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# Examining the societal impacts of nanotechnology through simulation: NANO SCENARIO

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*This article describes a university-sponsored experiential-based simulation, the NANO SCENARIO, to increase the public's awareness and affect attitudes on the societal implications of nanoscience and nanotechnology by bringing together diverse stakeholders' perspectives in a participatory learning environment. Nanotechnology has the potential for massive societal effects across all sectors, globally. Thus, new forms of education are needed to prepare members of society for making complex decisions about policy, governance, and values. Here, the authors examine the theoretical and conceptual framework of the simulation, which uses improvised role-play and perspective-taking to engage the public in a transformative learning experience. As part of this examination, they describe the uses and constraints of simulations with open-ended goals and without competition and prescribed rules. They believe educational role-play scenarios with active participation of the public can serve as a dynamic method for civic engagement across a range of complex, interdisciplinary topics and new technological dilemmas.*

**KEYWORDS:** *civic engagement; education; experiential learning; issue-based exercise; implications of nanotechnology; large scale activity; nanoscience; nanotechnology; perspective-taking; role-play; scenario; simulation; societal effect of nanotechnology; stakeholder perspectives*

This article describes a university-sponsored community educational activity using a role-play simulation to (a) foster learning about the societal implications of nanoscience and nanotechnology by (b) bringing together diverse stakeholders' perspectives in (c) a participatory experiential learning environment. The NANO SCENARIO takes an issues-based approach (Errington, 1997) where not all the facts are known, the issue can be viewed from many different perspectives, and the outcome is not known in advance. In addition, an issues-based role-playing scenario, such as the NANO SCENARIO, empowers the participants to explore beliefs, attitudes, and values surrounding an issue (Errington, 1997). In this article, we examine the theoretical and conceptual framework of the NANO SCENARIO, which uses improvised role-play and perspective-taking to engage the public in a transformative learning experience about the societal effects of nanotechnology. In particular, the theoretical aspects of a simulation with open-ended goals and without competition and prescribed

rules are compared to Lewin's gestalt psychology and model for group-level change. An interesting implication of this theoretical examination is the paradox where participants may change their attitude toward a subject or object that exists outside of the simulation, because they do not feel that playing in the simulation affects their everyday lives. Similarly, participants may be more open to learning by focusing on the process of playing a role rather than the outcome of the simulation. After playing the NANO SCENARIO and the debriefing session, the efficacy of role-playing scenarios is justified by the positive feedback and comments from participants.

### **Preparing the public for nanotechnology effects on society**

Calls for improved communication with the public about science and public science education programs have been increasing (Rogers, 2005). Interdisciplinary science, technology, and society (STS) programs, like the one at the University of Texas at Austin, are part of current efforts to better understand the complex social, cultural, historical, and political contexts within which nanoscience as a scientific practice is situated. Global concerns about powerfully transformative technologies, such as nanotechnology, include such issues as safety, governance, policy, benefits and risks, privacy, jobs, innovation, scientific breakthroughs, cultural divides, and so on. The potential for massive societal effects from nanotechnology has been a focus of new efforts to bring scientists, policy makers, and the general public together, which has led several countries to establish citizen panels, citizen juries, and public dialogues. For instance, large-scale public outreach has been used by the United Kingdom's Office of Science and Technology (2005), such as Sciencewise and the Nanotechnology Engagement Groups programs, to provide platforms to ensure that as many groups, individuals, and organizations as possible are able to help shape the government's public engagement programs for civic education with regard to emerging technologies (see also EUROPTA Project, 2002; Participatory Approaches in Science and Technology, 2006; Sclove, 1999).

We embedded the NANO SCENARIO within a larger framework, a Civic Forum,<sup>1</sup> which provided basic information about nanotechnology. The NANO SCENARIO was conducted as part of this large-scale civic engagement model focused on the societal implications of nanotechnology. The NANO SCENARIO brought together diverse stakeholders' perspectives in a participatory, experiential learning environment. Part of what motivated us was the realization that many members of the public do not know the implications of nanotechnology in our society. This is true even though fears about the potential dangers of new materials and manufacturing processes, along with utopic visions of new solutions to persistent problems such as health and energy, have been articulated in a wide range of media (Keating & Jarmon, 2005). The issues and the stakes are anything but trivial.

