither technological nor social character of an organization predominates in change – they work together to structure and, hence, reconstruct each other – the fundamental idea underlying “adaptive structuration.”

The organization of constructs in EAST-2 reflects an organization of participatory decision-making process. The constructs are grouped into convening, process, and outcome categories.

Constructs about Convening a Participatory Situation

Three constructs consisting of 11 aspects characterize the convening influence about a decision situation when information technology is involved.

Construct 1: Social-Institutional Influence. Social-institutional influence is usually based in law, mandate, policy, social norm, or natural events (i.e., influences commonly outside the control of any single individual). One aspect of social-institutional influence is power and control, which refer to the entitlements that are granted by formal or informal mandate (e.g., laws and regulations or special interest group awareness). Whether specific participant groups intend to exercise their power is a concern to all participant groups (Susskind and Field 1996).

A second aspect of social-institutional influence is subject domain. Sharing an interest in subject domain is what principally brings people together into participatory decision processes. Many decision problems from the domain of environmental and land management contain intangibles that cannot be easily quantified, and their structure is only partially known or is burdened by uncertainties. These problems require the participation of people representing diverse areas of competence, political agendas, and social values. Environmental and land management problems are characteristic of at least three kinds of uncertainty, which adds to the complexity. One type of uncertainty relates to knowledge about the natural environment (i.e., what we don't know about natural processes and the influences that humans might have in such processes). A second type of uncertainty is about the intentions in related fields of choice from a technical perspective (i.e., is one solution technically better than another). A third type of uncertainty is about values (i.e., which valued concerns in society are those that should be pursued), often at full awareness that we cannot pursue all values of concern. Beck (1992) observed that major social conflict in western societies has become centered on the distribution and tolerability of risks for social groups, regions, and future generations, leading to the label of “risk society.” With such interests running high, environmental problems thus lead to a democratic dilemma for at least two reasons. First, allocat-

ing resources to address such problems require that we consider possible redistributions of such resources. Second, there are multiple loci of relevant knowledge with which to make such decisions (Coenen et al. 1998).

A third aspect of social-institutional influence involves the persons, groups, and/or organizations as convener of participants. The convener can potentially exert fundamental influence in setting a topic and direction for discussion, and might also be the party that acts as the facilitator for the participatory decision process. The influence of the convener can be amplified or diminished, depending on the organizational and technological arrangements of decision process.

A fourth aspect of social-institutional influence is choosing the number, type, and diversity of participants that are brought together to address a problem. Access to the discourse in terms of giving voice to all groups who are impacted by a complex problem situation sets up an ironic dilemma. The larger the group with different interests being convened, the more opportunity for conflict. Thus, it is perceived that more interests means longer solution times. However, when all interests are not convened at the beginning of a process, there is more opportunity for challenge at completion of the process (perhaps in the form of a law suit). Thus, even though convening more groups in the short-run might appear to extend a process, not convening the appropriate groups sets up the risk of having the deliberation fail through continual challenges (Susskind and Field 1996).

A fifth aspect of social-institutional influence (not reflected in Figure 1) comes from a collection of rules and norms as social structures among participants. Such structuring influences the modes of participation in a public decision process. The modes of participation are in turn adopted as a matter of expectations for communication, cooperation, and collaboration.

Construct 2: Group Participant Influence. One aspect of group participant influence deals with participants' expectations-based values. Values set the stage for participant perspectives about expected benefits and outcomes. Different perspectives on values lead to differentiating between the facts that get stored in GIS and the social values used to interpret the facts. In participatory decision processes, values get often exemplified as concerns. Participants' interpretations of the effectiveness in decision-making depend on how their concerns are addressed during the decision-making process.

A second aspect of participant influence, participants' views/knowledge of the subject domain and each other, mainly involves how participants approach the importance of the topic and how they approach each other in terms of "friendship" or "enemy" feelings. Stakeholder views develop as a result of experience and educational background with topics; people build for themselves a frame of reference for particular issues and they sometimes share them. Frames of reference are anchored by "reference points" (i.e., familiar information elements that are used as a basis for interpreting material and each other's backgrounds). Often, it is because of the similarities and differences in world views and

values, experience and trust, and knowledge and expertise that people align themselves into stakeholder groups; world views and values are more important to the alignment, experience and trust are next, and knowledge and expertise are less important. The difference in stakeholder perspective leads to different values, objectives, and criteria being articulated as the basis of solutions of group-influenced problems.

