Experimental Comparison of System Dynamics versus Traditional Facilitation in a Real World Public Participation Application

Abstract

This paper reports on an experiment comparing the relative effectiveness of standard group facilitation techniques with system dynamics facilitation techniques in a real world stakeholder participation process. The experiment tested the hypothesis that the system dynamics approach would lead to: (1) better decisions; (2) greater participant focus on relevant materials; and (3) higher procedural satisfaction. The system dynamics approach yielded better decisions and focus but lower procedural satisfaction among participants.

Keywords: facilitation, public participation, environmental decision making

Introduction

When government agencies initiate a decision-making process to resolve environmental problems, they often solicit input from affected public stakeholders. Such public participation can have several benefits. As a recent National Research Council (NRC) report on *Public Participation in Environmental Assessment and Decision Making* states (Dietz & Stern, 2008, p. 2):

> "When done well, public participation improves the quality and legitimacy of a decision and builds the capacity of all involved to engage in the policy process. It can lead to better results in terms of environmental quality and other social objectives. It also can enhance trust and understanding among parties."

Done poorly, however, public participation can make things worse. Ineffective facilitation of stakeholder involvement can also lead to legal challenges, delays in decision-making, failed processes that do not solve the problems. Participants are often frustrated with the process, feeling their input has been ignored. The NRC report points out that the results of public participation depend greatly on the characteristics of the process.

This paper describes an experiment comparing the relative effectiveness of traditional or standard group facilitation techniques with system dynamics facilitation techniques in a real world stakeholder participation process. In February 2008, the City of Los Angeles held a city-wide conference to involve stakeholders in a Solid Waste Planning process. Approximately 200 people attended the conference. The full group was given a presentation introducing the solid waste system and posing key management questions. They were then simultaneously divided into two groups for discussion of the management alternatives. Half of the group participated in small group discussions run by a professional facilitator who use standard methods for directing the conversation and recording participant ideas on a flipchart. The other half of the group – the experimental group -- participated in small group discussions using a system

dynamics simulation model. The model and its development are described in Stave (2008).

The experiment tested the hypotheses that a system dynamics-based group process would lead to better decisions, greater focus on relevant information and more procedural satisfaction among the participants than a process facilitated using standard group discussion techniques. Standard group discussion techniques include commonly used group facilitation techniques such as brainstorming, dot voting, or SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis, for example. "Better" decisions are points of leverage with a higher potential of solving the given problem within the given constraints. In this case, better, or more effective decisions are those more likely to reduce the amount of waste sent to Los Angeles' landfills to as close to zero as possible, as close to 2030 as possible, while minimizing cost and maximizing reductions in greenhouse gas emissions.

Basis for the Hypotheses

Why should a system dynamics approach lead to better decisions, promote a higher level of participant focus on relevant materials, and give participants a better feeling of procedural satisfaction?

Classical decision theorists argue that good decisions are made following a set of rational procedural steps. They believe rational decision makers strive to agree on goals, completely evaluate alternatives and consequences, examine all critical data, and optimize outcomes based on agreed upon evaluation criteria. They expect participants in group decision processes are capable of and willing to be rational (Higgins 1991). Starting with Dewey's (1910) process of "reflective thinking," a number of researchers and theorists (e.g., Janis and Mann (1977), Gouran and Hirokawa (1983), Gouran et al. (1993)) have identified the following "ideal" procedural steps to describe how rigorous decision makers behave in a group setting:

(1) identify, discuss the problem and goals;
(2) define the problem;
(3) identify problem causes;
(4) generate alternative solutions;
(5) collect data;
(6) establish criteria for solution effectiveness;
(7) analyze alternative solutions against criteria;
(8) identify consequences;
(9) evaluate, discuss alternatives; and
(10) make decision.

Behavioral decision theorists, on the other hand, argue that decision makers are limited in critical ways. For example, they have limited information availability, processing capability, and flawed mental models. These limitations lead to satisficing, bounding of rationality, and heuristic behavior that interferes with the rationality of the decision analysis and the degree to which participants can develop a thorough analysis and shared view of the problem or solutions. Simon (1957) points out that rational analysis requires complete knowledge and an unrealistic ability to anticipate

consequences. Because decision makers have limited knowledge of relevant information and limited mental ability to process information and anticipate consequences, he says they "satisfice," that is, select alternatives that are "good enough" rather than ones that would maximize the decision outcome. Simon also points out that humans tend to oversimplify the scope of the decision analysis to a more manageable set of information, what he calls "bounding" rationality. According to Arnold and Feldman (1986), bounded rationality makes sense because decisions are always incomplete and based on inadequate information. It is impossible to identify all possible alternative solutions or completely analyze alternatives because we cannot possibly predict all possible consequences, therefore, it is impossible to maximize or optimize decision outcomes. Tversky and Kahneman (1974) and Hogarth (1987) suggest that decision-makers often rely on short-cuts, or rules-of-thumb to reduce the overall complexity of their decision-making task. They contend such heuristic behavior interferes with the ultimate effectiveness of the decision outcomes because it produces systematic error or bias.