Our goals for the NANO SCENARIO included four outcomes: (a) increased awareness of nanoscience and nanotechnology, (b) greater understanding of possible societal implications of nanotechnology and nanoscience, (c) increased sensitivity and respect for roles and perspectives of other stakeholders, and (d) increased

awareness of civic communication processes along with a greater sense of responsibility to participate.

### **Understanding multiple perspectives and perspective-taking**

Nanotechnology's complex societal challenges require the engagement of multiple perspectives, diverse imaginations, and more effective communication between scientists, policy makers, business leaders, and the public. In these efforts, it is important to note that the *public* involves a diversity of people, groups, and organizations whose individual members have their own complex perspectives, motivations, and needs. Thus, in a robust model for community engagement, complexity must be integrated into the simulation design, both to avoid simplistic situations and solutions and to fully engage the imaginations of participants by moving them into a "space of contradiction" (Warren & Hytten, 2004, p. 337). Participation also entails a share in the *responsibility* for outcomes. An underlying assumption of the simulation is that greater understanding of different perspectives on nanotechnology enables citizens to think more critically and to participate in diverse and unanticipated social and civic situations more effectively (Murphy, 2004).

Our simulation brings together multiple stakeholders through a carefully integrated design. In particular, the NANO SCENARIO is based on four fundamental concepts. First, participation in role-playing scenarios can be transformative and can include discovery and insights about ourselves and others, humor, open-ended communication experiences, and action-oriented communication. Second, for players previously unknown to one another, an effective scenario can function as a "new frame," causing special (rather than routine) attention to the ongoing activity. This special attention can involve a heightened awareness of new and different perspectives on events, thereby providing for the possibility of learning about diverse perspectives and creativity. Third, role-playing characters create an opportunity for players to exist inside the imaginary world of the scenario while simultaneously observing the performances of others (and oneself) from the outside. Finally, participating in scenario role-playing stimulates spontaneous communication and makes explicit other kinds of social knowledge (tacit, kinetic, and experiential) critical for effective civic engagement and action, which can lead to future behaviors beyond the duration of the scenario itself (Thiagarajan, 1996).

### **Brief overview of the NANO SCENARIO**

At the beginning of the NANO SCENARIO, participants assume roles and perspectives different from their ordinary lives with the emphasis "on the role as it interacts with other roles" (Greenblatt, 1988, p. 15). Each role has its own underlying and interwoven network of relationships, goals, and contradictions. The simulation described here includes five rounds of "play" organized around a township with a mayor and 49 other individual citizen role profiles that evoke complex interacting systems of roles (Greenblatt, 1975a). Several townships can play simultaneously in different spaces; for example, we have tried four different townships.

A critical feature of the NANO SCENARIO is its flexibility for different outcomes. The goal of the NANO SCENARIO is not to “win” (there is nothing to win) or for a township to arrive at a consensus or even at some final resolution. The goal is for participants to discover others’ perspectives to achieve a greater understanding of the contradictions and complexities of nanotechnology and its effect on society. Each participant had three assigned objectives during this immersive communication activity:

1. to find out what different kinds of nanotechnology activity and ideas are circulating among participants of the simulation,
2. to become better informed about the example we provided of nanotechnology-based fictional vaccines, and
3. to be open to new information that could change participants’ positions.

In addition to these three general objectives, each role has its unique contradiction-laden and relationship-specified instructions. However, participants interpreted their role, instructions, the roles of others, and incoming information to make decisions accordingly, which in turn affects the other participants’ interpretation of the circumstances. Each participant weaves a strand of participation in the simulation to create an interwoven web of meanings and significance (Geertz, 1977). Thus, although all townships receive the same scenario narrative, what emerges depends on the individual participants, the dynamics of the group, and the imaginations of all involved. A final debriefing session provides an opportunity for reflection and learning. This simulates participatory civic engagement because engagement is situated in the particularities of the context of each local social organization and the specifics of the community and its practices (Arias & Arias, 1980; Boal, 1979/1985; Howard, 2004; Lave & Wenger, 1991).