A third aspect concerns participants' trust in the process. Because in many cases the public is disillusioned with the political process, participation in collaborative decision efforts is on the rise. A fourth aspect of participant influence comes from participants' beliefs and feelings about technology. The emotive issues for GIS technology are often under studied, but in some cases may be as important as the technology itself. Feelings and beliefs are likely an important aspect of reinforcing a person's experience with technology. Such experiences encourage and/or hinder expressing one's interest in considering new ways of accomplishing tasks.

Construct 3: Participatory GIS Influence. One aspect of social-technical information structuring deals with the combination of place, time, and channel of communications. Whereas rules and norms for social structuring are social-institutional aspects of participation, different types of meetings structured in terms of place, time, and communication channels also have an impact on who says what and when during participation in a decision situation. The physical (or virtual) setting of a place has a significant impact on whether people attend a discussion. Being able to attend a meeting due to scheduling (distance and timing) constraints is a fundamental concern in participation. More local and more frequent meetings do not always enhance the opportunity to participate, since more time away from some other activity (perhaps work) is not always as convenient. It is for that reason that technology-supported meetings have been on the increase to open channels of communication.

A second aspect of social-technical information influence involves the availability of social-technical structures as information aids. These structures provide information aids to support the participatory effort. Three types of information aids are often integrated into a spatial decision support system. These are cartographic visualization tools, spatial and attribute data query tools, and analytical models. Computer-mapping techniques implement cartographic visualization tools. Spatially referenced database management systems implement spatial and attribute data query tools. Spatial analysis techniques support analytical model development, and decision analysis techniques make use of the results of spatial analysis to introduce evaluation of multiple alternatives for decision-making. A spatial decision support system integrates those techniques in a computerized, analytical environment that supports participants in their search for solutions.

Constructs and Aspects of the Participatory

Process

The central box in Figure 1 represents an expanded view of a participatory decision process flowing from appropriation (construct 4), decision process (task) management (construct 5), and emerging information (construct 6), and back to appropriation and so forth around.

Construct 4: Appropriation. Appropriation is the act of invoking a structure, whether the act is one time or continual (DeSanctis and Poole 1994). Continual appropriation of the same structure can be called “use” but does not include the act of continual use once invoked. Various appropriation acts structure the character of the information use. One aspect of appropriation involves social-institutional influences (i.e., appropriating at any time any one or more of the five aspects of social-institutional influences).

A second aspect of appropriation concerns appropriation of participant influence. When participants are recognized by others in the participation process, then they provide voice to certain concerns. These might be concerns important to interested and affected parties, concerns of clarification from technical specialists, and/or concerns of allocating a redistribution of resources by managers or decision makers. Participants as the “agents of change” in conversation introduce information about concerns based on their trust with the process of getting a “fair voice.” Sometimes that information is introduced through the use of GIS technology based on their belief that such technology treats information in a way that suits their need for information.

A third aspect of appropriation deals with appropriation of participatory GIS influence. We know little about place, time, and communication channel influences on information use in geographic problem solving and decision-making. Most people recommend anytime, anywhere access, as this covers all situations. However, the advantages and disadvantages to the various forms of place and time meetings when map information is being discussed are not known. In addition to physical settings, we know little about how information technology can be put to best use under different types of participatory process methods. There is an inherent tradeoff between sophistication (representational and analytical power) and ease of use of decision support tools. More sophisticated tools are often more challenging to use, despite the enormous effort put into making tools “user friendly.” This tradeoff becomes even more significant when the users of decision support tools are people of various educational and cultural backgrounds. A non-specialist approaching GIS software often naively expects to work with a set of virtual maps that portray an “objective, shared understanding” about the world. However, GIS has roots in many disciplines and its effective use requires a considerable knowledge, suggesting that there are “multiple realities” to be portrayed.

