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Using Technology to Increase Citizen Participation in Government:
The Use of Models and Simulation

E-Government Series

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IBM Endowment for
The Business of Government

E-GOVERNMENT SERIES

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FOREWORD

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On behalf of the IBM Endowment for The Business of Government, we are pleased to present this report, "Using Technology to Increase Citizen Participation in Government: The Use of Models and Simulations," by John O'Looney.

This is the first in a series of reports addressing a core issue of democracy: the challenge of engaging the public in meaningful ways in their roles as citizens. Actively engaged citizens go beyond exercising their right to vote—to becoming informed citizens, citizens able to contribute to public debate in meaningful ways, and citizens able to better influence the decisions that affect them.

Over the past four decades, public trust in government has declined, from a high in 1962 of 76 percent to a low of 21 percent in 1994. In 1998, the Pew Charitable Trust sponsored a groundbreaking study that found that citizens who felt engaged in meaningful ways with their government tended to have a higher level of trust in government. Over the same four decades, many citizens felt increasingly alienated from government. Its size, its bureaucracy, and its distance from citizens contributed to this feeling. Efforts to increase citizen participation through traditional means of public hearings and public notices did not do the job.

But now technology offers the potential to break down these barriers. In this report, Professor O'Looney describes early efforts to engage citizens via the use of models and simulations. These tools can be used both to educate citizens about complex issues, so they can be better informed, and to allow citizens to actually participate in public debates and decision making.

We trust that government executives across the nation will find this report a useful "how to" guide on using technology more effectively to increase citizen participation in government. The report describes some experiences of pioneers in using forms of technology and outlines how to develop and use such tools. Today's teenagers who play games such as "SimCity" are likely, when they become adults, to use the gaming skills acquired in their youth in their new roles as voting citizens to more actively participate in government. As a result of this increased participation, it may now be possible to restore trust in government and democracy.

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EXECUTIVE SUMMARY

This report is designed to help public managers understand and build powerful interactive information technologies for deepening citizen understanding of and engagement in government. The specific systems in question include computer models, simulations, and decision support technologies (MSDST).

In addition to identifying promising uses of these technologies, this report provides guidance on design principles and programmatic components important for developing and making effective use of interactive citizen learning and participation-enhancing tools.

The first section of the report describes the major trends and factors that are likely to lead to increased use of MSDSTs for citizen understanding and engagement.

The next two sections discuss and offer numerous examples and case studies of specific technologies for improving citizen understanding of government and citizen engagement in government, respectively. Based on these case studies, interviews with creators of MSDSTs for citizen participation, and a review of the literature, the final section of the report suggests a series of actions steps for how to go about building MSDSTs for citizen participation.

These steps include the following:

Phase 1: Steps for Planning MSDSTs

1. Conduct an outcome assessment.
2. Thoroughly understand the process or system being simulated and the context for the construction of the MSDST.
3. Validate the underlying model for the simulation.
4. Develop conceptual models of the proposed learning for the targeted users.

Phase 2: Steps for the Operational Development of MSDSTs

1. Identify a development team.
2. Determine the simulation or play format.
3. Experience the MSDST using paper or role-playing prototypes.
4. Choose a development technology.
5. Build a computer prototype.
6. Understand and provide rich context and scaffolding.
7. Provide just-in-time learning support.

Phase 3: Steps for Deploying MSDSTs in Specific Contexts

1. Increase opportunities for learning about, manipulating, and discussing the system dynamics and underlying assumptions.
2. Provide sensitivity information to the user.
3. Help users to share insights and combine problem-solving skills.
4. Enhance the ability to build conclusions or theories from imprecise and uncertain data.
5. Allow users to navigate through concepts in multiple ways.
6. Fashion the MSDST to adapt to the objectives and needs of its user.
7. Create tools that allow citizens to be their own simulation developers.
8. Use MSDSTs to reinforce and enhance existing communities.
9. Match the implementation context to identified needs and available resources.

While following these principles of development should improve the chances that the technology that is developed will be worth the time and resources spent, developers and supporters of these new technologies will nevertheless need to ask a number of evaluation questions: Are all the participants in a simulation challenged to think critically and at a higher level of cognition? Are the participants provided opportunity to explore the boundaries of their personalities and their opinions, and to adopt multiple perspectives? Can the users challenge the assumptions of the model? Finally, a key test for technologies of this type is whether they support participation in the real world rather than acting as a substitute for it.

Understanding the Changing Environment for Technology-Supported Citizen Involvement

Journalists touring the former Al Qaeda safe houses in Afghanistan found evidence of Al Qaeda members using the Microsoft PC Flight Simulator, a simulator that commentators have noted is very close to a professional flight simulator—an expensive, specialized piece of equipment typically available only to a small number of people under controlled conditions. While the September 11 terrorists went on to learn to fly using professional simulators, the potential for their attempting flight with only the widely available PC flight simulation experience says a great deal about the democratization of technology and the effectiveness of simulation experiences in the learning of complex skills.[1]

The promise of the new age is that information technology will allow more people better means to understand the issues of the day and to influence the decisions that affect them.[2] The specific technologies in question include computer models, simulations and decision support technologies (MSDST).[3] As the authors of a recent paper on citizen participation suggest, "Technology offers no magic solutions, but it may provide the means for more people to have an impact on the decisions that affect them."[4]

Three forces in particular appear to be driving this movement: 1) citizens are demanding more channels for participating in government at a time when the challenges of governing have become more complex, 2) younger citizens expect to learn about and engage the world through computer-mediated experiences, and 3) new technologies that build on advances in the science of learning (as well as computer science) are becoming widely available.

Because of this last trend, designers of educational simulations are beginning to create learning environments and tasks that insure that:

- Users' prior knowledge is taken into consideration.
- Users work through problems rather than simply recall an answer.
- Users' new knowledge is deep and well organized.
- Users learn about their own learning strategies.
- Users are better able to overcome the factors that have been found to distort decision making (perceptions that discount quantity issues, social psychology biases that favor status quo or "no action" options over potentially more beneficial alternatives that might require action, and organizational factors such as the transaction costs associated with the coordination of multiple stakeholders in complex decision environments).

In addition to the three major factors, trends in other respects—for example, funding and organizational support for MSDSTs, public managers' level of comfort with enabling technologies, and improved understanding of the role of technology in citizen participation—also appear to be positive with regard to fulfilling the promise of these new technologies for citizen participation.

Frequently, as governments come to rely heavily on narrowly defined expertise for policy advice, the advice of citizens is discounted. Moreover, with limited budgets, governments cannot hire experts in all the areas that might be relevant to a complex decision. As such, only some expertise is consulted. Decisions regarding transportation, for example, are frequently based solely on the advice of road and traffic engineers. As a result, trade-offs that should be considered by citizens possessing a holistic view of the choices are rarely addressed. For example, the safest, most cost-efficient road from the engineering viewpoint is usually wide, made entirely of impervious surface, situated on land without slope, denuded of trees, and designed with numerous one-way flows and without bike lanes. Alternatively, roads designed by strict environmentalists would have substantially different characteristics and lead to substantially different outcomes (such as less pollution and loss of wetlands, but more accidents). The point is not that one set of experts is correct while the other is in error; rather, it is that decisions that may seem simple and a matter for experts are rightly understood as involving trade-offs among values. For example, even within the context of making decision about a new road based on environmental considerations, there are substantial differences between designing roads so as to reduce air pollution and designing them so as to reduce water pollution.

Generally speaking, what MSDSTs have to offer citizens is a more integrative way of seeing and experiencing the complexity of the issues governments face. Public managers have traditionally shied away from promoting citizen participation because many have felt that this will simply make the governing process less orderly. What MSDSTs have to offer these managers is help with educating citizens and with an orderly identification and choice of alternative policies or futures. The promise of the new age is that technology can support a larger decision-making role for citizens at a time when this role has been severely reduced.

In the review of technologies for citizen education and participation that was conducted for this report, most of the applications identified were still based on a single issue or subject area and most were designed to help citizens better understand that issue domain. However, there were also a number of examples of MSDSTs designed to help citizens to truly engage issues and wrestle with making appropriate trade-offs among competing values. Simulations that model public sector budgeting, international relations, and land-use planning stand out in this regard. Of these, land-use planning applications seem to be the most highly developed.

Although this report does not specifically attempt to analyze policies for fulfilling the promise of these technologies, some findings do suggest that the direction of this revolution should not be entirely left to commercial developers of software. Such developers—particularly of educational software and games—have much to offer in terms of establishing standards for high-impact graphics and user interfaces. They are also doing the most to fuel consumer demand for simulation and decision-support technologies. However, citizen engagement is an activity that must exemplify public sector values of objectivity and transparency.

Because it is unrealistic to expect commercial developers to place a high value on transparency, governments may have a role to play to stimulate the development of highly transparent technologies for use by citizens. The European Commission, in this regard, has developed an innovative funding model—one that builds on private-sector expertise while supporting public values. The Commission funds consortia of private and public technology developers to create new software for the use and benefit of citizens. The software itself is fully owned and can be marketed by the consortia, but to receive the funds the consortia have to demonstrate consideration of citizen needs—not just the needs of commercial enterprises.

Factors Stimulating an Increased Demand for MSDST

Factor 1: Citizens Demanding More Participation

As citizens demand more participation in the deliberations and activities of government, public officials will be challenged to manage this participation. This challenge is heightened by the complexity of modern government and public policies, the increased role of experts in policy development, and the expansion of online communications that tend to undermine deliberation. While modern communications networks may have increased the challenge posed by citizen participation, other technologies in the form of MSDSTs can be used to help citizens learn, analyze, and deliberate within a public participation framework.

The citizen participation movement is alive and well. At the same time that citizens are demanding more of a voice in public decision making, legislative requirements for citizen participation, changing professional norms, and recognition of the value of social capital are legitimizing an enhanced role for citizens in numerous areas of public affairs and management.[5] Over the last several decades, a diverse set of channels for citizen participation have been used—from advisory bodies, to study commissions, to public meetings and forums, to written comments on proposed rule making, to negotiations and mediations, to e-mail and web-based comments and forums. The advantages of citizen involvement are myriad and include increased problem-solving ability, better channels for communication, improved program implementation, protection from criticism, and clout in the budget process,[6] among others. (See "What Are the Advantages to Involving Citizens at the Local Level?")

While the importance of citizen participation has been accepted by most contemporary theorists of government and public management, actual promotion and acceptance of technologies that enhance citizen involvement and participation has been less prevalent.[7] There are a number of possible causes for the discrepancy between the stated desire for increased citizen participation and the lack of support for technologies that will enhance such participation:

- The experiences of public managers and officials with the primary technology of this type (i.e., e-mail) have not all been positive. The ease of use of this technology has sometimes resulted in public offices or the offices of elected officials being flooded with messages. For example, when the U.S. Department of Agriculture opened up its public comment process on a proposed rule related to organic foods to citizen input via the Internet, the number of comments (which typically would be under 5,000) jumped to over 270,000. Because of the legal obligation to give just considera-

What Are the Advantages to Involving Citizens at the Local Level?

1. **Ensure that good plans remain intact over time.**

   City councils, planning commissions, city managers, and city planners tend to come and go. Even the best of plans can be dismantled or watered down over time. A plan created by citizen involvement will have a long-lasting, stable constituency.

2. **Reduce the likelihood of continuous battles before councils and planning commissions.**

   Arguments over "density" and "use" have become the center of attention rather than the more concrete questions about whether or not a particular development will enhance or damage the area. A proactive process with a well-designed citizen-involvement component allows citizens to understand exactly what it is they are getting and assures that everyone will be happy with the plan and the individual projects at build-out.

3. **Speed the development process and reduce the cost of good projects.**

   Well-designed projects that have not included citizen involvement may face citizen opposition, which can slow or stop the project. There are considerable costs associated with this for both the city and the developer.

4. **Increase the quality of planning.**

   Professionals are not the only ones generating good ideas. Conversely, citizens are not necessarily wiser than public officials and professional staff. Programs and projects that are the result of an informed citizenry, guided by experts, deciding what it is they want their community to be, are likely to be superior in the long run. Sharing makes good citizens—and better communities.

Source: Local Government Commission, http://www.lgc.org/freepub/land_use/articles/reinvention.html tion to each comment, the burden on the department was substantial. Similarly the high volume of e-mail sent to elected officials (produced sometimes by e-mail chain letters and organized e-mail campaigns) has led many congressional offices to stop accepting e-mail from constituents and other citizens.

- While broad-based citizen participation is desirable in the abstract, actually managing this type of participation represents substantial additional work for public organizations.
- The legal foundation for using or not using certain technologies is sometime not clear, or when clear in the law, not well-understood by public managers.[8]
- Governments have yet to have substantial experience with managing citizen participation through technology.
- The problems faced by public managers and officials have become much more technical and complex, making it more and more difficult to include lay citizens as equal participants. Rather than attending to citizens, public decision makers may in these cases become more dependent on the advice of scientists and other experts.[9]

While the appropriate role of experts in public policy and administration has long been a matter of debate in the field of public administration, there is little likelihood that the world will somehow become less complex and that governments will therefore have less need for experts. The challenge for the citizen empowerment movement, then, is not to drive out expertise, but rather to induce experts to share their knowledge in ways that allow citizens to more fully participate in the dialogue. In this regard, three problems are frequently experienced when experts become consultants to citizens. First is the often cited use of technical jargon and shorthand, which makes explanations by experts less than clear to ordinary citizens. Second is the relative scarcity of experts themselves. If enough experts were available, there would be more time and opportunities for citizens to get the answers they need to be better civic participants. Third is the expense of experts. If expert advice were cheap enough, average citizens could hire their own experts to help influence public policy in the direction they desire.

The development of simulations, expert systems, and other decision support technologies represent one potential response to the problems associated with the role of experts in public policy and administration. Properly designed, these systems can incorporate much of the knowledge of experts, and can act to extend the availability and lower the cost of accessing expertise, while also lowering jargon-created barriers to learning. Just as important, these technologies can act as teaching tools that can begin to educate citizens so that they are more capable of participating in public decision-making processes.