This review of decision theory suggests that while a more classical, rational or "ideal" approach to decision making would seem to lead to "better" decisions, human limitations mean that group decision processes might tend toward less comprehensive or rigorous decision making.

In a meta-analysis of standard group facilitation techniques, Turner (2008) found that while standard facilitation approaches purport to follow a more ideal, rational approach to decision making, they actually seldom do so. Instead, they seem to support behavioral decision making. She evaluated 44 literature sources in which specific stakeholder facilitation process steps were identified. These references were obtained from a review of literature in the areas of decision making, group process, public participation, decision performance, as well as other online government or management group facilitation "how-to" manuals, and represent a comprehensive list of the "standard operating procedures" that group facilitators commonly employ. She compared the process steps identified in these 44 sources to the list of 10 ideal rational decision making facilitation process steps identified above (shown in Table 1).

This analysis confirmed that standard facilitation processes fall short of rational analysis. Instead, they focus on just three steps: 93% of sources included a step to define the problem; 91% of sources included a step for generating alternatives; 75% of sources included a step for making decisions. Only 34% of standard processes recommended collecting data in their decision making process. Only 32% of standard methods involved analyzing alternatives, and only 18% made an effort to identify consequences of alternative solutions. Just 27% of standard processes establish criteria against which solutions would be judged to determine their ultimate effectiveness in achieving the stated goals, and a mere 11% of standard processes devoted effort to evaluating and discussing the options, yet 75% of the sources actively made a decision. These data suggest show that such standard facilitation practices appear to be more likely to "jump to solutions" without a thorough analysis of the decision situation.

Table 1.

10 Ideal Rational Group Facilitation Process Steps	1. Identify, discuss problem and goals	2. Define problem	3. Identify problem cause	4. Generate alternative solutions	5. Collect data	6. Establish criteria for solution	7. Analyze alternative solutions against	8. Identify consequences	9. Evaluation, discussion	10. Make decision
Frequency of Occurrence of Process Step	19	41	8	40	15	12	14	8	5	33
Frequency of Occurrence of Dominant Themes as a % of Total Sources (44)	43%	93%	18%	91%	34%	27%	32%	18%	11%	75%
(Creighton, 2005)		X		X			X			X
(Michaelson, 1996)	X	X		X					X	X
(Osborn, 1963)		X		X						X
(Robson, 2002)		X		X	X		X			X
(Bormann, 1990)	X	X		X						X
(Rosander, 1989)	X	X			X					X
(Schotes, 1988)	X	X			X				X	
(Littlejohn, 2002)	X	X		X		X				X
(Prowse, 2004)		X		X	X	X				X
(Robson, 2002)		X		X	X		X			X
(Lawrence, Shaw, Lane & Eisner, 2000)		X				X	X	X		
(Schwartz, 1994)		X	X	X						X
(Holistic Management, 2002)		X		X		X				X
(McNamara, 1999)		X	X	X						X
(Dombeck & Wells-Moran, 2005)		X		X	X					X
(Phelps, 1997)	X			X			X			
(Wilson, 2005)		X		X						X
(Bordley, 2001)		X		X	X	X		X		
(Club Managers Assn. of America, 1991)	X	X		X	X		X			X
(Straus, 1999)	X	X		X					X	X
(Frey, 1996)	X	X		X		X				
(Frey, 1996)		X		X				X		
(Patton & Downs, 2003)	X	X		X	X	X				
(Maruska, 2004)	X	X		X	X					X
(Arbach, 2000)		X		X	X	X		X		X
(Littlejohn, 2002)	X	X		X	X				X	X
(Gregory, 2000)	X	X		X				X		
(Weldon, 1993)	X	X		X		X	X			
(U.S. Environmental Protection Agency, 1998)		X		X		X	X			X
(Culik, 1993)		X		X				X		X
(Corder & Thompson, 1996)	X	X		X			X			X
(Grunig, & Kuhn, 2005)		X		X				X		X