Construct 5: Group Process. One aspect of group process concerns idea exchange as social interaction. Renn et al. (1995) used

Habermas concept of communicative competence to characterize the ability of participation strategies to support different types of discourse, providing participants with an ability to exchange ideas. Four types of discourse were characterized: explicative, theoretical, practical, and therapeutic. Explicative discourse involves terms, definitions, grammar, and the everyday use of language; the participatory process should allow conversations that make reference to worldly events in everyday language. Theoretical discourse involves references to scientific studies as in an objectified world; the participatory process should also allow reference to the detail of the nuances of complex problems described in terms of technical (discipline-based) language. Practical discourse involves social needs and the appropriate forms (norms) of social interaction; the participatory process must support social interaction that develops out of conventions people know from their everyday experience. Therapeutic discourse makes reference to the subjectivity of a speaker in terms of sincerity and authenticity of claims. Conflict is undoubtedly going to arise in complex situations where values differ. Coping with those conflicts can be handled by permitting therapeutic discourse. How geospatial information tools can support these different styles of communication in order to encourage certain types of participatory process for certain types of problem tasks, effecting certain types of outcomes, is still a matter of empirical research.

A second aspect of group process focuses on participatory task flow management, which concerns the structuring into stages, steps, or phases, either from a pre-determined agenda, an open agenda, or a mixture of both. Renn et al. (1995) characterized the fairness of participation strategies in terms of three criteria: agenda and rule making, moderation and rule enforcement, and discussion. Agenda and rule making deal with who participates in setting the agenda and the rules by which the group will interact. Moderation and rule enforcement deal with whether the group process is facilitated and whether a facilitator enforces the rules that have been established. Discussion involves the degree to which all who are impacted by the decision have a voice in the process. A group process that is fair is a basic tenant in a direct democracy. Few complex public-private problems are addressed through direct democracy; more of them are addressed through a representative democratic process. However, one of the major issues seems to be that representative democracy is not functioning as it once did. Thus, participatory decision situations appear to be on the rise.

A third aspect of group process is the behavior of participants toward each other. This concerns the working relationships that develop as ideas are exchanged and the decision process proceeds. Stakeholder behavior involving conflict has been studied, and idea differentiation and integration are both important (Susskind and Cruikshank 1987, DeSanctis and Poole 1994). Obermeyer and Pinto (1994) see the introduction of GIS as encouraging more conflict between groups rather than less conflict. Jankowski and Nyerges (2001b) investigated group conflict in decision support for habitat redevelopment site selection and found that maps are less likely to be associated with discussion conflict than tables

– a table being more an analytic display for priority ranking of habitat sites than a map.

Construct 6: Emergent Influence. One aspect of this construct is the emergence of social-technical information influence. Although various technological capabilities are provided by software and hardware as per the design of a system, certain other emerging structures might come to light during the treatment of information. The emergence of social-technical structures such as new map designs or database designs might help a group with further information structuring. However, such emergence could make information easier or more difficult to understand in the longer term. Consequently, the emergence of social-technical information structures has a rather significant impact on what information a group treats from activity phase to activity phase (DeSanctis and Poole 1994).

A second aspect of this construct is the emergence of group participant influence. A better understanding of values, goals, objectives, and beliefs are bound to come to light through participant conversation. Participants might clarify their own perspectives and/or the perspectives of others in regard to values, goals, objectives, and beliefs. Views of each other in regard to respectful opinion of what others have to say will undoubtedly get refined. Trust in each other might change as a result of ideas being exchanged. Those who encourage use of technology can have an impact on the feelings that participants develop in regard to its continual use. Feelings for people and technology might well be connected.

A third aspect of this construct is emergence of social-institutional influence. This deals with how rules or norms are brought into use and eliminated or reinforced during the decision process. Clarifying mandates and the problem at issue can lead to refocusing activity for any particular task. In regard to agendas, one can choose to make use of rules to keep the conversation on track or to de-rail it. The emergence of new rules about how people communicate during the participation will change the course of the interaction.

Constructs and Aspects about Participatory

Outcomes

Two constructs are part of the participatory outcomes in EAST-2: task outcomes and social outcomes.