Simulations and decision support technology may also be able to help address another problem that has been noted with much of the online communications related to civic issues—its failure to promote deliberation. As Stephen Bates, a fellow at Annenberg's Washington Program, has said about unmediated online communications: "It prompts more knee-jerk reactions than deliberative responses. It gives people a way to respond instantly and often angrily and aggressively without taking the time to mull something over. And when there is more interesting discourse, you can tell it's people who just love to hear the sound of their own voices. They're not really listening to other people."[10] One of the key problems with such technology is that it tends to work against the slowness that is characteristic of deliberative processes.[11]

While simulations are often built to speed up a process that is too long to experience without some sort of time compression, they can also be built to slow down or expand time or to force participants to go through certain steps before responding to others.

Factor 2: Changes in the Way the Next Generation Expects to Learn

While the demand for citizen-focused simulations is likely to increase as public officials realize how to use these tools as a way to expand the availability of expertise in forums for citizen participation, a similarly strong stimulus to development of citizen-oriented MSDSTs is the recognition that simulation- or game-based learning is the preferred way for youth (or the next generation of citizens) to learn. As suggested by the listing of some of the MSDSTs being used in schools today, MSDSTs and educational technology in general are increasingly playing more important roles. Perhaps more important than their use in formal educational settings is their use in informal environments such as children's play. A key indicator of the significant role of MSDSTs in informal learning can be found in data about the size of the computer-gaming industry. In this regard, the computer-gaming sector, estimated to be a $14 billion industry, is already thought to be larger than the film-making industry. Moreover, while some computer gaming has been criticized for leading to social isolation and violence, new research indicates that moderate computer game play—for example, 18 hours a week—is associated with higher levels of concentration and coordination. In addition, these moderate players appear to have more friends and better social skills, read more, play more sports, and are more likely to attend college than children who do not play computer games.[12]

The potential for building a new learning paradigm around simulation play has not been lost on the educational community. New departments of educational technology have sprung up and rapidly expanded in nearly every college, university, and school system in the country. Although spending on educational technology has primarily been focused on building computer networks and basic computer infrastructure, at some point in the near future, when the basic infrastructure is completed, this will likely change. At that point, more and more emphasis will be placed on the development of ever more sophisticated software that is better adapted to the higher learning needs of tomorrow's students.

As Roger Schank, a promoter of the trend toward more effective use of educational technology, suggests, computers "can bring the world's experts into the classroom in software that allows exploration, simulated experience, learning by doing, and hypothesis testing. Software can be built that makes children want to learn because it is so much fun. This is not the software we have now. What is there is boring drill and practice software that numbs the mind."[13] What Schank and others want to see is a major restructuring of academic courses into goal-based scenarios that will get kids excited. Schank describes what a typical high school social studies student might experience on his or her computer in 2010. The scene is from an interactive software course, Crisis in Krasnovia, which Schank is developing.

> The red phone on your desk rings in the middle of the night. The voice you hear is that of the White House chief of staff, alerting you to a crisis in the Eastern European country of Krasnovia. You're needed at the White House, pronto. "We'll send a limo," he says, and hangs up. After an emergency meeting with the president, you're given a classified intelligence report and access to the country's foremost diplomats, policy analysts, and military leaders. You are to submit a report in time for a presidential address that evening. The president is waiting to act on your recommendation.[14]

While current choices of software for civic education are typically not as well developed as the software that Schank describes, commercial vendors are beginning to develop programs that promise to be both highly interesting and educational. Hence, there is some hope that the next generation of MSDSTs for citizen education will be described in the way that Sue Ducat, former producer of the program "Washington Week in Review," characterized the My City computer program: "My City is an engaging way to interest future citizens in the way their government works. It could help reduce public cynicism and disassociation with the political process."[15]

Factor 3: Increased Availability of Technology That Builds on the Science of Learning and Decision Making

While both supply and demand factors suggest that we will see more development and wider distribution of models, simulations, and decision support technologies, how we view this trend will depend on whether or not these technologies actually lead to more citizens being prepared for citizenship. A key factor in this regard is likely to be the degree to which these technologies are actually effective in promoting learning and improving decision making and other higher-order thinking skills.

In the past couple of decades we have learned much more about how people learn. These findings have been summarized in a recent book by the National Research Council's Committee on Developments in the Science of Learning entitled *How People Learn*.[16] Three key findings from this study that have implications for the development |of educational simulations are that students have important preconceptions, that knowledge needs to be deep and organized, and that learning strategies are critical.

It is common sense (confirmed by research) that a person's preconceptions seriously impact their learning ability. Sometimes these preconceptions represent misconceptions and at other times they simply represent a failure to understand the special uses of terminology that often apply in a particular field and that differ from everyday uses of the terms. Understanding how prior knowledge impacts the ability to learn allows educational simulation designers to develop scenarios for testing students for common preconceptions and language issues that might impede (or possibly facilitate) learning and to develop ways to move students efficiently and effectively from their initial understanding to a grasp of the new concepts.[17]

Another kind of preconception that simulations can potentially help manage is beliefs and attitudes about the nature of learning. For example, it has been observed that some students approach learning as a way to prove their ability (such as by getting high marks) while others approach learning as a way to improve ability (such as by trying to develop understanding). These beliefs about the role of learning obviously influence learning behaviors, the choice of learning tasks, and the persistence of new knowledge.[18]

As a result of this kind of research, designers of educational simulations are beginning to design learning environments and tasks that force students to work through problems rather than simply recall answers. These environments are shaped so that learners experience and appreciate learning as an incremental process. For example, some of these programs explicitly provide feedback at scheduled times to encourage incremental comprehension of rules, models, or processes.[19]

The second key finding in *How People Learn* suggests that learners' knowledge needs to be deep and organized. In many subject areas, the traditional instructional method for achieving deep knowledge involved two distinct phases. In the first phase, students would learn (often in an introductory course) hundreds of facts, names, and concepts. Only then would they be able to go to the second phase, in which they are encouraged to wrestle with the more meaningful problems in the field or achieve what is called "usable knowledge"—the ability to transfer their knowledge to current problems or settings.

Because simulations typically allow people to observe, experience, or even manipulate complex objects and to point to or demonstrate what they mean before they have learned the technical names for these objects or concepts, it becomes possible for students to engage in the kind of meaningful, authentic discussion that is highly motivating before they go on to learn the technical labels. In this way, well-designed simulations can help reestablish the appropriate sequencing of the "romantic" (or motivational) phase and the "technical" phase of learning.[20]

As knowledge becomes deeper and more organized, people's understanding becomes more like that of an expert. Research suggests that while experts do not have better overall memories than other people, they are more skilled at seeing patterns, relationships, and discrepancies than are novices. In doing so, they can extract a level of meaning from information that is not apparent to others. As a consequence, they tend to do a better job of selecting and remembering relevant information, rather than trying to remember all the available information, a strategy that is both inefficient and self-defeating (as the acquisition of new information can sometimes make other information less accessible).[21]

Using knowledge about the mental schema and informational focus of experts in an area, designers of educational simulation can potentially build applications that help novices to more efficiently acquire similar mental maps and filters. For example, the developers of the GenScope simulation for learning genetics specifically designed the simulation around one of the recognized hallmarks of expertise in this domain of knowledge (i.e., an understanding of the relationship between events that occur at different levels of biological organization).[22]

Depth and organization of knowledge are also related to how a person's reasoning influences learning. For example, in some fields, traditional education will tend to reinforce a "cause to effect" or deductive type of reasoning even though deeper understanding is best facilitated through a more inductive or "effect to cause" reasoning. In these cases, simulations are especially useful because they are capable of manipulating the cause-effect sequence in any number of ways.

The third key finding in *How People Learn*—that learning strategies are critical—also suggests that educational simulations may have an important role to play. Learning about one's own learning strategies obviously involves a combination of personal reflection and the provision of personalized feedback by an outside agent. In an ideal world, all students would have a teacher available to listen to them at any moment and to provide immediate feedback on misconceptions or make suggestions about other learning strategies. In reality, teachers are rarely available for this kind of one-on-one interaction and assessment. Sophisticated simulations, however, have the potential to provide this type of feedback about students' learning strategies. For example, computer technologies exist that can track learners' responses or the focus of a student's attention, interpret what these mean in terms of a learning strategy, and provide relevant feedback and suggestions for trying other strategies that might be more appropriate.

Simulations/Decision Support as Means for Improving the Chances of Good Decision Making

Public sector decision making is becoming increasingly complex at all levels. Obviously, there has been an increase in the prominence of issues that demand some level of scientific understanding (pollution control). But perhaps less obviously, numerous areas of public concern that may appear amenable to lay citizen understanding and intervention (human services delivery) have also become quite complex. For example, contemporary thinking about human services delivery suggests that service workers cannot provide high-quality service based only on knowledge of their own agency's programs; instead, even frontline workers need to understand the interconnected network of agencies, programs, and services that make up a community of care.[23]

Whether in areas demanding scientific understanding or the understanding of complex human systems, the ability of citizens or even generalist public managers to make good decisions can be undermined by the complexity of the decision space. Moreover, because the space is public in nature, the decisions will typically involve politics and human discretion in some measure. When one combines increased complexity with politics and discretion, decision makers (whether citizens or officials) will often be subject to perceptual, social, and organizational factors that can distort their decision making. New knowledge about these decision-distorting factors suggests that simulations and decision support technologies may have a role to play in reducing the potential bias that these factors sometime contribute to public decisions. Table 1 summarizes how simulations might be used to overcome biases recognized in the decision science literature.

Short-Term Trends on the Future of Technology for Citizen Participation

These three major trends are likely to lead to increased use of technology for citizen participation over the long term. However, the short-term prospect for increased technology use in this regard will depend on such factors as effective funding strategies, public managers' needs and experiences with particular technologies, and a refined understanding of the role of technology in citizen participation. For the most part, the general trends in these areas are also positive.

Effective Funding Strategies

The potential for using simulations broadly in the education field has long been touted by computer industries. Now, however, the idea of fully transforming education and citizen participation in this manner is gaining foundation and government sup-

Table 1: Ways Simulations Can Be Used to Overcome Decision Distorting Factors

Type of Decision Distorting Factor	Potential for Using Simulations to Overcome the Factor
Perception-Based Bias	Use of sophisticated decision support system can facilitate the identification of utility-maximizing strategies, or strategies that emphasis objective quantity values rather than personal principles or distorted perceptions that bias judgments.[24] Applications can be programmed to more prominently display and explain utility measures (net benefit) that are considered to be more relevant to good policy decisions. Application can be programmed to sense and test for when a person's responses indicated unwillingness to trade a particular type of benefit—even for exceptionally large measures of other benefits. This information could then be conveyed to the user as feedback. Applications can be programmed to identify variations in the way users value time-related factors and to provide feedback to more accurately judge time in particular situations. For example, in a foster-care adoption simulation, feedback could be used to indicate how the lack of a permanent placement can cause psychological damage more quickly than the average adult would expect. Applications can be programmed to highlight lost opportunities for additional utility or to indicate the degree to which the simulation player's responses failed to maximize utility.[25] Simulations can be designed to explicitly identify biases such as bias toward one's own reference group. Attempting to identify such bias through real-world research is often impossible because subjects in the real world can usually claim that the decision that seemed to be based on a bias in favor of one's own group was actually based on some other factor. Because simulations can repeatedly pose a scenario while varying only a single factor (the race of a character in the simulation), they can more convincingly demonstrate to the user that bias exists.
Social Psychological Bias	Simulations can be designed to provide and to highlight objective measures of benefit. To overcome bias in favor of "no action," simulations can be programmed to give extra weight or emphasis to alternatives vis-à-vis the status quo so as to insure that people give equal consideration to the available options. Simulations can be designed to help citizens and public officials to better see and understand the potential benefits and conflict-resolving possibilities of identifying common interests and negotiating across domains. Also, as the task of integrating diverse interests becomes more computationally complex, simulations and decision support tools can potentially assist in handling these complexities.[26]
Organizational and Situational Bias[27]	Simulations can be programmed to help public managers and citizens to better understand the key relationships in the decision environment that researchers are discovering. Simulations can help users experience negotiations at different levels of resource availability and resource distribution among players. Simulations can be built to force users to experience negotiations under different resiliency scenarios (different probabilities of failure given the same user responses). Decision support technologies can help to lower search costs or to manage communications with stakeholders. Groupware decision support technology has been used extensively to assist with decision-framing tasks. These technologies facilitate: • The input of ideas by diverse groups (by protecting anonymity) • The identification and organization of ideas/options that are similar in nature • The weighing of each option by users • The development of cost-benefit matrices Simulations can and have been built that help users to learn how to analyze issues, better frame their interests. and evaluate and match their negotiation styles with those of expected opponents.[28] Simulations/decision support tools can be used to track historical behaviors of negotiation opponents or partners, summarize costs and benefits of various types, and simulate the costs and net benefits of different monitoring regimes or schedules.

port as well. Evidence of this support can be seen in two initiatives. One is the emergence of the Digital Promise project of the Century Foundation. The foundation is promoting the creation of the Digital Opportunity Investment Trust (DO IT), a nonprofit, nongovernmental agency designed to meet the urgent need to transform learning in the 21st century. One of the major purposes of the trust would be to create inviting training materials for civic engagement as well as to democratize the understanding of challenging subjects by using techniques such as modeling, simulation, student-developed design projects, information visualization; and multiple ways of presenting the same information.

The crux of the Digital Promise project's argument is that as a society, the United States has expended billions to wire schools and communities to the Internet—but practically nothing on online content. According to Thomas Weber, writing in the *Wall Street Journal,* this is "an effort akin to buying TV sets for everyone in the name of education, then leaving them to choose between 'Big Brother 2' and 'Witchblade.'" The trust fund, according to Lawrence K. Grossman, the former PBS president and a supporter of the Digital Promise project, would help build worthwhile places to visit in cyberspace. "You could have a virtual solar system, a 3-D model of a human body, or a re-creation of Mark Twain's America."[29]

A second initiative of interest is the European Commission's Information Society Technologies (IST) Program. This program places a special emphasis on "Systems and Services for the Citizen," which is currently funded at 650 million euros. IST supports research and development in a number of areas related to health, transportation, e-government, and the environment. Two features of this program are unique: first, the projects supported by the program must provide a means for citizen access to project products, information, and services; second, the funding mechanism is designed to hitch the development of technologies for citizen participation to the more politically strong goal of helping European IT developers improve their competitive position. This linkage occurs because IST provides 50 percent of the funding of projects that are proposed by public-private consortia but leaves the ownership of the software or systems entirely with the consortium. Because of the requirement of the 50 percent match by the consortium, the projects tend to have a high potential for commercial spin-off.[30]

Public Managers' Needs and Experiences

There is a tradition of public managers of large agencies that are responsible for complex decisions commissioning models or simulations for the purpose of informing public policy. Most often public managers will simply use the first-round estimates or the results of a model that has been built in conjunction with a study. In many instances, however, it would take only a minimal amount of additional resources to develop the model into a system that is computer based and that can be accessed for repeated use and analysis. This potential is often not realized because most policy makers tend to be focused on the short term and, therefore, do not have strong incentives to build systems that can be used again and again or used by other governments experiencing the same problem. Also, public managers are sometimes concerned about the level of uncertainty or accuracy associated with models. In these instances, policy makers may be reluctant to support the building of simulation models that might later prove misleading.[31] Finally, public managers may be concerned that simulation models run by citizens can potentially be used to demonstrate the advantages of policies different from those adopted by the current government. Fortunately, although public managers may not have sufficient incentives to transform government research models into simulations for citizens' use, other organizations (institutes of government, foundations, and universities) are typically not constrained in this manner.