(Grunig, & Kuhn, 2005)	x	x		x		x		x		x
(Brilhart, 1968)		x		x		x	x			x
(Kleindorfer, 1999)	x			x			x			x
(Forsha, 1995)	x	x		x			x			x
(ALCOA, 1989)		x	x	x			x			x
(Eitington, 1989)		x		x	x					x
(Forsha, 1995)		x	x	x						x
(Ingle, 1985)		x	x	x	x					
(Kelly, 1992)		x					x			x
(Miller & Howard, 1992)		x	x	x	x					x
(PQ Systems, 1992)	x	x	x	x					x	
(Brightman,1988)			x	x						x

(Turner, 2008, p. 31)

In contrast to the standard approaches described above, system dynamics facilitation takes a more classical approach to the facilitation of group decision making. System dynamics seeks to understand the causes of the problem and the consequences of alternative solutions. The fundamental principle of system dynamics states that the structure of the system generates its behavior (e.g., Sterman 2000, p. 28), which directs any attempt to change the system's behavior toward understanding its structure. To correct a problem or an undesirable behavior, system dynamics practitioners seek to understand the underlying structure creating the undesirable behavior and identify and test ways in which to intervene on the structure to change the problematic behavior. Systems models help participants identify and evaluate potential solutions. Table 2 provides a general comparison of the level of adherence of standard and system dynamics-based facilitation methods to the 10 ideal rational decision making facilitation process steps.

Table 2. Comparative Analysis of Level of Adherence

Adherence to the 10 Ideal Rational Decision Making Facilitation Process Steps	Standard Group Decision Making Facilitation Process Steps	System Dynamics Group Decision Making Process Steps
1. Identify, analyze problem and goals		X
2. Define problem	X	X
3. Identify problem causes		X
4. Generate alternative solutions	X	X
5. Collect data		X
6. Establish criteria for effective solutions		X
7. Analyze alternative solutions		X
8. Identify consequence		X
9. Evaluation, discussion		X
10. Make decision	X	X

Experimental Procedures

The experiment was conducted on February 2, 2008, during a city-wide conference held in Los Angeles (LA) to solicit input from LA stakeholders. This conference was part of LA's city-wide Solid Waste Integrated Resource Planning (SWIRP) process which was designed to identify ways in which to reduce the amount of solid waste sent to its local landfills annually. The experiment took place during a 90-minute morning work session in which attendees were asked to participate in small-group discussions to review and prioritize a set of eight alternative waste management policy options and provide LA officials with feedback on where it should direct its efforts in developing its solid waste reduction plans.

This experiment followed a quantitative design, using a between-subjects, single-factor, random assignment, two-group experimental design (Bordens & Abbott, 1991). 197 individuals took part in the experiment and were assigned to either a control group or experimental group. The control group was facilitated with standard methods, and the experimental group was facilitated with system dynamics methods. Pre- and post-intervention questionnaires were administered to measure the differences between group participants' responses to questions designed to identify the degree to which the facilitation method contributed to promoting greater effectiveness, focus, and procedural satisfaction.

Small-Group Work Session Task

The control and experimental groups met simultaneously and both were given the same task of reviewing and prioritizing a list of alternative policy options, or "leverage points" that could be used to help reduce the total amount of waste sent the landfills annually. The following is a copy of the handout all participants of both groups were given at the beginning of the work session:

ZERO WASTE PLAN
Solid Waste Integrated Resources Plan

Citywide Conference 2
Policies, Program and Facilities

Listed below are the leverage points in the recycling loop and example strategies identified by LA stakeholders for reaching zero waste. The idea of these leverage points is to say: if we could change something by a certain amount, what impact would it have? Today, we will discuss these leverage points, describe their individual strengths and weaknesses and the opportunities and constraints that come with each leverage point. We will then rate their potential impact (high, medium, low) with respect to waste reduction, environmental benefit, cost effectiveness, and ease of implementation. Finally, we will come up with a recommendation for how aggressively the City should pursue each leverage point.

UPSTREAM

Production Sector

1. What if we could increase the average useful lifetime of consumer products?
   Examples:
   - Increase product durability
   - Educate consumers on the consequences of excess consumption
   - Encourage repair and reuse
2. What if we could reduce the amount of waste in products and packaging?
   Examples:
   - Implement product and packaging bans or take backs for on waste reduction
   - Require manufacturers to reduce the weight of packaging
3. What if we could increase the recycled content of products and packaging?
   Examples:
   - Promote "buy recycled" campaign
   - Require manufacturers to increase the use of recycled content in products and packaging
4. What if we could make products and packaging more recyclable?
   Examples:
   - Implement product and packaging bans or take backs focused on recycled content
   - Require manufacturers to change the content of their products and packaging to make them more recyclable
   -