### **Theory, research, and application**

The NANO SCENARIO represents a first-of-its-kind simulation of the societal implications of nanotechnology. The NANO SCENARIO simulates authentic processes in which members of a community interact with each other concerning an issue of critical importance. The simulation is characterized by rich complexity, ambiguity, uncertainty, and value conflicts. The NANO SCENARIO also simulates the high degree of coherence and tight interconnectedness—economically, socially, politically, and technologically—of addressing a vitally important issue within a community.

Because of the absence of a goal to win, competition, or prescribed rules for playing, the NANO SCENARIO can be considered more of a simulation than a game (Teach, 1990). A simulation is a case study exercise of an aspect of reality “played” within an artificial context (Jones, 1998). In the case of the NANO SCENARIO, the aspect of reality being played is the collective roles assumed and acted by individuals engaged in a civic process. That is, in a role-play simulation, to wrestle with an issue, the players of the simulation must place themselves in distinct roles within a scenario that focuses their attention on social processes and multiple perspectives

(DeNeve & Heppner, 1997; Starkey & Blake, 2001). While acting in their roles, participants play with their tacit knowledge and existing expertise in an actual lived experience, which effectively draws them into the engagement (Anderson & Meyer, 1988; see also Chaikin, 1977; Schechner, 1977). During the engagement, players learn about the problem or situation while acting a role and improvising within the simulated circumstance (Cutler & Hay, 2000). The performative elements (i.e., narrative, mimetic, and improvisational) of participation have been shown to engage citizens with difficult social challenges while exploring different perspectives (Freire, 1978; Spratt, Houston, & Magill, 2000). This manner of participation and engagement affords the opportunity for players to understand issues that are difficult to comprehend without living through the experience (Winham, 1991).

The transformative power *as performers* is heightened in role-play simulations. As sociologist Erving Goffman (1956) has noted, “Scripts even in the hands of unpracticed players can come to life because life itself is a dramatically enacted thing. . . . In short, we all act better than we know how” (p. 74). While performing the role, players scaffold each other to reach beyond the simulated role itself, in a dialogic process, to a role in everyday life (Vygotsky, 2006; Wells, 2000). Kenneth Burke (1954) argued that while in playing and imitating others’ everyday social roles, “the distinction between acting and play-acting, between real and make-believe, becomes obliterated” (p. 254; see also Miller & Mansilla, 2004).

Thus, it is the improvisational role-playing in the NANO SCENARIO that is critical for improving understanding of different perspectives. Although there is general agreement that this type of learning is difficult to measure and methods for rigorous assessment of its effectiveness remain to be developed (Gosen & Washbush, 2004), simulations have been used in numerous education, corporate training, economic development, public participation, and leadership training projects in many regions around the world (e.g., Conrad, 2004; Duke, 1975; Kindervatter, 1987; Operation Day’s Work, 2000; SaLUT, 1982; Svendsen & Wijetilleke, 1985; Telesco, 2001; Warren & Hytten, 2004). An example of a simulation that has a similar learning goal to the NANO SCENARIO is the ISLAND TELECOM simulation (Bos, Shami, & Naab, 2006), which attempts to instruct participants about corporate social responsibility. As the creators of ISLAND TELECOM noted, a “simulation that uses students from different races, national origins, and backgrounds allows for a richer discussion of issues and exposes students to attitudinal differences of ethics across national boundaries” (p. 59).

Likewise, the main pedagogical goal of the NANO SCENARIO is to provide a mechanism for perspective-taking among four different stakeholder groups related to nanotechnology and society. The nearly 300 attendees playing the NANO SCENARIO came from very diverse backgrounds—from scientist to mayor—and it is that diversity of perspectives we feel can lend such value to the simulation. The particular social reality afforded by the possible implications of nanotechnology provides a complex degree of interacting variables, roles, responsibilities, contradictions, and constraints. Having to improvise a role and pursue its objectives, all amid the unfolding interaction of the scenario where other participants are improvising their own roles and goals, creates

unintended results and relationships. As learning design expert Margaret Gredler (2004) has noted, all players have as their objective to “take a particular role, address the issues, threats, or problems that arise in the situation, and experience the effects of their decisions. The situation can take different directions, depending on the actions and reactions of the participants” (p. 571). Simulation and game designers Feldt and Goodman (1975) have characterized the effect of improvising a different role in this way:

Through such a procedure of role assignment, the players begin to gain greater understanding of the totality of the system by putting themselves in the place of other persons in positions with which they are not familiar. They then gain some insight into the operation of their roles and some empathy for their problems within the operation of the system. (p. 174)

Gaining an understanding of the totality of the system is akin to the concept in Gestalt psychology that successful change in individuals occurs when they gain new insights into the totality of their situation (Lewin, 1948b).