Refined Understanding of the Role of Technology in Citizen Participation

How far we go in terms of developing technology to support citizen participation will depend on the answers we arrive at in response to questions such as the following:[32]

- Are the results worthy of the time spent on the simulation?
- Are all the participants in a simulation challenged to think critically and at a higher level of cognition? (For example, in courtroom simulations, does the citizen playing the role of the bailiff really learn much?)

- Can a simulation be too entertaining for some citizens and not entertaining enough for others?
- Are the outcomes important enough and broad enough to justify the time needed for a simulation player to reach exemplary performance?

Understanding the role of MSDST also involves thinking about how MSDSTs fit within the larger array of techniques for enhancing citizen understanding and involvement. According to the Local Government Commission, "successful citizen participation usually involves employing a variety of techniques in combination with one another. Combining different tools will lend greater credibility to a participation process, generate more meaningful, diverse response, and solidify long-term support for completing specific development projects and implementing broader policy goals."[33]

Understanding the diversity of ways for promoting citizen participation suggests that designers of citizen-oriented MSDSTs will want to develop ways to piggy-back on other efforts. The approach of the city of Denton, Texas, to surveying citizens for their visual preferences in order to develop new design standards represents an example of this kind of strategy. Denton integrated the Internet-based survey with a number of other activities, including:

- Having local merchants and Denton city departments offer weekly prizes
- Putting up posters around the city
- Distributing a newsletter to city residents
- Having the survey available in multiple places (city hall, libraries, community centers, and a kiosk at the mall)[34]

More specifically, it is becoming increasing possible for information technology to be connected to communication technology so as to increase the circle of participation and understanding. For example, one can imagine how a city might sponsor a community forum on a proposed controversial zoning. As participants in the forum consider alternative development scenarios, the visualizations could be broadcast on local television, and phone lines could be set up to allow home participants to provide their opinions. Similarly, a companion Internet site could provide a channel for web-based participation (through online webcasting and surveys).[35] The European Commission's CyberVote project, an innovative voting system for Internet terminals and mobile phones, and its CENTURi21 project, a network allowing citizens to participate in a single forum through multiple devices, suggest a couple of ways in which converging technologies can help support complementary strategies for citizen participation.

Understanding the role of MSDST in citizen participation also involves understanding how to orient citizen-focused MSDST with the spectrum of possible types of citizen experience. At one extreme of this spectrum, a simulation might be designed chiefly to produce a fun or thrilling experience. This is the primary orientation of commercial computer games. The popularity of these games among younger citizens represents a major challenge to today's civic educators. For many gamers, the increase in tacit knowledge (of how a simulated world works) is obtained without any conscious understanding of the underlying dynamics. Research in this area indicates that people can succeed in game-like activities, but nevertheless be unable to transform their experience into an explicit understanding that would be applicable to other fields. Moreover, in some cases gaming experiences may actually interfere with explicit learning.[36]

At the other extreme, MSDST can be oriented toward only the learning or recall of specific information or concepts. Scientific and mathematical modeling simulations, quiz-based simulations, and highly topic-focused classroom simulations often demonstrate this type of orientation. The potential pitfall of these simulations is that they will fail to engage or motivate the learner and fail to provide the learner with the experiential cue for understanding when the modeled relationships will be applicable.

The challenge for those who would attempt to engage citizens in learning about government is to produce an engaging, fun simulation experience, while also teaching certain content. Sometimes such simulations are referred to as "edutainment." In this respect, real-world, citizen-focused MSDSTs should perhaps not be evaluated on the same basis as classroom simulations. Teachers can structure classroom simulations in ways that intensely focus on the learning tasks at hand and thereby produce learning results in an efficient manner. This is accomplished in part because they are able (through the magic of compulsory education) to sacrifice some of the fun of simulation play that does not directly lead to new learning. The simulations themselves will nevertheless be a success because they are still more fun than traditional learning and because students form a captive user group.

In contrast to classroom simulations, MSDSTs for citizen participation must build in either a higher level of fun or a higher degree of real functionality (support for a real decision). In this regard, creators of these simulations need to ask questions such as:

- Would the "fun" be enough to draw people back to play the simulation over and over? What is gained by citizens playing the simulation again and again?
- Are there outside benefits that can be employed as inducements for citizens to use the simulation/decision support technology (citizens logging more hours on the simulators are invited to participate in governmental advisory committees)?
- How do we measure learning? Do the users need to be able to actually understand a complex public decision-making process (how different land-use policies each impact cost of infrastructure and service delivery), or is it sufficient that citizens have a greater appreciation of the complexity of public policy decision making in the area being simulated?
- Does the MSDST experience make it possible to get the "right" answer without really learning anything? Is this acceptable in the context in which it is being used?

The issue of context for use is obviously a major one for public managers who are considering the development of MSDSTs for citizen participation. There is general agreement that simulations are needed in many contexts. One cannot risk the lives of emergency personnel and others by training them only when real emergencies occur, one cannot wait for the results of a land-use plan to occur to evaluate the plan, and one cannot expect government officials to provide one-on-one tours of every government department to every citizen in the jurisdiction. Beyond this area of general agreement, however, the opinions about the value of simulation vary significantly. For example, there has been ongoing debate at Massachusetts Institute of Technology's (MIT) School of Architecture and Planning about the worth of computer-aided design, with some professors believing that use of these tools results in a loss of artistic quality and detachment from the work. A more global complaint in this regard is that simulations and other mass-produced technology may represent a lack of political will to fund face-to-face interactions adequately.[37]

In some respects, just as there is something amiss in having "a four-year-old manipulate virtual magnets to pick up virtual pins," so too having citizens enter into a simulated debate over a new land-use plan rather than participate in the debate that is going on in city hall is questionable. However, if the simulated land-use debate can be shown to represent good training for citizens to participate more intelligently and effectively in the real debate, then the simulation may be said to be worthwhile. In this respect, simulations, as Sherry Turkle has suggested more generally about the Internet, represent additional opportunities for people to explore the boundaries of their personalities and their opinions, to adopt multiple perspectives, and to form relationships that can be as or more intense than real ones.[38] If these opportunities lead to growth and a better sense of community, then they will have been justified.

Similarly, we might complain about the development of simulations for citizen education and involvement supplanting existing or traditional efforts to educate and involve citizens, but this complaint seems somewhat hollow considering the overall lack of citizen education expenditures on the part of governments. In these circumstances, high-quality simulations and decision support tools for use by citizens would represent a major step forward.

A major conclusion of this report is that our civic landscape is likely to be dramatically changed by citizens' use of MSDSTs. What is somewhat less clear is the appropriate role of government and the nonprofit sector in this transformation. Obviously, commercial providers of software—particularly of educational software and games—are leading the way (establishing the standards for high-impact graphics and user interfaces and fueling consumer demand for simulation and decision support technologies). Unfortunately, the educational and public-value impacts of some commercially developed software may not live up to expectations. In particular, software such as SimCity is frequently criticized for policy biases (tax too much and you lose) and the lack of transparency regarding the assumptions underlying the models. Even though more serious and sophisticated commercially developed modeling software such as the CommunityViz™ Policy Simulator module (described in the next section) does not seem to possess specific policy biases, the underlying software algorithms are nevertheless masked due to the proprietary nature of the research on which they are based. Because it is unrealistic to expect commercial developers to place a high value on transparency, governments may have a role to play to stimulate the development of highly transparent technologies for use by citizens. The European Commission funding model—one that builds on private sector expertise while supporting public values—may be one that governments in the United States should consider.

Finally, although we can and should reject the paradigm of computer games like SimCity that hide their assumptions from the user, we also need to recognize that we regularly use computers in the real world to perform tasks where the underlying workings of the computer remain obscure. As the sociologist Paul Starr has pointed out, "Policy making inevitably relies on imperfect models and simplifying assumptions that the media, the public, and even policy makers themselves do not understand."[39]

Models, Simulations, and Decision Support Technologies in Action

Effective citizen participation begins only when citizens have sufficient understanding of government and the issues that affect government decisions. Obviously, a good liberal arts education is the best foundation for citizen participation. Nevertheless, even well-educated citizens will often lack the special knowledge needed to understand the more complex issues that governments face. Models, simulations, and decision support technologies have a role to play in filling in these gaps.

Broadly speaking, MSDSTs can be used to address limitations in our capacity to experience the real world or convey our knowledge about this world or our ideas of what it should be like. In this regard, a citizen's knowledge about the world of civic life or public decision making is, like most knowledge, formed by recollections of the past, observations about the present, and speculation about the future. In each of these instances, citizens' abilities to absorb and convey knowledge can potentially be enhanced through better MSDSTs.

With respect to recollections of the past, citizens who are able to access the minutes of government meetings, program descriptions, planning documents, maps, old tax records—even pictures of what a community area looked like 15, 20, or more years ago—will be much better equipped to recall how past public projects, policies, or programs impacted the community. In addition to forming the basis of any good model of how government works, our best understanding of the past can be enhanced by information technologies such as geographic information systems (GIS) or advanced search engines and databases that can spatially reference and cross-index information for easier analysis.

Citizen understanding of the present is more problematic than understanding the past because the data are often incomplete or not current. As such, understanding the present may involve developing technologies for "getting people on the same page." Such technologies might allow for real-time viewing of important events (traffic on a road being considered for widening) or facilities (a historical building being considered for demolition). Similarly, they may support viewing of or participating in important processes (planning commission meetings or a simulated citizen vote on the same issues being considered by the commission).

Finally, effective citizen participation often turns on citizens' visions and understanding of the future. Obviously, this type of understanding is the most difficult because it is essentially speculative. Yet, we generally acknowledge that some speculation is more informed than others. For example, we commonly tend to give more credence to speculation that seems to be based on a heuristic than that which is based on free association or ad hominem arguments, and we give more authority still to the formal speculation of experts that is based on scientific modeling and the careful transference of research results.

While many public policy issues can be adequately addressed through a simple mental application of prior research results to the question at hand, there are also numerous cases where one would want to employ some sort of model, simulation, or decision support technology. This is likely to be true when:

- Feedback loops are too long.
- The research suggests complicated interactions among numerous variables.
- The real-world equivalent of the simulated world is inaccessible.
- We need to explore numerous "what if" scenarios that would take a great deal of effort and expense to explore in the real world.
- Making the wrong decision is costly or dangerous.
- Observations are too rare to achieve certain knowledge.

We can observe many of the circumstance that support the use of MSDSTs in helping citizens and public employees to better understand their world. Examples include:

- Training of emergency management personnel (or citizens who might get caught in an emergency situation) where real-world learning is dangerous.
- Citizens achieving an understanding of complex ecological systems that may need to be regulated through public policy. Achieving such an understanding may involve numerous "what if" experiments that cannot realistically be conducted in the real world.
- Citizens understanding how different transportation strategies or tools impact different values (travel time, pollution, accessibility, beauty).

Getting to the Point Where Citizens Are Able and Want to Use MSDSTs

Using MSDSTs to increase citizen understanding suggests that such MSDSTs represent a special class of educational technology—one distinguished by its content, purpose, and design. The content needs to be specialized enough to help citizens understand specific government actions, but general enough to allow a layperson to approach the subject without undue trepidation. The purpose of these MSDSTs would be to enhance the learning of people of citizen age or near citizen age. As such, these technologies would need to be designed with the needs of the adult learner in mind (adult learners may need more help with computer interfaces, but less help with vocabulary or metaphors). Finally, the design of these MSDSTs should share characteristics with other good educational technologies. That is, they should be able to shape the experience of the user to match the MSDST experience with the user's prior knowledge, learning needs, and learning styles. For example, such technologies may be built to provide different kinds of feedback in different time frames (real time, accelerated time, or slowed time), and to use different messages and media formats to customize and enhance the learning experience.

As suggested earlier, there are numerous existing MSDSTs, typically built for expert or academic use, which could be adapted for citizen use. By making highly technical software more usable and transparent (see "Redesigning Simulation Software for Non-Technical Users"), the number of users, uses, and applications expand tremendously.

Redesigning Simulation Software for Non-Technical Users

While the scientific community has long developed and used simulation models for any number of purposes, most of these simulations had little impact on the way in which governments operate because the average government did not employ the level of technical staff to enable use of these simulations internally, much less by citizens. This barrier to simulation use is disappearing as more simulations are developed for use by non-technical persons. A good example of this trend can be seen in the recent awarding of a contract for the development of an interface for a Transportation Analysis and Simulation System (Transims), which was originally developed at Los Alamos National Laboratory for the U.S. Transportation Department and the Environmental Protection Agency. By creating a highly user-friendly interface to a very complex simulation, Los Alamos Laboratory officials believe that the traffic simulation software will have much broader use, including use by emergency evacuation and environmental planning organizations. [40]

Examples of the Proliferation of MSDSTs

Citizens' acceptance and use of MSDSTs for understanding government will be enhanced not only by more accessible, user-friendly interfaces but also by the general proliferation of MSDSTs in the educational, work, and play environments. Evidence for the expanded availability of MSDSTs in all of these areas can be found.