DOWNSTREAM

Consumption Sector

5. What if we could change the average amount of material consumed by each consumer?
   Examples:
   - Massive and sustained public outreach and education campaign focused on waste prevention (also called "source reduction")

Collection Sector

6. What if we could increase consumer diversion rates?
   Examples:
   - Massive and sustained public outreach and education campaign focused on recycling
   - Mandatory participation in recycling and organics programs (single-family, multi-family, commercial) – no trash in the recycling and no recycling in the trash
   - Roll-out recycling and organics containers to all multi-family buildings
   - Roll-out recycling and organics containers to all commercial generators
   - Roll-out recycling and organics containers to all schools in Los Angeles Unified School District

Processing Sector

7. What if we could increase the processing capacity for diverted materials?
   Examples:

- Increase the presence of neighborhood scale facilities such as reuse centers and fix-it shops through technical assistance, grants, and incentives
- Increase the processing capacity of existing recycling and composting facilities through facility expansion or by adding more shifts
- MRF first (process residual waste prior to disposal to remove recyclables and compostables)
- Site new mulching and composting facilities
- Site new SAFE centers for collection of household hazardous waste and electronics
- Site new resource recovery parks for self-hauled materials
-

RESIDUAL WASTE MANAGEMENT

Disposal Sector

8. What if we could increase the capacity for alternative technologies? Examples:
    - Biological treatment of residual waste through anaerobic digestion
    - Thermal treatment of residual waste through waste-to-energy
    - Conversion of residual waste to biofuels

(City of LA, 2008)

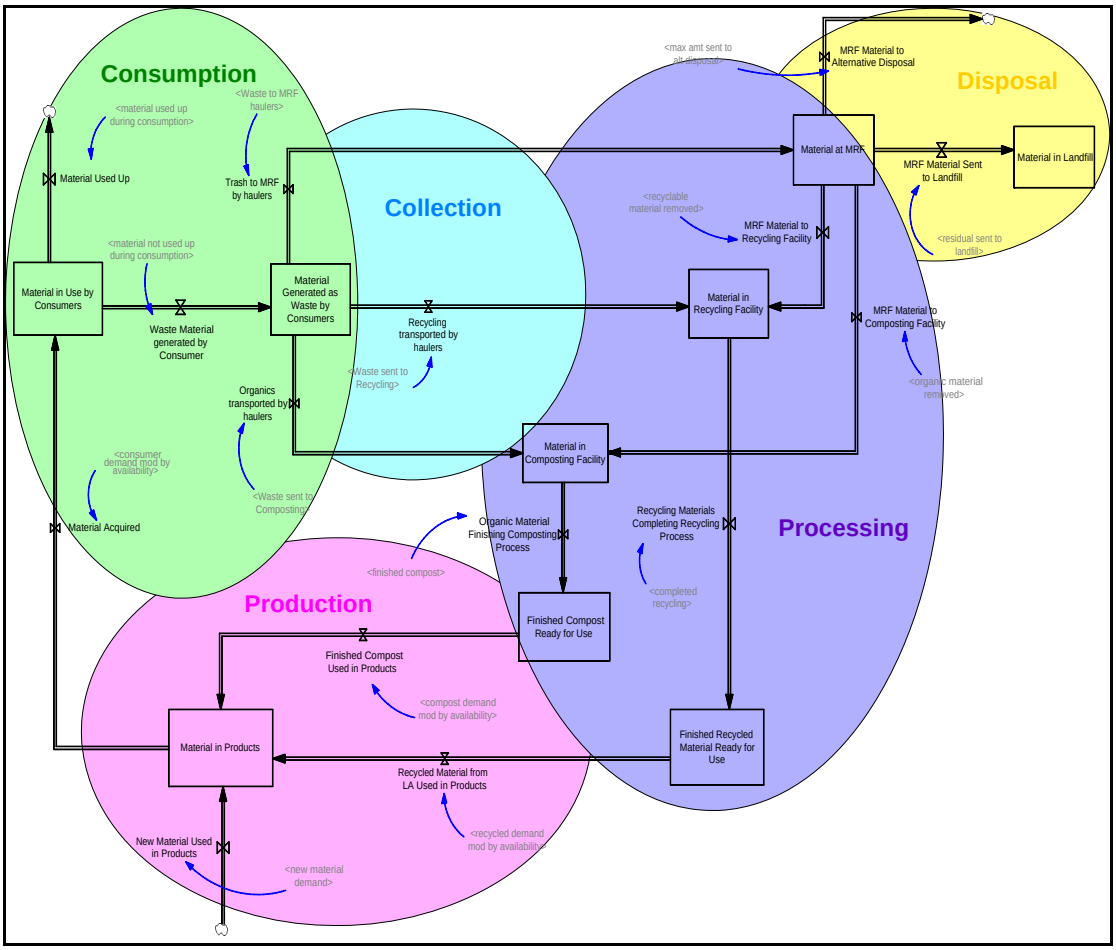
As the participants discussed, evaluated and prioritized each of these leverage points, they were directed to rate the policy alternatives by the following criteria: the amount of waste sent to the landfill, the relative costs, the relative greenhouse gas emissions, and relative level of effort to implement. Participants of both groups were asked to evaluate each of the eight leverage points against these criteria and provide feedback to the City of LA on which of the eight leverage points it should devote its time pursuing. This helped to ensure that participants of both groups were tasked with considering the relative merits of the policy alternatives under consideration.