## Goals and rules

The NANO SCENARIO situates the participants in a role with a common goal of learning more about four different nanotechnology fictional vaccines for the community, of which none is inherently better, through a process of engaging others in the township. The NANO SCENARIO can be characterized as role-playing with open-ended goals, and without competition and prescribed rules, in a simulation of civic processes. As Myers (1999) points out, “The process of simulation is intrinsically related to the process of play” (p. 486). This form of play does not necessarily require a common goal or a set of formal rules for the participants (Klinger, 1969). Each person in a role-play simulation constructs his or her own goals, where goals are defined as internal representations of desired states (Austin & Vancouver, 1996). These states include outcomes, events, or processes.

Many of the early business simulations did not include a prescribed winning goal, but instead, the participants were expected to agree on their own goal for the exercise (Cohen & Rhenman, 1961). The developers of these early business gaming simulations did not think any predetermined criteria for winning were needed or even desirable (Thavikulwat, 2004). For instance, one of the first business game simulations, the American Management Association’s TOP MANAGEMENT DECISION SIMULATION (1957), was administered “not only (without) any analytic definition of the criterion function, but even any explicit mention of a particular goal” (p. 73). However, even though there was no explicit goal stated, the game involved competition between teams, which implied a goal of winning the game, although the criteria for winning the game were vague and ambiguous (Cohen & Rhenman, 1961). Many years later, Wolfe (1994) asserted, “The simulations being used today are not that much different from those created in the late 1950s” (p. 276). Yet there have been recent calls for business game simulations to provide more explicit scoring methods and goals so that it is easier for the participants and administrators to assess the learning outcomes of the players (Thavikulwat, 2004).

Even without explicit scoring and goals, participants of business simulations were still bounded by the business world norms. Likewise, participants in role-play simulations play roles that are bounded by a tacitly agreed social system of norms of the exercise and of everyday life that constrain their actions (Csikszentmihalyi & Bennett, 1971). These social norms guide the participants' actions, which can take the simulation into different directions, depending on the participants and circumstances, as noted earlier. The process of role-playing is not predetermined but instead is shaped and revised as the players engage each other within a scenario (Cutler & Hay, 2000). The focus on process goals rather than the outcome goal (i.e., goal-to-win) can enhance self-perceptions of accomplishment, self-efficacy beliefs about applying the new knowledge in the future, and intrinsic motivation to continue learning after conclusion of the current exercise (Zimmerman & Kitsantas, 1997). It is interesting that the lack of focus on a common goal is contrary to Lewin's (1948b) concept that effective change at the group level required agreement on common (outcome) goals. Perhaps, in a role-playing simulation, the players' minds are more open and accepting of new information and action when playing another person's role instead of their everyday role. That is, when situated within their everyday role in life, people must agree on a set of common goals before being open to new information and perspectives, and willing to work with others to accomplish the goals in spite of the challenges. In contrast, when acting the role outside of everyday life, people feel freer to think and act differently within the context of play, without the need to establish common goals. Paradoxically, although participants consider this context as not affecting their everyday roles and lives, because they are more willing to learn, they may change their attitude toward a subject or object that exists outside of the simulation. Thus, the experience may change them in ways that they did not expect before participating in the role-play (Sogunro, 2004). This may be why role-play simulations and games are powerful ways to change people's attitudes and behaviors (Sogunro, 2004).