General and Business-Use Technologies

Consumer research

Research results from Michigan State University's Media Interface and Network Design [M.I.N.D.] Lab show that adding 3-D products and virtual sales agents to e-commerce sites generates significantly better product knowledge and elevated purchase intent in consumers. Specifically, consumers were found to have learned 40 percent more about products in virtual sites than they did in reality. Frank Biocca, director of the lab, explained, "Real products are great, but they just sit there; they don't explain themselves." The interactive features of a 3-D product make the difference in consumer learning.[41]

Business education

Literally hundreds of business and process simulations have been built both for the purposes of improving business education and for improving a business process.[42] One recent high-profile example involved internationally recognized Babson College. The college has formed an alliance with Indeliq, a provider of performance simulation e-learning solutions, to develop a suite of seven web-based simulations entitled "Building Business Acumen." These simulations will be used to develop high-value business skills in a form that comes close to learning by doing.[43]

Crisis management

Some of the most effective training for crisis management comes in the form of role-playing responses to simulated events. Oftentimes the simulated events are communicated via notices from a game master or computer event manager. Researchers at MIT Media Labs, however, are using Thinking Tags, small wearable computers networked to each other via infrared beams that provide signals both to the wearer and to other participants, to begin to more effectively use technology to enhance real-life, participatory simulations. The players in these real-life, participatory simulations are not just watching the simulation; in a very real sense they *are* the simulation. For example, if the simulation is of an epidemic (a bio-terrorism event), the participants do not need to struggle to keep track of which player is sick, for the flashing red lights signaling sickness are part of the clothing of their fellow participants. The questions that follow—Who got them sick? When? How? Why?—are part of discovering the vectors for disease transmission that underlie the disease simulation.[44]

Educational-Use Technologies

Science education

Open College Online Simulations Workshop includes more than 300 interactive simulations from mathematics, economics, 3D-geometry, statistics, mechanics, thermodynamics, electricity, and other subjects. These simulations, based upon the visualization of the mathematical model of a phenomenon, help students learn by experiencing simulated phenomena, examples, and schemes.[45]

Davidson College scientists Mario Belloni and Wolfgang Christian are developing a physics curriculum based on interactive computerized simulations. The curriculum, called Physlets, uses small computer programs to simulate physics concepts. Belloni and Christian believe that the new curriculum overcomes many of the inadequacies of other multimedia learning approaches because the simulations are authentic, adoptable, and adaptable. The publisher of the Physlets book, Prentice-Hall, has incorporated Physlet-based interactive problems into five of its textbooks.[46]

Students at Mesa Elementary School, Boulder, Colorado, are learning about what makes for sustainable ecosystems, but not from a science book. Rather they play an interactive computer simulation program that challenges the students to keep a virtual animal species, which they have created, alive based on the survival traits of the animal and the rules of the virtual world in which it lives.[47]

Social science

The recent development of agent-based models for developing artificial societies—in which thousands of simple but interacting computer programs demonstrate highly complex behavior—is providing an opportunity for social scientists to develop a common paradigm for understanding complex phenomena such as migration, conflict, corruption, inequality, pollution, and sexual choice.[48] Building and using these models have led to new insights about how slightly different public policies might have substantially different impacts under various conditions. For example, artificial societies for modeling corruption (or the interaction between honest and corrupt agents) have suggested that policies that target corruption among high-profile individuals may be much more effective than more evenhanded law enforcement—even if the latter policies might result in higher overall odds of being caught. This is the case because under conditions of limited knowledge (i.e., the corrupt do not always know the real odds of being caught), the fear of being caught can become more important than the overall odds of actually being caught. As the author of a recent article on artificial societies recently concluded: Growing societies on computers "will probably never enable us to foresee the future in detail—but we might learn to anticipate the kinds of events that lie ahead, and where to look for interventions that might work."[49]

Civic education

Students across the nation play The Electronic Model Congress (TEMC) simulation in which the classroom becomes part of a community partnership of businesses and the local legislative office. The businesses include a media group, a polling organization, a special interest group, and an auditing company. The legislative staff members and students buy and sell services electronically. The class also chooses two legislators and a piece of legislation. They contact peers in schools across the United States as they conduct business and promote legislation via the TEMC computer program. E-mails, contracts, polls, and other information are sent and received daily. Auditors keep careful track of finances. The legislators try to find co-sponsorship for their bill in other classrooms, so it can be placed on a final federal agenda.[50]

Students in some schools are challenged to use the Internet to research and prepare a presentation on food irradiation as a method of reducing the risk of food-transmitted illness. Students conduct online polls and surveys and present their findings to other social studies students who act as members of the House of Representatives Investigating Committee. These students, in turn, write legislation concerning food irradiation.[51]

Decisions, Decisions Online provides teachers complete lessons, videos, online discussion boards, and polling and quiz capabilities designed to help teach current events topics in social studies and science while students practice decision-making skills.[52]

International relations

The University of Maryland's ICONS (the International Communication and Negotiation Simulations) program offers educational simulations of international relations at both the university and high school levels. Students at a participating institution represent the decision makers of a selected country and negotiate solutions to global problems via the Internet with peers around the world.[53]

The River City News

Classroom, Inc., simulations are designed to help students develop and strengthen basic skills in reading, writing, and math. In addition, they help youngsters become proficient in acquiring and using information, thinking critically, communicating viewpoints, solving problems, and making decisions. The simulations tend to be based on workplace experiences, but many also involve social issues.

The River City News simulation introduces students to the day-to-day management issues inherent in running a daily newspaper. Taking on the role of managing editor, students work toward national standards in language arts, social studies, media literacy, and life skills as they address issues facing newspapers everywhere. Activities in the 12-episode program include copy editing stories, choosing photographs and graphics for news features, reporting a story (includes conducting interviews, checking sources, and outlining/writing the story), laying out the paper, meeting with community leaders, and managing day-to-day business (budget issues, advertising, personnel problems, etc.). All episodes emphasize reading and writing.

Public Policy Oriented Technologies

Policy development

The Manhattan Institute has developed a mathematical model capable of simulating how different types of voucher programs, implemented in New York City, under differing state and local education policies, would affect the distribution of families by income, other socioeconomic variables, and parents' perceptions of public school quality. Based on the model, the Institute makes an economic case that expanding choice in places like New York appears favorable.[54]

The FAIR program of the Commission of the European Communities developed a simulation called IMAGES (Improving agri-environmental policies: a simulation approach to the role of the cognitive properties of farmers and institutions). This simulation models the factors that influence farmers in deciding whether to adopt environmental improvements and was used to help policy makers formulate more effective environmental improvement programs.[55]

Organizational operations

VirtualU, a sort of "Sim University," is described by its developers as a "virtual alma mater of Malthusian forces, invisible hands, and stakeholders." The player of the simulation adopts the role of the president of the university. The goal is to survive in office by making appropriate decisions regarding expenditures for such things as instruction, research, diversity in students and faculty, infrastructure maintenance, sports programs, development offices, and alumni reunions.[56]

Planning

Numerous computer tools (UrbanSim, California Urban Futures, What If?, Smart Growth Index) have been developed to help model the impacts of land-use changes. Some of these planning aids have been adapted to support citizen education and participation and are described in more detail later. The number and variety of simulations being used in the planning process has become so great as to lead the Environmental Protection Agency to commission a study of the strengths and weaknesses of various planning support software.[57]

The accepted availability of these tools is further evidenced by The National Capital Planning Commission's recent requirement that architects submit three-dimensional computer models of all projects proposed to be built on public land in Washington D.C. According to Michael Sherman, a community planner for the commission, these models "allow us to control what we're going to see as opposed to what the applicant wants us to see," Citing the example of the proposed World War II memorial on the Washington Mall, Sherman noted: "We were able to evaluate the impact much earlier on. We could see whether the views of the Lincoln Memorial and other historical landmarks were blocked. It was very helpful to see the memorial from the perspective of a pedestrian, which you can't do with a physical model." Michael Kwartler, director of the Environmental Simulation Center in Manhattan, suggests that these models help create "a kind of accountability. You can't be seduced by someone's perhaps overly optimistic vision."[58]

Locating unwanted land uses

UCLA's Urban System Laboratory is building a Learning System for Environmental Investigation and Restoration. This simulation will allow users to interact with a simulated city (based on the UST Urban Simulator) and thereby explore a variety of complex hazardous-waste sites in virtual simulations. The virtual simulator will enable users to investigate a site via drilling and sampling procedures, simulate fate and transport processes, test remediation strategies and realize costs—all in an accelerated time frame. The simulator will likely change the way environmental science and engineering is taught, suggests William Jepson, director of the UCLA Urban Simulation Laboratory.[59]

Training

The Los Angeles Police Department, recently tasked with providing security for the Metropolitan Transit Authority (MTA), plans to use a 3-D simulation to familiarize personnel with the miles of tunnels (which are very difficult to explore while the trains are running). The simulation will also be used to expose workers to training scenarios that pose different problems and task officers with developing appropriate responses.[60]

Building or facility design

Reservoir Civic Centre Redevelopment Melbourne (Australia) used a variety of building simulation tools to help designers produce a building that performed well in terms of life cycle costs in all environmental areas and still met budgetary, aesthetic, functional, and social goals. Stakeholders were charged with maximizing energy efficiency, water efficiency, indoor air quality, and use of recycled materials, while minimizing construction waste and embodied energy. Although such simulations are necessarily technical in nature, citizens and policy makers often have strong interests in how public buildings are constructed in terms of life cycle costs.[61]

Increasing Citizen Engagement in Government

If increasing citizen understanding of government is the first step in enhancing citizen participation, increasing the capacity to engage citizens with government officials, programs, and policy-making processes represents the next step. There are two distinguishing features of technologies designed to increase engagement as opposed to understanding. First, engagement-supporting technologies tend to include some communications and data-aggregation capacities. That is, engagement occurs when people know more about each other and are able to communicate more about what they know. Whereas increased understanding can take place as individual citizens go about learning on their own, engagement tends to take place in groups. Secondly, engagement tends to occur around more concrete or situation-specific events or challenges. The distinguishing features of engagement have some implications for technology and infrastructure design and for the context of their use.

Sometimes models, simulations, or decision support technologies are designed specifically to increase understanding but not engagement. In other instances, the same MSDST that is used for increased understanding is employed to also increase engagement. Frequently, it is the context in which the MSDSTs are used that determines which of these purposes the technologies fulfill. For example, the same simulation that might be used by students of city planning to learn about urban dynamics may also be used by a government as part of a design charette or workshop for citizens or planning officials.

In practice, some MSDSTs are more likely to lead to increased citizen engagement than others. Typically, these MSDSTs are ones that directly speak to a policy or agenda item in government or that feed into the process whereby public opinion on a particular issue or the current government agenda is formed. Because such engagement-focused MSDSTs tend to address more exactly specified domains or problems, these MSDSTs often tend to be more complex and, therefore, potentially more difficult for non-technically trained citizens to use.

With simulations designed to increase understanding, it is often possible to simplify the MSDSTs in order to get the main points across. This is not usually the case with MSDSTs designed for engagement since the product of the MSDST needs to be sophisticated enough to speak to a particular, often highly complex, real-world issue or agenda item.

Ultimately, MSDSTs designed for enhancing engagement are ones that point toward a decision on the part of government officials or managers. Such MSDSTs are particularly good at tasks such as:

- Identifying the likely impacts of a land-use plan that will not be realized as a built environment for another 50 years. In this case, the feedback loop is too long to understand the impact of the government's decision.
- Identifying the areas that should be targeted with public funds for redevelopment or that might be good candidates for a locally unwanted land use.

- Processing the information flow in mass deliberations so as to make it digestible to decision makers.

In addition to overcoming built-in limitations to using the real world as a test bed for new policy ideas, MSDSTs can also be used to:

- Help stakeholders to recognize problems that would have gone undiscovered (that the flow of pollution from a new landfill will threaten an important water source in 15 years).
- Help deconstruct the overall decision problem into sub-problems (what can we do in the new land-use plan to minimize water pollution, and how much will each policy option impact this goal?).
- Help solve problems that an individual decision maker alone would not even attempt (estimate the increase in particulate matter exposure that is likely to occur given five alternative land-use plans).
- Help a decision maker reach solutions faster and/or more reliably.
- Help stimulate thoughts about the problem or a new perspective (what would the neighborhood look like were the city to allow granny flats or higher-density development?).
- Develop compelling evidence to justify a position, thus helping the decision maker secure the agreement or cooperation of others.
- Help stakeholders to ground their discussion of an issue in terms of different concrete, albeit simulated, options.

MSDSTs, Engagement, and the Internet. For the most part, MSDSTs for citizen engagement have been limited by the constraints of traditional technical infrastructures (analog phones). Since the infrastructure could not be used to coordinate multiple, simultaneous communications, the effective result was that government-engaging citizens needed to be in the same physical space or room to communicate effectively as a group. If one was attempting only to increase citizen understanding, this barrier could be overcome (via distribution of educational software). With widespread access to the Internet, it becomes possible to deploy both technologies for understanding and those for engagement via the network. Engaged citizens can now, in many cases, interact with their government and with each other through the Internet, but the Internet also makes it possible for these communications to be mediated by MSDSTs. This capability is, obviously, still in an infant state. However, the same could be said for multi-player computer gaming via the Internet just a few years ago. If the development of multi-player computer games is any guide for development of MSDSTs for citizen engagement, we can expect multiple simultaneous citizen-to-citizen-to-government interactions via MSDSTs within a decade or two of the development of desktop MSDST experiences for these users.

MSDSTs, Engagement, and the Context for Use. As suggested above, the context in which an MSDST is used has substantial impact on the degree to which the technology supports citizen engagement. A number of suggestions for shaping the context for use are provided in the final section of this report. A key development in this regard, however, is the creation of more user-friendly model-development or authoring tools (See description of CommunityViz below for an example). As these tools for creating models become easier to use, it becomes possible to consider the value of citizens *performing more and more of the construction* of models and simulations for their own use or for learning about or analyzing an area of public policy.

Having citizens create their own models is likely to raise a number of issues and create new challenges for public managers. However, one can also argue there are some potential advantages to citizens becoming so thoroughly engaged. For one, the act of building a model or simulation is often a powerful learning experience for the modeler. Secondly, the process of creating a model forces citizens (and the civic-minded organizations that might support such model building) to more precisely define their understanding of how the domain works and what the potential consequences of various courses of action within that domain are likely to be. This process, in turn, tends to lead the model builders to become more empirical and to engage in deeper levels of research into areas of interest. Logically speaking, the results of such model building would be to reframe political arguments so that they are more amenable to resolution through empirical study and negotiation rather than conflict.