Group Facilitation Intervention

Prior to initiating their task, both the control and experimental groups were given the same overview presentations, the same list of leverage points and the same four criteria upon which to evaluate the leverage points. Because the control and experimental groups met simultaneously, different facilitators were used for both groups. All facilitators were well prepared and enthusiastic about participating in this experiment. To help ensure a consistent facilitation of the administration of the groups' task, all facilitators were required to participate in a facilitator training exercise prior to the event. The primary difference between the two groups was the method by which they were facilitated. The control group was facilitated with standard methods and the experimental group was facilitated with system dynamics-based methods.

Figure 1 illustrates the components and relationships of the model developed for use at this conference. The computer model was used by participants of the experimental group to help simulate what would happen if the City implemented any of the leverage points under consideration. This helped the participants to take a more rational approach to understanding the differences in the relative levels of effectiveness among the alternative leverage points. It also kept participants maintain focused on the fact that the solid waste management system is a system of interconnected parts rather than isolated elements or unrelated or irrelevant issues.

Figure 1: Zero Waste System Dynamics Model



(Stave, 2008)

Survey Instrument

The goal of this experiment was to measure whether groups facilitated with system dynamics-based approach would yield better decisions, greater focus and higher procedural satisfaction than standard facilitation methods. We used a pre- and post-intervention survey to compare the relative differences between two groups' responses. The pre-intervention survey included demographic information to determine whether the groups were different to start with. Other questions measured attitudes, behavior,

and knowledge related to waste management. Six of the questions in the pre-intervention survey instrument were also asked in the post-intervention survey instrument.

The post-intervention survey instrument included a variety of different types of questions. In addition to the six pre-intervention, it also included Likert-scale questions to measure if participants strongly disagree to strongly agree with a series of 20 statements. These questions were modeled after various process assessment survey instruments and related research developed by Wilson (2005), Gottlieb (2003), and Brilhart (1968).

We modeled many of the pre- and post-intervention survey questions after the instruments used in research conducted by Huz (1999) and Rouwette (2003). Both of these studies involved a between-groups experimental design and administered surveys to measure the level of effectiveness of system dynamics modeling. While each had a different research focus, both research projects sought to measure participants' responses to questions regarding their experience. The focus of these questions was very close to what we were seeking to measure in this study. While we were tempted to replicate a blending of the specific questions asked in these two studies, the focus of our study was different enough that we chose not to replicate these prior survey instruments exactly.

To develop questions regarding participant view on the process, we turned to research in group process and group performance research. Primary sources included Brilhart (1968), Gottlieb (2003), Wilson (2005), Rees (2005), and Zakay (1984). Their research focuses on understanding how group process affects group performance, how facilitation affects group process and performance. The procedural satisfaction questions were modeled on the work of these researchers.

Overview of Results

We analyzed pre-and post-intervention surveys from 197 participants (101 surveys from the control group and 96 surveys from the experimental group). Only participants who completed both the pre- and post-intervention questionnaires were included in the analysis. Data from the questionnaires were entered into spreadsheets and verified to correct data entry error. Responses to open-ended questions were entered verbatim and later coded. Special efforts were made to hide the unique participant identification numbers and sort participant responses prior to coding the responses, so that the coders would not know whether the respondent was in the control or experimental group.

We used the Statistical Package for Social Sciences (SPSS), version 16.0, to conduct statistical analyses of the results after all the results were recorded. The normality distribution of each variable was tested using the Kolmogorov-Smirnoff test, and all variables proved to be non-normally distributed. The control and experimental groups' responses were compared for pre-and post-intervention values using the

Kruskal-Wallis Test. A level of statistical significance of $p \leq 0.05$ was used to determine statistical significance.