Construct 7: Task Outcomes. Two aspects appear to be fundamental in regard to task outcomes. One aspect is character of decision outcome. Because decision outcomes tend to be so diffuse, depending on the circumstances of the participatory effort, a reasonable approach is to focus on process rather than outcomes. Multiple characteristics of decision processes such as fairness, transparency, efficacy, and inclusiveness can contribute to effectiveness of participatory decision-making.

The second aspect linked to task outcome concerns decision outcome and participant structuring dependence. The

major concern is the stability of an outcome based on whether it lasts beyond the duration of decision-making process. Several researchers suggest that “decision sustainability” is a pragmatic, substantive criterion that could be used to evaluate the quality of decision outcomes. Decision sustainability involves the ability to manage worldly events in such a way as to preserve the “validity” of the decision without having to overturn the action that was decided.

Construct 8: Social Outcomes. One aspect that concerns social-institutional outcomes deals with whether there is an opportunity for challenge of the outcome. The degree to which any decision issue is final and whether it can be changed through further considerations is rather important to promote the results of a process. Some of the participation processes facilitate the opportunity for challenge, whereas others prohibit it outright. Risky decisions should always be amenable to challenge if new and better information arises.

A second aspect of this construct concerns the reproduction and temporality of the group participant structuring. This aspect deals with the stability and longevity of the social relationships among group participants, particularly as promoted in multiple meetings (DeSanctis and Poole 1994). Successful participation can spread through decision processes far beyond the immediate and direct. This is one place where the possibility of participation-based learning supported by GIS could be considered. The impact of participation-based learning about decision-making would seem to be a fertile subject for more in-depth research.

A third aspect of this construct concerns the reproduction and temporality of social-institutional structuring. Such structuring in regard to changing mandates for power or control is only likely to occur over repeated projects – either successes or failures. However, continued successes with projects encourage similar projects to be addressed in the same way, whether this involves the task domain and/or the way that participants are convened.

Eight constructs with the respective 25 aspects presented above likely constitute the single largest enumeration of issues concerning decision-making within a geographical context. In addition, each aspect can spawn several variables when making the EAST-2 operational, ultimately contributing to the comprehensive nature of EAST-2. The above constructs and aspects, together with respective variables, are but concepts that in and of themselves can be used only for developing a “task description” of each macro-phase in a decision situation. It is the premises connecting these constructs, aspects, and variables that turn a conceptual framework into a theory.

Premises of EAST-2

Premises are fundamental statements that tie each aspect on one side of the premise to an aspect of the other side. Premises motivate one or more research questions (as, for example, in Table 1) which, when phrased in terms of variables, can be considered hypotheses (propositions) about the dynamics of a decision situation. The research questions presented in Table 1 are a few examples of ques-

Premises	Research Question Motivated by Respective Premise
Convening Premises	
Premise 1. Social-institutional influences affect the appropriation of group participant influences and/or social-technical influences.	<ul style="list-style-type: none"> - In what way does the purpose of a decision task influence the types of geographic information structures (e.g., maps, tables, diagrams) appropriated by the participants? - In what way does the organization that convened the decision situation in combination with the diversity of participants influence the type of group participant structuring?
Premise 2. Group participant influences affect the appropriation of social-institutional influences and/or social-technical influences.	<ul style="list-style-type: none"> - How do the different perspectives such as those oriented to policy/decision maker, technical/scientific specialist, and interested and affected party influence the types of geographic information structures appropriated? - What types of social-technical information structures appear to be linked to differences in participant structuring?
Premise 3. Participatory GIS influences affect the appropriation of social-institutional influences and/or group participant influences.	<ul style="list-style-type: none"> - How does each of four meeting venues influence the generation of information structures (e.g., maps, animations, tables, and text narration) useful for understanding spatial criteria that can be processed with a GIS? - How do the social-technical capabilities of software get appropriated across meetings in relation to participants' trust in the group agenda which represents a plan for the process?
Process Premises	
Premise 4. Appropriation of influences affect the dynamics of social interaction described in terms of group processes.	<ul style="list-style-type: none"> - What types of geographic information structures are appropriated during the different intensities of participation that seem to facilitate an analytic-deliberative process and which information structures seem to hinder the process? - Appropriation of what types of group participant structures has what type of influence on group process?
Premise 5. Group processes have an affect on the types of influences that emerge during those processes, and emergent influences affect the appropriation of influences.	<ul style="list-style-type: none"> - What kinds of geographic information structures emerge during the different levels of participation in an analytic-deliberative process? - What emergent structures influence the type of appropriation that is undertaken?
Outcome Premises	
Premise 6. Given particular influences being appropriated, if successful appropriation occurs and group processes fit the task, then desired outcomes result.	<ul style="list-style-type: none"> - Given that a group appropriates a particular type of information structure that has been found to be useful in the past, and if the information structure is appropriated during "specific conditions," can we expect the outcome from the process to be satisfactory to all participants? - What structure appropriation under what conditions of group process appear to affect the dependence of the decision outcome on group participant structuring?
Premise 7. Given particular influences being appropriated, if successful appropriation occurs and group processes fit the task, then reproduction of social-institutional influences result.	<ul style="list-style-type: none"> - In what way are various social-institutional structures together with group participant structures linked to the opportunity to challenge the task outcome? - How do inter-organizational protocols and the social interaction during group process promote or discourage further group work?