Examples of Citizen-Engagement Use of Simulations and Decision Support Tools

This section presents a number of brief descriptions of MSDSTs that have been used or are designed to be used to enhance citizen engagement, followed by more detailed case studies of similar engagement-supporting technologies.

Public Budgeting

The University of California at Berkeley's Center for Community Economic Research (CCER) has developed an online National Federal Budget Simulator that lets web citizens try their hand at balancing the federal budget. Internet users can control a whole range of budget choices, submit a budget, and interactively see the changes in the federal deficit. Using a more advanced version of the simulation, Internet "senators" can get into the nitty-gritty of controlling mass-transit spending, weapons procurement, national-parks allocations, and social-welfare spending. Because the simulation also gives the players interactive control of the $455 billion in "tax expenditures" in the federal budget, people learn that there is a far wider range of possibilities for balancing the federal budget than is usually identified.[62]

A similar example of a budgeting simulation for local government called "You Run City Hall," developed by the City of Indianapolis/Marion County, is reported by the web master to be a very popular item on the website.[63]

Citizen Understanding of the Impact of Their Behavior

Fitzpatrick Engineering has developed a program we call "DEAD OR ALIVE?" so that an ordinary person can use the same tools formerly available only to automotive professionals to see firsthand the positive effect restraint systems can have on reducing injury in a car crash. With this program, a citizen is able to input their own personal data and car type into a crash simulation and see an animated sequence of what would happen to them in different kinds of car crashes.[64]

Understanding Community

Developed by the Center for Neighborhood Technology in Chicago, the Neighborhood Early Warning System (NEWS) helps citizens to identify signs of neighborhood decline before major blight occurs. NEWS tacks trends in seven key indicators of neighborhood health (code violations, housing court cases, water arrears, current and longer-term property tax delinquencies, fire records, and real estate sales). When the overall trend indicates decline, citizens are able to use the information to work with city and county agencies and community organizations to more effectively counteract housing abandonment, commercial decline, and financial disinvestment.[65]

Although paper maps have traditionally been an important means of modeling and understanding certain aspects of a community (zoning, land use, facility location), with digital technologies, the ability to build understanding of community life can be greatly enhanced. At the most basic level, digital technologies allow mapmakers to annotate the features of a map so that these features link to layers of text, diagrams, audio samples, pictures, and video content. These annotations can be as simple as a link on the map to a picture that is relevant to that area and as complex as having citizens be able to add their own annotations (related to what is positive or negative about the area) to a map location in any number of media formats.[66]

Understanding one's community can also involve making technical issues more concrete for citizens. A good example of this has been the use of digital video clips of traffic that are representative of the specific levels of service (LOS) measures used by traffic engineers. When traffic models produce results that suggest, for example, that the outcome of a new development will be a "D" level of service, citizens can understand what this means by viewing a 10-second clip of Level D traffic conditions while reading a description of the typical driver behavior under these conditions.[67]

Home Ownership

Computer models developed for the Location Efficient Mortgages program calculate the reduced monthly expenditures associated with not having to own, maintain, and insure a first or second car.

Developed by the Center for Neighborhood Technology (CNT) in conjunction with Fannie Mae, this program enables home buyers to obtain larger mortgages if they select houses close to transit, employment, and services. The savings from use of alternative transportation can be used to increase mortgage eligibility levels.[68]

Providing Citizen Feedback

In the City of Hampton, Virginia, the Permit Office, the Human Resources Department, and the Information Services Department joined forces and developed a touch screen customer feedback system. This system asks a series of questions of customers, such as which employee helped them (click on an employee's picture on the screen), how satisfied they were with the service, and whether they are contractors or home owners.[69]

Feedback is often much more powerful when it is correctly timed. The European Commission has sponsored two projects that provide more effective citizen feedback through intelligent timing of the message. These are:

- InfoCitizen: An agent-based technology that uses models of citizens' life cycles to help citizens to learn about (in a just-in-time fashion) and to negotiate public administrative systems more effectively.
- Heaven: A decision support system that will provide citizens and health authorities with information and advice regarding air and noise pollution hot spots as these spots become hot.

Participation in Planning Decisions

As computer-based planning tools have become more capable and user-friendly, hundreds of people have used these tools to play roles as "citizen planners." Sometimes professional planners will use planning-simulation and decision-support technology to help balance competing community interests or to achieve more acceptance of proposed plans by engaging citizens as co-planners.[70] Specifically, citizens are using these tools to:[71]

- Discover which underutilized parcels of land are most suitable for infill development.
- Identify the best place to put a new playground.
- Model how changes in allowable land use or density might impact infrastructure, energy and land consumption, and pollution levels.
- Identify which land—if targeted for conservation—would do the most to preserve the richness of species in an area.
- Identify if people in the neighborhood have safe routes to walk or bike to work or school.
- Efficiently locate new social-services or job-training facilities in areas with the greatest need.
- Identify which neighborhoods are bearing more than their fair share of locally unwanted land uses.

In one of the most dramatic uses of computer simulations in a public sector decision, in 1997 California Transportation Department (Caltrans) invited legislators, city officials, and other citizens to drive over a new design for San Francisco's Bay Bridge. The simulated experience involved a virtual drive through a panoramic view of the yet-to-be-built bridge and its environs. The experience was made possible by a combination of new software tools and visualization techniques and was employed to help convince citizens to accept the higher taxes and tolls needed to replace the existing earthquake-weakened bridge. Ironically, the Bay Bridge fly-through simulation helped convince citizens that a more expensive design option—one reminiscent of the current Bay Bridge and that distinguished the bridge from the background clutter—was preferable to the simpler, cheaper design that Pete Wilson, then governor of California, wanted to build and that city leaders were leaning toward. Nearly all the people who experienced the simulation were willing to say that the alternative design was worth the extra $200 million.[72]

Other visual simulation projects include:

- A real-time 3-D visualization of a proposed building restoration produced by the Berlin-based company *echtzeit* led to the acceptance of an innovative design that might otherwise have been turned down.[73]
- A virtual model of the Michigan Civic Center Commons of the city of Sterling Heights, Michigan, developed by EDS is used by managers to plan, operate, and promote the complex.[74]

- A simulation of a planned public-safety building in the downtown area of the City of Rochester, New York, produced by Bergmann Associates was used by citizens to help evaluate key design issues for a $17 million project.

A number of 3-D GIS simulations produced by the Environmental Simulation Center (ESC) have been used to allow citizens to participate in:

- The redevelopment of a community (by visualizing and commenting on different proposed housing alternatives)
- The development of new zoning ordinances related to the availability of sunshine (ESC worked with the Parks Council of New York City to implement "sunshine zoning" around city parks and playgrounds)
- The development of a regional transit plan (see Case Studies section for details)

Computer models of entire cities and regions are becoming increasingly common. Such large-scale models as the one being developed for Los Angeles by researchers at UCLA will link virtual-reality technology with traditional two-dimensional Geographic Information Systems and modeling algorithms to expand the potential uses of these applications. In addition to helping citizens and decision makers to visualize proposed changes, they can be used to market facilities a city has to offer, map socioeconomic data, and develop community-based asset and problem environments that can be used in community planning and redevelopment projects.

As California Senate President Bill Lockyer said, "The public demands—and is getting—a larger voice in the planning decisions of publicly funded construction projects through the use of urban-simulation technology." A key use of these simulations, Lockyer suggests, is to help build consensus among the people, industry, and government.

The underlying concept of these simulations appears to be that independent, objective, and verifiable information can make complex issues comprehensible to both the general public and design professionals, thereby enhancing the level of public debate in the planning process and allowing all parties to participate equally in the decision-making process. The ultimate promise of such tools is greater clarity and efficiency in the development process. As Cynthia Shea wrote:

> Instead of waiting months for permits and approvals, developers will be able to run their proposals through GIS-based indicator packages and see immediately if their ideas are compatible with community goals. Instead of endless meetings with multiple departments, regulators will be able to assess the social, economic, and environmental impacts of a project with the push of a few buttons. Objective measurements of anticipated change will become easier while unanticipated negative consequences should become less frequent.[75]

Understanding Sustainable Development

Virtu@lis, a project funded by the European Union, stands for Social Learning on En**VIR**onmental Issues with In**T**eractive Information and Comm**U**nic@tion Techno**L**og**I**e**S**. The project focuses on using information technology and environmental modeling to help citizens learn about public policies related to sustainable development.

The project information system (currently under development) is being designed to address the four domains of agricultural pollution, climate change, freshwater resources, and marine capture fisheries. The Virtu@lis system will include learning tools for improving citizens' awareness of environmental management and risks in these areas. Four specific types of information communication technology tools are being developed: personal barometers, allowing the quantification of environmental impacts of individual lifestyles; scenario generators, exploring changes in patterns of economic activity toward sustainable resource use; multi-player games, allowing individuals to learn about problems of governance and resource access, and virtual visits or interactive digital environments within which the learning may take place.[76]

Linking Models and Simulations with OnLine Communications

While simulation technology can help to initiate and inform discussions of government plans, intensifying the engagement of citizens may require that model and simulation technology be linked with communication technologies and contexts that enable more citizens to have online discussions with local politicians and each other. The city council of Kalix in Sweden took on this challenge when it facilitated online deliberation by citizens in the redesign of the town center. After looking at the renovation plans, citizens could give their opinions and could vote online on the various options. Approximately 1,200 of the 15,000 inhabitants participated.[77]

Obviously, voting represents only one of the numerous tools of democratic decision making. Lobbying, town meetings, initiatives, consulting, letter writing, and petitioning represent some additional tools that can be used to link citizens with their government. With the expansion of online technologies, many of these tools are being reformed or reinvented. With regard to developing technological innovations that support citizens consulting with their governments, European governments appear to be taking the lead. For example, citizen of Scotland can use the Scottish Parliament's online petition system to create a petition, include supporting background information, and submit the petition. Once submitted, other users can sign the petition and participate in online discussions of the petition topic. While the current set of citizen-to-government communication tools tend to be generic, one can easily imagine how online models and simulations could be tied to more functionally specific tools for communication. For example, citizens might post the results of their own town center development designs on the web for review by other citizens, who might then sign an online petition supporting one or more design options.

Case Studies of MSDSTs for Engaging Citizens

Transit-Oriented Development in Princeton Junction, New Jersey

Creator: The Environmental Simulation Center, Inc.

Website: http://www.simcenter.org/Projects/Princeton_Junction/princeton_junction.html

Problem/Issue

A new development was proposed for Princeton Junction, an area between New York City and Philadelphia on a commuter and Amtrak line. A number of ideas for redevelopment had been proposed or were outlined within existing planning documents. However, planners and citizens could not really visualize how these ideas and plans would potentially impact their communities.

How Application Works

The Environmental Simulation Center (ESC) created a 3-D base model of existing conditions such as topography, existing buildings, roads, train tracks, and the transformers for the rail lines. Then ESC used its "smart" Kit-of-Parts™ and Model Library™ to add additional "proposed" models of buildings, tracks, etc., based on the words and numbers in the existing development plans of the participating communities. At a meeting of the members of the Planning Department and Commission, community participants were invited to drop structures into the computer model. The model itself then calculates the new demands for transit ridership, retail space, parking requirements, school trips, and other values.

Technology

The key technology used is a real-time 3-D modeling package from Multigen Paradigm. This application is tied to a GIS database.

Impacts

The group's initial response to the 3-D visualization of their development was "that's not what we meant at all." The visualization immediately brought home that there was a mismatch between what the group wrote and what they each thought it was going to look like. The remainder of the hands-on workshop was devoted to changing the design to better reflect what they did mean.

The plan called for two-story mixed-use buildings reflecting a residential scale and fronting an automobile-free village green. The group quickly changed two-story buildings into three-story ones because they felt the added story gave the area a more urban feel, while hiding the huge transformers behind the taller buildings. The added density also made retail and commercial uses more viable. However, because the system instantly recalculated the parking requirements, the group quickly realized that additional parking would be needed and that parking structures would be preferable to surface parking. "The community said the new design still looked too suburban, so they asked about bringing in a road and more pedestrian activity. Little by little, through this process, the design became more like a traditional townscape."[78]

Related Project by The Environmental Simulation Center (ESC):
City of Houston, Texas,
3-D GIS Housing and Urban Development (HUD) Pilot Project

Through a HUD grant, the ESC is teaming with Houston's Department of Planning and Development to develop decision support software to help city officials and citizens develop more effective economic reinvestment strategies. The project is focused on improving the ability of Enhanced Enterprise Communities (EEC) neighborhoods to attract investment and promote redevelopment. The project will involve creating a virtual-reality tour based on a Social Compact Neighborhood Markets Study and a community technology initiative. The tour will allow the Planning Department and community to visualize and receive data related to different design alternatives. The creators assert that the "3-D model will be contextual, interactive, site-specific, and in real time," and that the project will "develop an iterative, interactive design process involving the challenge of building consensus and translating conceptual design preferences into visual imagery and sense of place in a virtual-reality environment."

CommunityViz™

Creator: Orton Family Foundation

Website: http://www.communityviz.com/

Problem/Issue
The ability to forecast future development and its impacts under different design and policy guidelines or requirements has been limited to professional modelers and planners with substantial resources and support. CommuntyViz brings a sophisticated set of tools to smaller communities and to citizens who have some basic GIS computer skills. Although citizens can potentially use CommunityViz on their own to better understand their community's development issues, the software does not provide any particular set of simulation algorithms (except for those related to population and economic growth) for analyzing the impacts of different scenarios. That is, the user must typically supply their own algorithms based on their own research. For example, in order to model water use based on the growth or placement of population, one would have to supply the program with a formula for per capita water use under different land characteristics or land-use conditions.

How Application Works
CommunityViz is a set of GIS-based planning tools (see Appendix) that enable non-programmers to develop sophisticated models of community development. The software suite includes three modules:

- Scenario Constructor: This module allows the user to conduct a systematic evaluation of an alternative development plan. Each alternative, or scenario, is evaluated in the context of user-specified desired outcomes. For example, a community with several options for landfill siting might want to assess the impacts on open space, the potential for pollution of water sources, or impacts on property values. Scenario Constructor quantifies these effects and compares them across scenarios.
- Policy Simulator: This module is similar to traditional land-use models that are used to forecast population and employment, probable land uses, and economic change for planning purposes. Policy Simulator is somewhat unique in that it uses agent-based modeling to make its forecasts and integrates with a geographic information system interface to displays the results of its forecasts via charts, tables, and maps. Policy Simulator allows users to ask "what if" questions by experimenting with different local policies (primarily zoning policies) in a simulated environment. It takes into account these local policies and forecasts how the policies might affect community development, both spatially and temporally.