Demographics and Descriptions

The Kruskal-Wallis Test revealed no significant differences between groups with respect to demographic and descriptive questions, summarized in Table 3.

Table 3. Demographic and Descriptive Questions

	Control Group		Experimental Group		Kruskal Wallis Test	
Question	*n*	Mean	*N*	Mean	Chi-Square	Asymp. Sig. ($p = \leq .05$)
How many SWIRP meetings have you attended before this one?	100	1.76	92	1.62	0.196	0.658
Do you recycle?	101	4.24	96	4.17	0.497	0.481
How many years have you lived in Los Angele?	94	3.52	91	3.56	0.225	0.635
Current Zip code:	94	2.77	95	2.39	2.058	0.151
Sex:	99	1.58	94	1.49	1.439	0.23
Highest level of education	97	3.52	94	3.48	0.029	0.864
Age:	97	2.64	95	2.74	0.506	0.477
What kind of housing do you live in?	98	1.43	95	1.38	0.809	0.368
Do you own or rent?	96	1.42	93	1.31	2.228	1.36
How many people live in your household?	98	2.76	94	2.76	0.008	0.93
Annual household income:	90	2.71	89	2.7	0.046	0.83

Summary of Results

The following three tables summarize questions associated with each of the three hypotheses. These tables summarize the question, the total number of responses and the mean for both groups, along with the chi-square and statistical significance determination for each question. We also included a column on the summary tables to indicate when a significant difference ($p \leq 0.05$) was identified between the groups' responses to help highlight whether or not the difference supported the research hypothesis.

Table 4. Summary of Statistical Analysis of Hypothesis 1 Questions

Hypothesis 1: Participants in group decision making facilitation processes that adhere more closely to the ideal group decision making facilitation process steps will identify more effective solutions to resolve the stated problem, than will participants in groups using standard facilitation methods.							
Goal	Question	Control Group		Experimental Group		Kruskal Wallis Test		
		N	Mean	*N*	Mean	Chi-Square	Statistical Significance ($p = \leq .05$)	If significant, does it support hypothesis?
Goal: Identify which group actually identified solutions that were objectively more effective in helping achieve zero waste.								
	What do you think is the best thing for the City to focus on in order to move towards Zero Waste? (Pre-intervention, as coded for systemic value)	82	1.8	80	1.88	1.469	.226	
	What do you think is the best thing for the City to focus on in order to move towards Zero Waste? (Post-intervention, as coded for systemic value)	79	3.49	80	4.7	4.821	.028	Y
Goal: Identify which group had higher level of confidence in their ability to select the best solutions.								
	We are helping the City of Los Angeles discover the best options for achieving Zero Waste.	80	4.2	74	3.92	5.738	0.017	N
	I feel confident that my group's suggestions represent the best approach to Zero Waste planning.	80	3.79	75	3.39	10.848	0.001	N
	How much do you know about the solid waste challenges in LA? (Pre-intervention)	82	3.45	80	3.23	2.182	0.14	
	After this morning's workshop, how much do you know about the solid waste issue in LA? (Post-intervention)	82	3.88	78	3.55	6.302	0.012	N

Table 5. Summary of Statistical Analysis of Hypothesis 2 Questions

Hypothesis 2: Participants in group decision making facilitation processes that adhere more closely to the ideal group decision making facilitation process steps will stay more focused on relevant information related to the stated problem, than will participants in groups using standard facilitation methods.

		Control Group		Experimental Group		Kruskal Wallis Test		
Goal	Comment or Question	*n*	Mean	*n*	Mean	Chi-Square	Statistical Significance ($p = \leq .05$)	If significant, does it support hypothesis?
Goal: Identify which group was more focused on relevant information.								
	What do you think is the best thing for the City to focus on in order to move towards Zero Waste? (Coded for degree of influence of materials presented)	81	3.04	80	4.51	7.787	0.005	Y
Goal: Identify which group was more influenced by what they learned during the process.								
	I learned something new about Zero Waste management.	81	3.89	79	3.86	0.189	0.664	
	I changed my ideas about Zero Waste management during this workshop.	81	2.94	78	3.08	0.765	0.382	

Table 6. Summary of Statistical Analysis of Hypothesis 3 Questions

Hypothesis 3: Participants in group decision making facilitation processes that adhere more closely to the ideal group decision making facilitation process steps will be more satisfied with the interpersonal dynamics, process, and outcome of the group decision making experience, than will participants in groups using standard facilitation methods.