## **Development and implementation processes**

### **Developing, testing, and revising**

The NANO SCENARIO was alpha tested with 25 players, revised according to feedback, beta tested with 36 new players, and revised a second time. This proved to be an optimal time to train moderators (they also played the scenario). Beta testers were recruited as "runners" during the actual scenario to assist with logistics and distribution of information and scenario artifacts. Important elements such as optimal design for role identity badges, spatial layout of the townships and informational signage, the timing of aspects of the game, and elements for in-game reflection, information sharing, and reassessment were developed.

## Preparing for the NANO SCENARIO event

To effectively organize the simulation games and the townships in advance, we required pre-event registration by all participants. The pre-event online registration form was also designed to stimulate an immediate sense of participation for registrants. Applicants arriving at the Web site are asked to self-identify membership in one of the four stakeholder group options (academia, the private sector, government, and the general public), and this preregistration identity is used to coordinate the assignment of different roles for them to play during the NANO SCENARIO. Registrants, in addition to identifying their stakeholder group, are asked to submit a question they have about nanotechnology. This helps to focus their attention on this topic and the formation of their perspectives. For example, three themes generated by the questions for the event were as follows: (a) How will nanotechnology improve the social and economic lives of the world? (b) Will potential security technologies cross the line of "security" and invade people's privacy? and (c) What measures are/will be in place to prevent a misuse of the technology?

Finally, participants were provided with background and preparation leading up to playing the NANO SCENARIO simulation, including checking in and viewing a display of posters of questions asked by the participants concerning nanotechnology. The posters prompted participants to think about their existing knowledge and to consider new questions on the topic before engaging new information and texts (Dole, Valencia, Greer, & Wardrop, 1991). Participants also watched an educational film about nanotechnology, entitled *Small Futures* (<http://sts.utexas.edu>); listened to civic and community leaders lend additional credibility to the learning activities; engaged with an interactive panel of experts on nanotechnology; and visited a "Nano Fair" exhibition. The purpose of these activities was to build a "felt need" in participants that Lewin (1948a) argued is critical for effective change to take place for a group. Finally, participants laughed with a professional comedian.

We believe that humor can be an effective way to invite participation and to create an informal and relaxed atmosphere. Humor can help create a safe space for improvisation and imagination; engaging imagination is key to exploration, risk taking, and creation of new and often surprising connections (Wenger, 1998). To this end and to address some participants' reticence to become actively engaged in a role-playing exercise, we engaged as our host a professional improvisation master-trainer who has facilitated corporate learning activities. He trained the participants by modeling how to participate using humor, respect, imagination, and acting skills such as improvisation.

## Implementing NANO SCENARIO

As mentioned earlier, a critical feature of the scenario is its flexibility for different outcomes. Participants find themselves improvising possible futures and creating new communication pathways. What emerges depends on the individual participants' role improvisations, the dynamics of each group, and imaginations of all involved. The NANO SCENARIO narrative and the character roles expose members

of the public to potential social, ethical, and political challenges of nanotechnology that lead to a deeper understanding of how diverse stakeholders can be influenced and constrained by limited resources, knowledge, and obligations. Participants are assigned to any role that is *different from* the stakeholder group they identified with during online registration. The complex character roles and interwoven relationships present multiple perspectives designed to reflect some of the complexity of everyday life in an analogous community; this feature allows for customized localization of the entire design (see Greenblatt, 1975b) and assessment (Thorelli, 1997).

After the simulation, participants were engaged in a debriefing exercise. The debriefing process is one of the most critical design features of any experiential learning activity, just as it is in real life when people discuss and strive to make sense of incidents that occur in the world around them. Reflection and debriefing are particularly important when an activity has brought diverse people together to engage complex issues, such as the social implications of nanotechnology (Crookall & Arai, 2005; Duke & Greenblatt, 1975; Greenblatt, 1988; Lederman & Kato, 2005).

## Results and discussion

Simulations can help participants explore realistic and timely depictions of a highly complex world through experiential role-play (Starkey & Blake, 2001). However, it is important to acknowledge that, as Dugdale, Pallamin, and Pavard (2006) have noted, “such close-to-reality simulations are expensive to organize, difficult to design, time-consuming to perform, and complicated to assess” (p. 226). Claims of success, therefore, are conditioned by this knowledge concerning the limitations of assessment in the field of experiential learning (Ruben, 1999). In their review of scholarship on assessing experiential learning effectiveness, Gosen and Washbush (2004) have argued that “the problem lies at least in part in the nature of learning and the learners’ expressions of it. Learning is an internal mental process, and what is learned and how it is learned is unique for each individual. To create an instrument able to capture what is actually learned is easier said than done” (p. 284).