- SiteBuilder 3-D: This module allows users to build photo-realistic models of community sites that include buildings of different types and densities as well as terrain models that mirror existing terrains.

Technology
CommunityViz combines ArcView GIS extensions (for all three modules) with custom C++ programs for the Policy Simulator forecasting and a MultiGen 3-D component for the SiteBuilder 3-D module.

Funding
The Orton Family Foundation has supported development of the software.

Context for Use
Because CommunityViz essentially provides a shell through which a user can link any GIS-defined land or spatial characteristic (location, slope, soil type, land use, vegetation type) with any other related variable (pollution, water use, costs, accessibility), the potential uses for this software are nearly unlimited. Unfortunately, the flexibility and openness of the software to numerous uses and its GIS base (which requires some time to learn) translates into heightened barriers to use by citizens, particularly those who do not have the resources to learn how to use and develop data layers for GIS software or to conduct the research needed to develop appropriate formulas for the various impacts being modeled. Given this qualification, CommunityViz nevertheless represents an excellent example of how highly sophisticated software can be made dramatically more user-friendly. As such, it represents a class of software that can be effectively used by organized groups of citizens (rather than individual citizens) who can distribute the tasks (one person could learn the interface, one how to gather and incorporate GIS data, others how to develop specific development scenarios, and others how to develop the formulas to be used in scenario analysis.

This approach to using the software is suggested by the types of citizen users of CommunityViz. For example, 1000 Friends of Minnesota, a citizen organization focused on protecting the state's environment and resources, used CommunityViz as part of the Eureka Township Envisioning Project, a planning process for exploring alternative growth scenarios and anticipating potential impacts resulting from land-use decisions.

Uses
CommunityViz has been used in a number of different ways and settings including the following:

- Affordable housing—Steamboat Springs, Colorado
- Growth management plan—Eureka Township, Minnesota
- Alternative futures—Lyons, Colorado
- Growth management—South Kingstown, Rhode Island
- Fire risk management—Missoula, Montana
- Neighborhood growth patterns—Falmouth, Maine
- Scenario comparison and analysis—Santa Fe, New Mexico
- Redevelopment strategies—Tacoma, Washington
- Corridor vs. downtown development—Morrisville, Vermont
- Annexation vs. infill—Carbondale, Colorado

Impacts
Case studies conducted by CommunityViz suggest that the software has enabled citizens, planners, and public managers to:

- Better understand the impacts of different development scenarios on water quality and septic capabilities.
- Better understand the changes to the physical landscape that are likely to occur as a result of different development plans.
- Better forecast how expected patterns of growth might impact existing schools, businesses, available land, and taxes.
- Identify the most cost-effective strategies (tree and brush clearing near homes; prescribed burns; additional water sources; roof, siding,

and deck-construction alternatives; and strategic placement of fire protection resources) for promoting fire safety.

- Understand the relative costs and benefits of different approaches (traditional, new urbanism, smart growth) to growth management in terms of a variety of factors including economics, open space, environment, and community character.
- Identify areas in which redevelopment of a certain type would be affordable (due to availability of facilities such as water, power, rail, high-speed communications to support that type of development).

Funding
The Orton Family Foundation has supported development of the software.

Related Software
While CommunityViz represents a concerted effort to create highly flexible and sophisticated planning software that can be used by citizens, other applications also have been developed that allow citizen input or use, including:

- *What If:* A simple-to-use GIS-based planning tool that can be employed to structure and support decisions about the suitability of land for a different (or a more or less intense) land use. This software can be used to integrate into an analysis of land suitability the weights that citizens might give certain factors in the suitability decision. For example, citizens might want to give a weight of -1 to land being considered for a school use that was within a quarter mile of a large industrial site.[79]
- *Place3s:* This application provides some of the same functionality as CommunityViz with respect to identifying the impacts of different community development plans (on energy use, pollution levels, infrastructure costs). However, instead of being a shell for the user to provide any number of formulas for measuring impacts, this software incorporates research-based formulas and algorithms.[80]
- *Sprawl Decisions:* Like Place3s, this application incorporates a number of research-based impact formulas into a simulation. Because Sprawl Decisions is not based on GIS or other imported data from a real community (it employs cell-like areas of a community whose values can be specified to mimic a real community), it is designed more as an education tool than a tool for supporting decisions about specific development plans. However, because this application is entirely web-based, teachers and students of civic education and citizens may be able to make immediate use of the technology.[81]

EUREKA!
(California's Budget Balancer)

Creator: The Center for California Studies

Website: www.csus.edu

Problem/Issue
The genesis of the EUREKA! project can be found in the recent history of California's state budget. The Center for California Studies describes this history as a systematic weakening of budget flexibility due to changes such as "Proposition 13, which capped local property taxes; Proposition 4, which limited state spending; and Proposition 98, which mandated a certain portion of the state budget be appropriated to education." These changes reached a crisis point in 1992, when California experienced a 64-day budget impasse, disrupting lives and undermining the credibility of state government. Despite these impacts, observers noted that the media continually failed to cover the budget process in depth or before it reached a crisis point. One of the purposes of the EUREKA! simulation was to help dispel citizen ignorance of "the impacts of constitutional and voter-initiated constraints, the mechanics of the budget process, and potential solutions to budgetary challenges."[82]

EUREKA! includes budgetary figures and proposals from the Legislative Analyst's Office and the California Department of Finance, as well as budget proposals from a gamut of political and ideological persuasions. The simulation also incorporates constitutional restrictions faced by legislators and the governor. The implementation of EUREKA! throughout the state occurs in sessions in which a mock legislature of California citizens are charged with balancing the budget, making choices similar to those made by elected officials.

How Application Works

Application inputs are divided into two categories: revenues and expenditures. Participants can raise taxes and cut programs as they wish to achieve a balanced budget. Each participant receives a handbook with software application instructions, a briefing on the budget and associated constitutional and structural restrictions, a glossary of budget terms, and details on all revenue and expenditure proposals. All information is contained in the application, with the added benefit of automatic calculation of the fiscal impact of proposals. The handbook reinforces understanding of the budget-making process and serves as a tangible reference that players may take home and use in additional budget simulation sessions they convene.

Technology

EUREKA! was programmed by Broderbund and works as a stand-alone software application.

Context for Use

Participants in each session are divided into groups of nine so that each group can experience the tension between a simple majority and the two-thirds majority required by the state Constitution. Host campuses invite members of the university, extended community (faculty and students as well as business, labor, nonprofit, and education leaders of the surrounding communities) to participate in EUREKA! sessions. Participants thus face the same diversity of interests and constituencies faced by the legislature.

Use

The Center for California Studies has developed and implemented EUREKA! sessions at a number of universities (San Jose State University, Cal Poly Pomona, California State University Fullerton), and in San Diego in conjunction with the annual meeting of the California League of Women Voters.

Impacts

The purpose of EUREKA! is to underscore the impact of changing revenue bases, fluctuating expenditure demands, and constitutional and structural constraints. The computerized budgets developed during each simulation are compiled in a final report, which is thought to provide a good indicator of public opinion regarding the state budget.

Funding

EUREKA! is partly funded through a grant from the William and Flora Hewlett Foundation. The Hewlett Foundation has also funded the activities of an informal coalition of groups concerned with California's ongoing budget challenges. These groups include the Center for California Studies as well as the California Governance Consensus Project, the California Budget Project, the League of Women Voters, and the UCLA Extension Public Policy Program. Each of these groups brings different and important resources to bear on understanding and improving the state budget process.

Partner Activities

The California Budget Project prepares briefing papers and analyzes reform proposals, providing technical expertise for legislators and other stakeholders. The Consensus Project brings stakeholder groups together to forge agreement about what ideas can best solve budgetary challenges. The League of Women Voters uses its statewide network to inform citizens of the intricacies of various proposals and facilitates community discussions. Finally, UCLA Extension's Public Policy Program offers conference operations and research and analytical support as the group of organizations seeks to advance a reform agenda.

How to Build Models, Simulations, and Decision Support Technologies to Engage Citizens

In some form or another, models, simulations, and decision support technologies have existed for decades, primarily for use by scientists, social scientists, planners, and other professionals. Only recently has there been any effort to democratize these technologies. Planners, who have a long tradition of considering citizen input in the planning process, have been in the forefront of this movement. As planners' tools have begun to move from paper-based to computer-based, planners have begun to express more concern about the design of information landscapes and workspaces. A key finding of this report is that well-designed MSDSTs can potentially support the enhanced involvement of citizens in public affairs. Exactly what "well-designed" means will obviously evolve as we see and experience more examples of these systems. The purpose of this section is to begin to identify some of the broad principles of design that appear to apply when creating technology for use by citizens.

At the broadest level, designing a system for citizen understanding or participation will involve numerous choices regarding the amount of control that a user has, the information and data layers that will be included in the system, the definition of problems, the kinds of analysis that will be available within the system, the user's ability to perform independent analyses, and the kinds of evaluation (or processing of the results or experience of the technology) that will occur.[83] A system designer's choices in these regards will typically depend on the specific functions that the system is supposed to perform. While there are obviously many design principles that would apply in situations where specific functionality is desired, what follows is an attempt to outline design steps and principles that might be applicable to models, simulations, and decision support tools used for a variety of functions.[84] These steps were derived from both a review of the literature and interviews, and are organized into three categories that represent three phases in technology development: 1) steps for planning MSDSTs, 2) steps for the operational development of MSDSTs, and 3) steps for deploying MSDSTs in specific contexts.

Phase 1: Steps for Planning MSDSTs

Step 1: Conduct an outcome assessment. An outcome assessment involves two sub-steps: The first step is to identify the knowledge that one wants the MSDST user to come away with. The second step involves understanding the mental model of the process or system being simulated that citizens might already possess.

With intended end-users one will want to identify:

- The level of prior knowledge of the activity that these users typically possess
- Their favored learning style and format
- Key motivators or activities that they consider to be fun

The optimal context for the use of MSDSTs would be one where *self-regulated learning* is evident among the targeted users for the simulation. A *self-regulated learning* context exists when citizens:[85]

- Find the environment to be intrinsically motivating.
- Actively engage in planning, setting their knowledge objectives, and tracking and evaluating their own learning.
- Actively select and structure the environment to best suit their own learning styles.

While one cannot plan on having users who are self-regulated learners, one can work to accommodate such users (by including design features that allow them to structure the environment to meet their learning style).

Step 2: Thoroughly understand the process or system being simulated and the context for the construction of the MSDST.
A *process assessment* results in a detailed conceptual map of the process that one wants to simulate. Conducting these assessments typically involves interviews with subject-matter experts, the persons commissioning the building of the simulation, and intended end-users. In interviews with experts, one will want to ask the respondents to describe or explain the process or skill involved, identify the typical steps in the process or skill, and explain how one event might lead to another or how one decision might impact further events and decisions. In interviews with the MSDST sponsors, one will ask about intended learning goals, the strengths and weaknesses of current approaches used to reach these goals, and the key improvements over existing approaches that are hoped for with the use of the new technology.

Step 3: Validate the underlying model for the simulation.
The failure to validate the rules and relationships that drive an MSDST can act as a major barrier to the adoption, acceptance, and effective use of the technology, particularly by skeptical citizens.[86] The validation process can take different forms depending on the type of MSDST. For example, in simulations of population growth and land use, models will often be validated by running the simulation on historical data to see how closely the simulation prediction matches the real outcome. Validation of role-playing scenarios might be based on qualitative studies of role dynamics. For example, in a simulation designed to promote safe sex behaviors among high-risk populations, the simulation creators interviewed a large number of individuals in the high-risk group to better understand and document the key decision points and influences on safe sex behavior in typical dating situations. Scientific-oriented simulations are obviously more easily validated as they are typically based on well-accepted relationships or scientific laws. Simulations of social phenomena can be based on best-of-the-breed studies or analyses, or on meta-analysis of relevant studies.

While model validating by means of reference to existing knowledge is important, validation also should occur during development and testing by having experts or intended users test or react to the model or prototype simulation. Here is how one development team went about this task: The actual [manufacturing] process was recorded on video, digitized, and stored on a PC. Then animations of the process (i.e., the simulated version of the process) were developed. The animations were synchronized with the video of the real process, and both were then projected to a room of people who were familiar with the real process. People in the room were then invited to discuss the strengths and weaknesses of the simulation. Revisions were made to the simulation, and the process was repeated until the group was satisfied that the underlying model was valid.[87]

Step 4: Develop conceptual models of the proposed learning for the targeted users.
Conceptual models are artifacts or metaphors designed by people such as engineers, teachers, or instructional designers to help users understand a system or process.[88] Such models typically will involve use of something familiar as a basis for understanding something that is less familiar (a personal computer is like an office desktop; a legislative process is like a sausage factory). Conceptual models and metaphor can help the software designer generate ideas about how to potentially connect with the target audience of users. Obviously, conceptual models for citizens need to be ones that are widely understood.

Phase 2: Steps for the Operational Development of MSDSTs

Step 1: Identify a development team.

While commercial computer games will often involve the participation of scores of technicians, graphic artists, managers, story-board creators, and programmers, costing millions of dollars, our research and interviews suggest that MSDSTs being built for promoting citizen participation are more likely to be low-budget affairs that are the brainchild of a project champion and that are able to employ technically skilled people only on a catch-as-catch-can basis. Because some MSDST formats require specialized technical skill, the lack of resources to employ people with these skills has obvious implications for the development of high-end MSDSTs. There is some evidence, however, of the emergence of groups that are attempting to assist with the transfer of technology from the higher end of the spectrum (Department of Defense high-level architecture simulations) to the middle or lower end. University computer science departments will often possess students or staff who are familiar with "bridging" or middle-ware technologies and who can provide cutting-edge capability at a moderate cost.

Step 2: Determine the simulation or play format.