Goal	Question or Comment	Control Group		Experimental Group		Kruskal Wallis Test		
		n	Mean	*n*	Mean	Chi-Square	Statistical Significance ($p = \leq .05$)	If significant, does it support hypothesis?
Goal: Identify which group was more satisfied with the interpersonal dynamics.								
	I felt included in the discussion.	81	4.32	73	4.15	2.1	0.147	
	I had opportunities to share my ideas during the discussion.	82	4.39	74	4.16	5.276	0.022	N
	I had opportunities to explain my ideas during the discussion.	82	4.33	73	4.1	5.234	0.022	N
	I felt other participants respected my views.	80	4.34	71	4.03	7.841	0.005	N
	There was a lot of interaction among group members.	81	4.26	75	3.91	3.524	0.06	N
	We dealt constructively with disagreements among members.	82	3.93	70	3.8	1.084	0.298	
	All members of my group agreed on our group's recommendations.	81	3.37	72	3.44	0.158	0.691	
	Are you likely to attend another SWIRP meeting after this one? (Pre-intervention)	82	4.22	79	4.32	0.193	0.661	
	After this morning's workshop, are you likely to attend another SWIRP meeting? (Post-intervention)	82	4.2	80	4.25	0.003	0.959	

Goal: Identify which group was more satisfied with the general meeting structure, process rigor.							
We discussed all options presented.	81	3.74	76	3.13	12.34	0	N
Our group worked hard to develop recommendations.	81	4.05	74	3.66	6.035	0.014	N
My group worked well together to develop its recommendations.	80	4.11	75	3.8	3.685	0.055	
The discussion was well structured.	82	3.79	74	3.18	11.806	0.001	N
The tools we used in the discussion were helpful.	81	3.78	77	3.44	2.667	0.102	
Goal: Identify which group demonstrated a higher level of support for process/outcome.							
I feel confident that my group's input will help to achieve Zero Waste in Los Angeles.	80	3.94	76	3.58	8.951	0.003	N
I fully support my group's recommendation.	78	3.95	73	3.64	5.621	0.018	N
I am enthusiastic about the idea of working towards Zero Waste in LA.	82	4.5	77	4.32	4.858	0.028	N
I believe the City of Los Angeles values my input.	82	4	75	3.81	2.132	0.144	
How possible do you think it is to achieve Zero Waste? (Pre-intervention)	82	3.9	79	3.95	0.669	0.413	
How possible do you think it is to achieve Zero Waste? (Post-intervention)	82	3.93	79	3.78	0.833	0.361	
How possible do you think it is to achieve Zero Waste by 2030? (Pre-intervention)	82	3.9	79	3.92	0.013	0.909	
How possible do you think it is to achieve Zero Waste by 2030? (Post-intervention)	82	3.8	80	3.71	0.484	0.487	

General Summary and Implications of Results

We hypothesized that the facilitation method that adhered more closely to the classical methodology -- system dynamics -- would yield a higher degree of effectiveness, focus, and procedural satisfaction than the standard facilitation methods which do not adhere closely to the classical decision making methodologies. We expected that because standard facilitation processes enable behavioral decision making tendencies which limit the scope of decision analysis, participants would be less likely to identify the most effective solutions. This study showed that participants in the system dynamics group decision making facilitation process did identify more effective solutions. It also showed participants in the system dynamics based group focused more on the information provided about the system, but that they did not have a higher degree of procedural satisfaction.

Discussion of Results Related to Hypothesis 1: Better Decision

To determine which group was better able to identify the more effective solutions for solving the solid waste problem in LA, participants were asked before and after the work session to identify the best things LA could do to achieve zero waste. Both groups were given the same background materials for their deliberations. Participant responses were coded for their systemic value or the degree to which the response would achieve the stated goals. The coding of systemic value of the participants responses was based on an objective evaluation of the relative merits of the eight leverage points under consideration. This objective evaluation was based on the expert opinion of solid waste managers and consultants and the use of the system dynamics model to evaluate each leverage point with respect to its relative level of effectiveness in achieving the stated goals (achieving zero waste by 2030, minimizing cost, and maximizing reductions in greenhouse gas emissions). Policy levers were coded on a scale of 0 to 10, with 10 being the best or most effective solution possible.

While there was no significant difference between pre-intervention responses ($p = 0.567$), there was a significant difference in the post-intervention responses ($p = 0.028$). In the post-intervention responses, the experimental group's mean score was higher than the control group. Thus, the experimental group participants were better able to identify more of the more effective leverage points than were the control group members after the intervention.