Table 1. Example Research Questions Motivated by Premises in Enhanced Adaptive Structuration Theory

tions that could be posed. Each premise is a general statement, and each premise statement consists of a subject construct related to an object construct. Hence, each research question asks something about how a subject aspect relates to an object aspect, thus many different questions could be posed. In the context of empirical, social-behavioral research on participatory decision-making, we could say: "how does one variable relate to another variable?"

The seven premises in EAST-2 presented in Table 1, together with the respective example questions, indicate that a wide variety of interesting, empirical research opportunities exist with regard to the use of GIS in participatory settings. Articulating social-behavioral explanations by way of the premises and the research questions they motivate is intended to lead to a "deeper

understanding" about the impact of software designs on GIS support of participatory decision-making. Addressing any one or more questions among such a wide variety of questions is a considerable challenge.

The challenge "begs" for a systematic approach to empirical social-behavioral research so that we can better understand of how empirical results relate to each other in our attempts to build knowledge about the implications of PGIS use. Such a systematic approach is particularly important when trying to understand the nuances of "participation models" (e.g., the three-phase participation model set forth by Renn et al. (1995) as described above). Jankowski and Nyerges (2001a) outline 18 research strategies that could be used to unpack the "process relationships" in such

a model. Choosing among research settings (field, lab, or field-lab), among treatment modes, among data collection instruments, and among data analysis approaches are all important, and thus impact the nature of the empirical evidence derived.

Conclusion

Participation models can help us organize the way we think people interact during work in participatory settings. Empirical studies of participation models that help organize our understanding of the use of participatory GIS are an activity that can contribute to “participatory geographic information science.”

Although participation models abound in the literature, we have little understanding about the efficiency, effectiveness, and equitable benefits and costs of how different models structure participant interaction. When placed in the context of participatory GIS use, we have even less knowledge of such issues. An organizing framework for arraying the multiple constructs (and corresponding detailed aspects) of a participatory situation is beneficial in helping to organize the kinds of research questions that can be examined. The Enhanced Adaptive Structuration Theory as an organizing framework suggests that people structure situations; in turn, situations structure people’s interaction. Technology enables, but it also constrains – thus the need for a systematic approach to empirical studies of such situations.

A wide array of empirical research strategies exists. The 18 strategies outlined in Jankowski and Nyerges (2001a) are compared to each other to provide a sense of what each strategy might contribute to such empirical investigations. Having an understanding of how one strategy differs from another, and hence why we might use one research design rather than another to examine a single participation model or to compare participation models would help us build knowledge in a systematic way. Only through systematically comparing evidence from a variety of research approaches will we gain an overall sense of how and why one participation model in comparison to another provides us with efficiency, effectiveness, and equity advantages and disadvantages. As there is little empirical evidence at this time to point to these advantages and disadvantages, there is considerable opportunity for empirical research to help develop a geographic information science of PGIS use.

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