There are numerous formats that can be combined to make for interesting MSDST play or experience. Formats can be strategic in that they define the overall goals of the user, or they can be tactical in that they define user interface capabilities. At the highest level of format choices, one needs to decide if the technology is to be used by a single user/player or by multiple users/players simultaneously (a multi-player simulation). Single player formats have the advantage of being playable without having to recruit other players. Yet multi-user technologies can potentially provide:

- A heightened sense of motivation (one is playing or judging oneself against another person rather than a mere machine)
- A wider range of creative and realistic responses that only humans can provide
- A wider range of behaviors that can potentially be modeled (one can build in actual town-meeting-like votes, negotiations, psychological gambits and factors)

Once one has settled on a single or multi-player format, other strategic format choices include:

- Quest, maze, or journey formats: involve a player navigating through 2- or 3-D virtual space to reach a destination.
- Microworld formats: have two characteristics: 1) they present the person with the "simplest case" of a domain while typically allowing them some means to reshape the microworld so as they can explore increasingly more complex ideas, and 2) they match the person's cognitive and affective state such that the user immediately knows what to do in the world. A classic example is the child's sandbox.[89]
- Conflict formats: involve players having to battle enemies or overcome forces that are out to undermine their goals.
- Calculating formats (including statistics and econometrics[90]): involve players changing input parameters (expenditure figures) and receiving updated figures on related parameters (tax receipts needed to balance the budget). While all simulations tend to be built on different sorts of underlying calculations, calculating formats tend to be ones where the user is asked to explore numerous trade-offs among a diversity of goals based on different inputs.
- Stimulus-response/logical-consequences trees: involves players making choices that then determine the next step in a narrative and the new choices that will be available to the player at that stage. These branching choice formats can rapidly become very complex as the possible choices at each successive stage quickly grow to a very large number.
- Timed-response formats: the dominant format for many commercial games such as flight and driver simulations in which the players' ability to quickly react to a new environment (the appearance of a mountain on the horizon or a driver in front of them) determines the outcome.

- Parameter-setting, agent-based formats: form the basis for many of the more advanced social science simulations and other simulations that attempt to model complex interactions (traffic simulations that model the interaction of vehicles with the road and traffic-signal network). Agent-based formats are ones where the player sets the parameters of different computer agents (computer code representing objects) and then starts the simulation, which involves the interaction of the agents based on fairly simple rules. The key feature of agent-based simulation (and what makes it different from calculation formats) is the potential for emergent behavior (or behavior that was not specified in the original simulation rules) to occur.

At the tactical level, one needs to make choices as to how the user will interact with the MSDST. In this respect, example choices could include:

- Development of levels of difficulty in play or decision making.
- Variations on how the player will input choices or responses (point and click, drag and drop, typed input, mouse over, drop-down choice lists, radio buttons).
- Variations in display (text, graphics, video, 3-D worlds, GIS).
- Variations in the degree to which random events will play a role in the MSDST.
- Developing the ability of an MSDST *master* to set the parameters of an MSDST that is then played by others. Such a capability can be particularly useful in training situations where the MSDST master has identified the skill level of the players ahead of time and then sets the parameters (difficulty level) of the MSDST accordingly.
- Variations in delivery channels (via stand-alone desktop software, web-based, web-based using a central database)
- Developing a tight linkage between the content and the MSDST context. If one can easily extract the content from the context (as is the case with question-response type simulations), such a tight linkage probably does not exist.
- Designing the appropriate cycle of experience, reflection, and explanation. A key design advantage of simulations is that a learner can experience something first, so that when the explanation occurs it is grounded in a felt experience.

Step 3: Experience the MSDST using paper or role-playing prototypes.

A number of MSDSTs have been built based on earlier non-computerized versions of a simulation. For example, for several years, University of Georgia Professor of Law Jim Smith employed a simulation for teaching real estate law. This simulation involved hundreds of hours on the part of the professor acting in the role of a judge of the contracts negotiated by the law students. In general, Professor Smith used his judgment about the quality of the negotiated contracts and about individual class members' level of participation to specify an outcome (or grade) for the simulation players. Programming a computer-based version of the simulation (one where the computer would rate the level of play and level of participation) required Professor Smith to specify much more clearly what behaviors or actions he wanted students to demonstrate during the simulation.

Building a paper-based prototype will often involve:[91]

- Using brain-storming activities.
- Employing an illustrator to graphically represent the simulation activities.
- Developing the look and feel of the simulation more completely. For example, some MSDST developers use large white boards with magnetized surfaces that will allow magnetized paper game pieces to be moved around a simulated playing area as though these pieces were being dragged and dropped on a computer screen.
- Getting pseudo-players to think out loud to help the developers understand the players' unique perspectives and issues.
- Role-playing how users/players might react to having to correct errors during different parts of a simulation or to receiving different types of motivational or correctional feedback.

Step 4: Choose a development technology.
The appropriate choice of a development technology will likely emerge from the findings of the outcome assessment, the experience with the paper/role-playing prototype, the choice of MSDST formats, and the skill set of the development team. In an ideal world, this choice of technology would not be influenced by the prior determination of development team members. Rather, the development team would be built around the choice of technologies. Because of the lack of extensive resources that can be devoted to MSDSTs for citizen participation, this more logical development strategy may have to be discarded in favor of the technology that development team members are familiar with. Even in this case, however, respondents to our interviews suggested there is often substantial debate around this choice. As one person noted, "We changed languages midstream several times in order to find one that would provide quick development and a pool of programmers who could work with the language."

Step 5: Build a computer prototype.
Building a computer prototype can be frustrating because development teams often discover that many of the ideas that seemed simple in the paper-based prototype are difficult to reproduce in computer code. The challenge in this effort is to identify what are the concepts, interactions, experiences, and skill-development factors that are at stake and to discover if there are ways to retain them by using other designs, program features, or user-interface elements. Answering a number of questions can help developers begin this process.

- How much text needs to be included as part of the play of the MSDST? When and where is it needed? How obvious does the text message need to be to the player (should it appear automatically or require a mouse click)?
- Do you need to provide directions on how to play, or simply allow users to discover the rules of play as well as the educational content built into the game pieces and their relationships?
- How technical does the language need to be? Can non-technical players understand and be comfortable with using technical terms without defining those terms prior to the MSDST experience?
- How easy or difficult should it be to get to supporting documentation such as a glossary, explanations of the technical process, and so on? How many steps make it too difficult for the player to get supporting information? What automatic presentation of supporting information would be obnoxious to players?

Consider using a rapid prototyping strategy (where determining the educational objectives happens at the same time as development and evaluation of the prototypes). This strategy can facilitate having users provide feedback, and it is particularly valuable in cases where the user is in a position to help determine what actually needs to be taught and how learning can best occur. With rapid prototyping, the user becomes a "co-designer."[92]

Step 6: Understand and provide rich context and scaffolding.
The importance of context to learning has been increasingly recognized by researchers.[93] Context relates to a number of features of an MSDST: the richness of supporting materials, the variety of the media, the structuring of the issue or problem, the availability of help, and the medium of the instructional communications. It has been correctly argued that, properly designed, computer simulations can provide a richer and more orderly context of supporting materials, media, ideas, and subject-matter relationships.[94]

It is also clear that the instructional context of MSDST-based learning is typically less rich in terms of informal, nonverbal cues than interpersonal contacts are. While an extensive interpersonal context is not always important to learning, it can be crucial in some cases. Recent research on the use of virtual offices has shed some light on this issue. This research suggests, for example, that the existing level of trust between virtual workers and management is key to whether computer-mediated communications was an acceptable or preferred method of interaction. Groups with a high level of trust in management actually preferred receiving information via e-mail or written communications as this was deemed highly efficient. However, groups with low levels of trust in management preferred face-to-face interaction, possibly so that they could potentially use nonverbal cues to get at the underlying message.[95]

What this research suggests for governments and others who are creating learning simulations and decision support tools for citizens (or employees and decision makers) is that when these learning tools deal with subject matter that is controversial or are offered by governments that are not trusted by citizens, there will be reduced likelihood of their being accepted and used. This is unfortunate in the sense that it is often in the areas where government action is most controversial (land-use decisions) that education of citizens is most needed. Recognizing this phenomenon, however, can prompt MSDST designers to address the problem. This might be done in any number of ways:

- Incorporating more video of trusted individuals into the MSDST.
- Introducing the MSDST only, primarily, or at least initially in a face-to-face context where questions can be addressed.
- Making a "game master" available via telephone.
- Having groups and experts representing the various factions in the controversial issue area test and validate the MSDST for objectivity and fairness.
- Incorporating alternative points of view or understanding into the feedback provided to the MSDST user.

Providing a rich context within an MSDST means that the MSDST should incorporate the explanatory capability of human experts—both content experts and experts on how people learn. Typically, this might mean that the MSDST gives more and more basic information in less technical language to novice players. Similarly, the simulation tasks at this level should be less challenging. As users become more skilled in the simulation play, the amount of contextual help may diminish, but the kind of help will become more task specific or focused on a finer point of strategy or understanding.

In this way, providing a rich context acts as a scaffolding process, giving help that is appropriate for the current level of play, but also preparing users for the next-stage challenge. Scaffolding also applies to the idea that rich context can help users transfer their knowledge and skills to other areas. Providing such rich context within a simulation can involve a number of activities such as:

- Using a variety of media (sound, text, images, video, charts) to convey the messages.
- Providing tutorials, demonstration simulation runs, or step-by-step introductions to the use of the simulation.
- Providing hints as to next steps or strategies (automatically or by request of the user).
- Linking to outside resources. One of the obvious strengths of web-based simulations is that they provide an opportunity to link the user with a wide variety of contextually relevant material.
- Providing a summary or synthesis of the player's activities and impacts at the end of each round of play.
- Providing choices or suggestions as to the level of difficulty that the user wants to (or should attempt to) experience at each stage of the MSDST.
- Providing explanatory capability similar to that provided by human experts[96] (see discussion about Simulations and Learning above).

Step 7: Provide just-in-time learning support. Just-in-time support is about using both the users' mistakes and their successes as key opportunities to direct users to materials, activities, and feedback that reinforce the key learning objectives of the MSDST or allow users to move to the next level of challenge or learning task. One of the key advantages of computer-based simulations is their potential for capitalizing on the "oh-no" or "ah-ha" moments as they happen.

Phase 3: Steps for Deploying MSDSTs in Specific Contexts

Step 1: Increase opportunities for learning about, manipulating, and discussing the system dynamics and underlying assumptions. Citizen understanding and engagement are often fostered by providing citizens with opportunities to think deeply about philosophical or ideological values. MSDSTs are truly growth-inducing experiences when citizens feel they are able to work with and understand the MSDST at a foundation level. This point is frequently made by theorists of educational technology.[97] For example, Sherry Turkle, professor of the sociology of science at MIT, has called for the development of new critical standards and skills for judging simulations. She argues that we begin to discriminate among simulations based on the degree to which users are able to understand and challenge the built-in assumptions. Turkle illustrates the need for these new skills by describing how a typical 10-grade player of SimCity had distilled a list of top 10 rules for the game. Rule number six grabbed Turkle's attention: "Raising taxes always leads to riots." Turkle suggests that a central goal for computer education must be to teach students to interrogate simulations in the same way we teach them to read text in a critical manner. She points out, "Increasingly, understanding the assumptions that underlie simulations is a key element of political power. People who understand the distortions imposed by simulations are in a position to call for more direct economic and political feedback, new kinds of representation, more channels of information … and greater transparency in their simulations."[98] Obviously, what is true for youthful simulation players is also true for citizen users of MSDSTs.

Step 2: Provide sensitivity information to the user.
Sensitivity information is a particular type of feedback that helps the user to understand the degree to which the responses, experiences, or information produced by the MSDST is uncertain (or different from that produced in real life) and where the sources of that uncertainty might lie. Uncertainty can exist in the structure of the model (are we certain that the model includes all the factors that influence the model's output or results), in the assumptions made in constructing the model, and in the specifications or algorithms of the model's outputs. Sensitivity information can be important because decision makers will accept a simulation's output or experiences differently depending on the level of uncertainty and the sources of that uncertainty.[99] Sensitivity information is particularly important to citizen users of these technologies since it is the information that is most likely to provide citizens with cues as to how much passion they should express for or against modeled policy alternatives.

Step 3: Help users to share insights and combine problem-solving skills.
While this design feature is more difficult to implement within a single player or use-at-home type MSDST, there are numerous ways in which users can be enabled or encouraged to share insights and combine skills. These include the following:

- Development of a user group bulletin board or list of users' e-mails
- Web posting of users' comments and suggested strategies
- Opportunities for citizen user groups to meet in officially sanctioned settings (formal policy development workshops or planning charettes)

Step 4: Enhance the ability to build conclusions or theories from imprecise and uncertain data.
Many of the decisions in the public sector tend to be ones that are related to fuzzy or sticky problems. These are problems that have multiple sources and that often have an intractable element to them (poverty). Part of the intractable feature of these problems is related to the fact that there often exist trade-offs in many or most of the obvious ways of solving a problem (one could possibly solve the poverty problem by issuing checks to the poor, but this could result in a lowering of the motivation to work). While MSDSTs should not build in obvious answers, they can provide tools that could make the building of conclusions easier.

For example, assume a simulation was developed that related different land-use policy choices to different types of environmental costs and benefits. In such a simulation, a user might discover that the choice of a particular type of street grid (network) resulted in fewer vehicle miles traveled than alternative choices. Fewer miles traveled translate into less air pollution of certain types. At the same time, however, this grid style of street network consumes more land and creates more impervious surface, which in turn results in greater water pollution. In this case, the simulation designer might provide the user with a decision factor weighting sheet that would help the citizen to weight the value (or relative cost) of different impacts with respect to their own situation (one community might have a substantial problem with air pollution (and therefore a strong incentive to reduce these pollutants), but only a minor problem with water pollution. By providing a problem-weighting sheet where the user can specify different weights for different goals or measures, the simulation can assist citizens to more easily arrive at a conclusion that is relevant to their needs.

Step 5: Allow users to navigate through concepts in multiple ways.