Nevertheless, at the end of the simulation, all participants were asked to work individually and fill out a one-page evaluation sheet that posed these three questions: (a) What is your biggest takeaway? (b) What have you learned that was unexpected? and (c) What can we do to improve the format or any other aspects?

Sogunro (2004) argues that the “acid test” to justify the efficacy of role-playing scenarios is positive feedback and comments from participants. Based on responses to our evaluation instrument, participants overwhelmingly reported that they learned about nanotechnology and its societal implications, that they enjoyed the interactive role-play simulation, and that they learned about others’ perspectives and about themselves as well. For example, one participant wrote, “I enjoyed the role-playing session. The most instructive element for me was how ‘all’ actors, i.e. government, businesses, the public, academics, were constrained to some degree by limited resources, knowledge, and various obligations.” A graduate student in educational administration reported

learning something about how she prejudices others, especially in learning situations: “I have found I have to battle biases when constructing new knowledge . . . we constructed new worldviews in a mere two hours.” For another, “It sounded like nanotechnology will indeed have a significant effect on the future. Now I know what nano means as well as some of the developments being made.”

Many participants said that they learned how important access to information is, how critical leadership roles can be in a community, and how something as important as privacy rights can be affected by nanotechnology: “Role-playing brought to life how passionate society is in a situation like this—virtually every walk of life is concerned—for health reasons, environmental and civil rights—their right to privacy.”

New insights about public perceptions were another major takeaway for some participants; for example, one wrote, “Huge public distrust of government and industry about ‘the unknown’ of nanotech.” For others, their biggest takeaway had to do with the societal effects of nanotechnology: “It is amazing that nanotechnology is going to be prevalent in all parts of society, not just science.” A powerful takeaway for others was the opportunity to engage with the diverse stakeholders represented by the participants: “I was able to speak to and listen to people of different societal positions and opinions.” A number of participants were concerned about the role of the public in national nanotechnology policy: “We need an overall scientific and technical strategy for the country that is developed by all stakeholders.”

One of the primary objectives of the NANO SCENARIO simulation was perspective-taking and better understanding of others’ views. One participant trained in neuroscience wrote,

Before I came to this conference, I thought that I was going to attend to learn a new science, nanotechnology. However, after I attended this conference, I ended up with an understanding and respecting the way people think about new technology. . . . In the scenario, I suddenly realized that “I am living in a real world.” This is like the real world, so there are definitely some people who do not think in the same way I think and do not do things in the way I expected. I felt great when I understood this. I definitely started to respect different opinions coming from other people. I believe that this take home message will follow me forever.

## Conclusion and future challenges

STS programs nationally and internationally are using new approaches to better understand the complex social, cultural, historical, and political contexts within which nanotechnology as a scientific practice is situated. This article has presented a university-sponsored civic engagement model, the NANO SCENARIO, focusing on the societal implications of nanotechnology by bringing together multiple stakeholders’ perspectives in a participatory experiential learning environment.

Several improvements could be made to the simulation design, including the addition of postsimulation breakout discussion groups. Building on the critical recommendations of Lederman and Kato (2005), the debriefing process could be

extended to include more formal consideration of the roles of the facilitators and moderators. The basic structure of the scenario designs can be customized further to address local situations and contexts. Finally, a more rigorous and integrated assessment feature would enhance the further development of the NANO SCENARIO simulation and other such efforts and activities.

In conclusion, through improvised role-play and perspective-taking, the open-ended NANO SCENARIO simulation is designed to lead participants to a deeper understanding of diverse stakeholders' views by exposing participants to potential social, ethical, and political challenges of nanotechnology in the complex context of a simulated township.

## Note

1. The Civic Forum on the Societal Implications of Nanotechnology was held on October 1, 2005. More than 400 people registered and nearly 300 attended the all-day free civic education outreach event. See [www.sts.utexas.edu](http://www.sts.utexas.edu) for more information.

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