What this design principle implies is that to the degree that MSDSTs are programmed to mimic the dynamics of a real-world domain, MSDST users should be given the choice to explore these dynamics from multiple perspectives. This capability should help citizens who see things from one perspective or reference point to be able to communicate with other citizens who tend to process information from a different perspective. They might do this, for example, by finding and pointing out similar material or information that has been formatted to meet the needs of citizens with different preferred perceptual filtering. Some of the alternative information-processing options include:

- Direct perusal of documents, descriptions, and records that are ordered in a sequential or hierarchical structure (as an academic course might be ordered).
- Sampling of snippets of materials or documents, as these might be relevant to or associated with a particular task. For example, in a legislative simulation, the player might be given a short biography of a famous legislator to read prior to the start of the simulation. The context for this material might be an opportunity to advance more quickly through the simulation if the player is able to correctly answer a question about this legislator. This opportunity would stimulate interest in the biography. However, it would also be worthwhile if when players answered the question (correctly or incorrectly), they were directed toward a relevant or related portion of the biographical material.
- Location or spatially based access to media and documents.
- Chronologically based access to information (through a log of a user's moves through a simulation).

Step 6: Fashion the MSDST to adapt to the objectives and needs of its user.

Fully implementing this design principle would obviously be impossible. However, as authoring tools become more powerful and user-friendly, the cost of providing more customized experiences has decreased. Tailoring the MSDST to users' needs and objectives can mean a number of things in addition to the idea of scaffolding discussed above. For example, it might mean:

- Insuring that users receive the kind of feedback they want (some users may not want to be told about their mistakes or may simply find the noise associated with some type of feedback to be annoying).
- Insuring that the user's preferred learning style and media are emphasized (a simulation might allow users to obtain information through either a written case record or a video of a person relating the information in the record).
- Allowing users to skip activities they are not interested in learning about or activities/steps that could interfere with the activities that the user is most interested in.

Step 7: Create tools that allow citizens to be their own simulation developers.

One of the heroes in the world of educational technology is Seymour Papert, the MIT professor who created the LOGO programming language designed to allow children to begin to understand how a computer works and how to create simple programs and eventually piece programs together into more complex ones. Papert's vision was to democratize the computer and make it transparent. Similarly, it can be argued that the full and true value of a MSDST is only realized by those who build one. MSDST developers are in the best position to get inside the black box and to understand the underlying model.

While it is probably unrealistic to expect the average citizen to become a full-fledged simulation builder, following the design principles outlined above should result in an application that will provide some of the experience of being a model builder. Specifically, by allowing the user ample opportunities to change the MSDST assumptions (or the variable mix or values in an algorithm), one is essentially allowing the user to begin to build their own model. At the same time, one may need to provide feedback as to how these changes might affect the underlying validity of the simulation or its sensitivity to uncertainty.

Also, while currently it is only the rare citizen who would engage in his or her own policy simulation development, this may not be the case in the coming decades for two reasons. First, contemporary education is oriented around the constructivist philosophy, which emphasizes learning by doing and "constructing" experiments and artifacts as a means of exploring a subject. Second, software engineers and educational technologists are developing more authoring tools for the development of simulations by non-programmers.[100]

Step 8: Use MSDSTs to reinforce and enhance existing communities.
This principle is based on the idea that people will be more likely to be engaged in a civic understanding and participation simulation if the other players in the simulation are members of the same community. Ideally, these participants will have met each other prior to having their experience mediated by a computer. Holding meetings where important community-building functions (social contracts, reciprocity) can take place also makes it more probable that the simulations of such functions will themselves become meaningful.[101] As Scott London has emphasized, "the important thing is that the electronic linkage reinforce already existing networks within the community, not attempt to recreate them."[102]

Step 9: Match the implementation context to identified needs and available resources.
Technology for citizen education and engagement can be implemented in three basic ways: through face-to-face group interaction (automated polling at a town meeting), as a centralized resource (information kiosks at a limited number of locations), or as an online resource (available via the Internet). Each of these implementation contexts demands or supports different levels and types of technology, user interfaces, and kinds of human assistance. Some implementation issues to keep in mind include the following:

- People in a group setting may be reluctant to use a technology perhaps out of fear of embarrassing themselves. In these instances, successful use of the technology may depend on the presence of facilitators who help the group members use the technology. Similarly, as a technology becomes more complex to use, it may be necessary to provide substantial technical support. This support could even include having staff "run the model" based on citizens' descriptions of a model's inputs.
- Centralized resources can typically do a better job than distributed resources of handling large amounts of data (full-motion video images) or data processing (complex transportation modeling). It is also easier to ensure that the citizen user will have access to human assistance when the technology is placed in a centralized setting (an information kiosk in the planning office when planning staff are available). Similarly, when help is not readily available or when one cannot assume that the user knows how to use the equipment (as one assumes when the user is on their own PC), the user interfaces for these resources will need to be designed in ways that are highly simplified (using a series of large touch-screen buttons rather than a mouse-accessed menu).
- Distributed resources can typically reach a much larger proportion of the population, but access to these resources may be limited to the technologically literate, while access to high-end applications such as online GIS may be limited to citizens with broadband Internet connections.

As public managers begin to develop MSDSTs for citizen understanding and engagement, they may find that some of the advice offered has become more or less useful and relevant. This is so because technology-based cultures (for citizen participation or other purposes) are rarely stagnant. As citizens become more sophisticated in using a technology, public managers may find that some ideas for shaping the context of use of the technology have become commonplace practice or, alternatively, have become outdated due to new technology infrastructures (ubiquitous wearable computing). Given the trajectory of technological development, the only thing we can be sure to expect from either technology or its citizen users is that each will likely change the other in unexpected ways.

Appendix: Geographic Information Systems

Geographic information systems, or GIS, is actually a generic term for a number of technologies that share a spatial orientation:

- **Raster mapping:** map based on equal area cells or pixels.
- **Vector mapping:** map based on lines, points, and polygons.
- **Network analysis:** calculate efficient routes or summarize network flows.
- **Spatial statistical analysis:** generate statistics based on user-defined geographic regions.
- **Geocoding and global positioning systems:** identify a specific location with standard map coordinates.
- **Computer assisted design (CAD) and terrain mapping:** create three-dimensional models of facilities, slopes, and landscapes.

GIS technology is being used at all levels of government to help manage information that has a spatial component. Some of the purposes of its use include:

- Helping local governments stay up-to-date with changes in land use, zoning, location names and addresses as well as the range of new subdivision, road, and commercial developments and infrastructure upgrades that must be mapped.
- Helping officials in charge of transportation to identify the most efficient routes.
- Helping law enforcement analyze crime data and manage their response to crime (by locating crime-fighting capabilities in the areas where they are likely to be the most effective).

At a generic level, the functions of GIS run from simple *inventory systems* (indicating that District A has five social services facilities, whereas District B has only one such facility), to *analytical purposes* (showing how Route A is more efficient than Route B for the delivery of sanitation services), to *planning and policy purposes* (identifying the advantages and disadvantages of locating a landfill in different parts of the community or establishing different areas for a new green space or wildlife protection corridor).

Because GIS technology is based on various 3-D coordinate systems, the visualization techniques available as part of a GIS system are powerful and can range from simple plotting of points, to use of symbols and cartograms (images that also convey more complex data), to color-, shape- or fill-based area mapping (where display changes based on underlying data), to time-based animation and 3-D displays and fly-throughs.

Because of the initial large expenditures associated with development of GIS, the uses of the technology have tended to be limited to those where public managers have identified specific cost-saving opportunities. Typically, advancing citizen understanding and engagement have not been high on the list of initial GIS projects. Nevertheless, numerous efforts have been made to use, or to convince governments to use, GIS in this manner—or what's more commonly called "Participatory GIS."

Participatory Geographic Information Systems

Participatory GIS is an entire class of applications of GIS technology and GIS-based models by persons who ordinarily cannot access or use advanced technology. Originally, GIS was a technology for experts with skills in database management and spatial data modeling. Nowadays, more user-friendly GIS and web-based GIS can often be managed by non-specialists, allowing citizens to use these tools to develop their own policy option and alternatives that better reflect community interests and empowering members of the community in question. One of the primary goals of the participatory GIS movement is to make spatial data and spatial decisions understandable and transparent to all.[103]

Creators

Most participatory GIS projects have come from university-based projects.

Problem/Issue

Geographic data and understanding has been limited to those who can afford the technology and have the skills to use it.

Technology

Participatory GIS can involve any number of components in addition to the basic GIS applications that link landscape features to underlying data about these features. These additional components might include:[104]

- Knowledge bases and simulation models from a variety of subject areas (in a planning GIS for a river basin, there might be a hydrology model, an ecological model, a knowledge base of economic development strategies, a model of dam engineering, and an economic model of the likely impacts of water restriction on local agriculture).
- A landscape/policy editing model (in the river basin planning GIS, the adding, deleting, modifying of vegetation, or altering the river course).
- Documentation components that document the users' choices in editing the landscape and how these choices impact the modeled outcomes.
- Collaborative choice facilitation components that help groups of citizens using the system to discover a consensus about preferable policy choices.

Impacts

Participatory GIS has been used in a number of settings to:[105]

- Help formulate policies and change behaviors to allow for greater sustainability (help village communities in the management of their communal forest resources).
- Provide less empowered citizens access to develop policy options related to zoning and new development.
- Help citizens understand and address the underlying causes of urban decay (citizens could identify properties that are tax delinquent and associate this information with crime locations).
- Empower citizens to participate in a community needs assessment through a comment function (a user can post a comment about a particular property—that it looks abandoned or drug activity was observed. With the information, citizens could petition the government to address specific, well-documented problems.
- Understand how people would react to an accident at a nuclear plant, and to explore the possibility of using GIS as a tool for risk communication.
- Understand how changes to a neighborhood (through the use of GIS-linked "prototype" images of streetscapes, buildings, and façade treatments) would impact a neighborhood.
- Involve citizens in a suitability analysis to help locate new parks and the walking paths and rest points within the parks.

- Define the spatial extent of property damage to landscaping investments caused by deer. This, in turn, helped locate the areas where the application of animal management practices would be most effective, and helped residents to grasp the extent of the problem and support a comprehensive management program.
- Map whether public resources for persons with disabilities are accessible and appropriate and consolidate data for use by members of disability organizations for their advocacy of new policies.

Design Issues

The effectiveness of participatory GIS technologies can potentially be enhanced through:[106]

- Use of game- and role-playing metaphors
- Opportunity for people to explore issues at home (rather than only in public meetings)
- Employment of skilled spokepersons in public meetings to do what people ask
- Use of hinge graphics (a panorama view works as a hinge between a particular situated view and a map view)
- Designs that move people through increasing levels of complexity
- Designs that promote critical thinking (different perspectives on the same issue)

Endnotes

1. Nicholas Lemann. December 17, 2001. *The New Yorker*, The Talk Of The Town—Dept. of Simulation; p. 36, Crash Practice.

2. Many of the tools specifically for use by citizens are still in the developmental phase. In order to broaden the scope of cases, we have defined technology-enhanced citizen understanding and engagement in a fairly broad fashion to include learning, simulation, and decision support tools designed for students of government, public decision makers and employees, and public sector program managers or consultants. Although the last category could include tools designed for scientific and technical managers, our focus is on tools or cases where a person with a strong general education could potentially use or take advantage of using the technology.

3. While the terms simulations, models, games, and decision support or expert systems have distinct meanings, there is also a great deal of commonality and overlap in these terms. All of them, for example, tend to involve an attempt to mimic a real or imaginary environment or system. As such, it is sometimes the case that the same computer program can and may need to be described using more than one of these terms. However, fine distinctions among these terms turn on how a computer program is used or experienced. If the computer program is primarily used to identify an optimal response to a real problem or situation, it might best be described as a decision support system. If the user primarily seeks to enjoy playing with the program to see what happens or if he or she can get better at using it, the program might be most appropriately described as a game. If the user's purpose is to obtain a better understanding of a subject area or domain that is not fully understood, the term model or scientific simulation is most appropriately used; but if the purpose is learning about a fairly well-understood area of knowledge, then the term educational simulation would likely come to mind. Obviously, some computer programs are designed to act in more than one of these ways, while others tend to have a dominant purpose or use, which then allows us to describe them using a more precise term.

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6. Ibid.

7. John O'Looney. 2000. *Preliminary Findings of a National Study of the Future of Public Sector Internet Services for Citizen Participation and Service Delivery*. http://www.cviog.uga.edu/govtech/cybsur.htm; John O'Looney. 2001. The Future of Public Sector Internet Services for Citizen Participation and Service Delivery in Local Governments, ICMA Yearbook. Washington, D.C.: International City/County Management Association.

8. See John O'Looney. "The Search for Digital Sunshine." *Government Technology's E.Gov, 1,2, 42-46;* John O'Looney. 2000. *Local Government On-Line: Putting the Internet to Work.* Washington, D.C.: International City/County Management Association.

9. Shelia Jasanoff. 1990. *The Fifth Branch: Science Advisors as Policymakers.* Cambridge, Mass.: Harvard University Press.

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11. Benjamin Barber, keynote address at DIAC '94 conference of the Computer Professionals for Social Responsibility, Cambridge, Mass., 1994. Cited in

Doheny-Farina, *The Wired Neighborhood*, p. 79 and found at: http://www.scottlondon.com/reports/networks.html#f28

12. Study Shows Moderate Computer Game Play Makes Kids Smarter, Game Parlor On-line. Found at: http://www.gameparloronline.com/article1025.html

13. Educational Outrage**:** An Occasional Column by Roger C. Schank. Column #11, posted 07/11/00. Found at: http://www.cognitivearts.com/html/outrage/outrage11.htm

14. Joshua Green. "No Lectures or Teachers, Just Software." *New York Times*. August 10, 2000, Section G; p. 6; Column 1; Circuits.

15. My City, an interactive CD-ROM distributed by McGraw-Hill Ryerson Ltd.

16. J. D. Bransford, A. L. Brown & R. R. Cocking. 1999. *How People Learn: Brain, mind, experience, and school*. Washington, D.C.: National Academy Press. Also see M. S. Donovan, J. D. Bransford & J. W. Pellegrino (eds.). 1999. *How People Learn: Bridging theory and practice*. Washington, D.C.: National Academy Press.

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20. See Bertrand Russell. *Education of Character,* New York: Philosophical Library, 1961.

21. Donovan, Bransford & Pellegrino, 1999, p. 12.

22. Genscope is a learning environment that uses the computer to provide an alternative to text-based science education. For more information, visit: http: genscope.concord.org/

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Mark A. Abramson and Roland S. Harris III, editors

Transforming Organizations
(Rowman & Littlefield Publishers, Inc., 2001)

Mark A. Abramson and Paul R. Lawrence, editors

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