We asked three supplemental questions to measure which group's participants felt more confident in their abilities to select more effective solutions. Since we thought the group facilitated with the system dynamics processes would be better able to identify the best solutions, we also assumed that they would have a higher degree of self confidence in their abilities and knowledge. However, the control group demonstrated a higher level of confidence in their knowledge of the issue although they demonstrated a lower level of understanding of which solutions will be more effective in achieving zero waste.

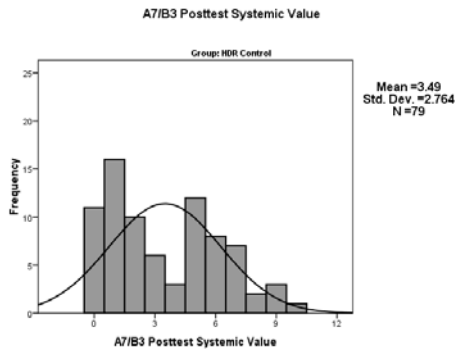
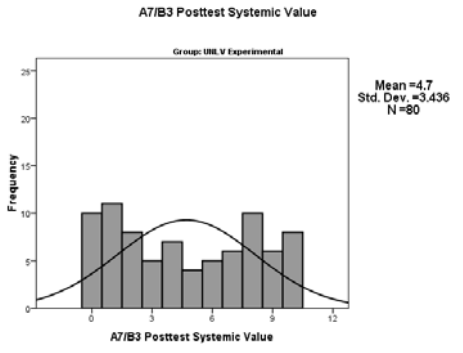
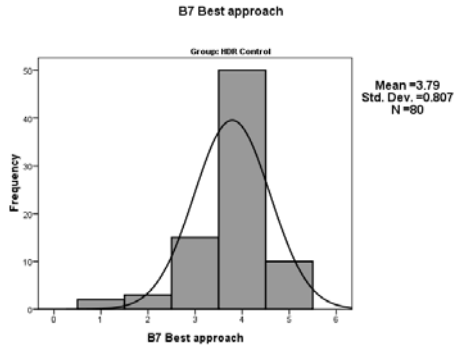
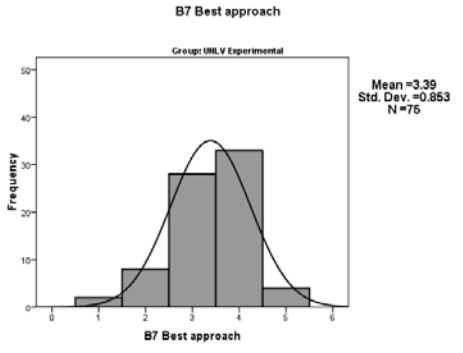
The level of significance of the differences in responses between groups to these questions is as follows: "We are helping the City of Los Angeles discover the best options for achieving Zero Waste" ($p = 0.017$); "I feel confident that my group's suggestions represent the best approach to Zero Waste planning" ($p = 0.001$); and "After this morning's workshop, how much do you know about the solid waste issue in LA" ($p = 0.012$). The control group's mean score was higher than the experimental group in each of these areas, even though they actually scored lower in their ability to select more effective solutions.

This inversion of self confidence and ability could be related to the idea that the when one learns new things, it often challenges their previous understanding of how things work and causes them to doubt themselves. The lower level of confidence in the experimental group could also mean that the participants do not recognize that they have improved their understanding. Research by Ajzen (1991) shows that people are often unaware that they have learned something and they are also frequently are unable to identify the provenance of the new knowledge. Since this experiment involved a computer model with which participants did not have time to become fully familiar, this lack of familiarity could have caused participants to have less trust in the output of the model. And even though on some level the participants absorbed the model output enough to identify better solutions, it is possible that there was not enough time for the information to truly sink in and transcend from information to a genuine understanding.

So participants in the system dynamics group made better decisions, but the participants in the standard group were more confident about the decisions they made. One potential explanation for these results is that the control group's higher level of procedural satisfaction could have created a positive image of the process and a false sense of confidence in the outcome. Conversely, the experimental group's lower level of procedural satisfaction could be artificially reducing their self confidence in the outcome. Given the available data, we cannot determine with certainty the cause of this inverse relationship between ability and confidence.

Figure 2 provides a sampling of the inverse relationship between participants demonstrated and perceived abilities.

Figure 2.

<table>
<tr><td colspan="2">Measure of Actual Ability: The experimental group had a significantly higher mean score (p = 0.028) than the control group in the coding of the systemic value of participants post-intervention suggestions for the best things LA should do to achieve zero waste.</td></tr>
<tr><td>Control Group Mean: 3.49
 
</td><td>Experimental Group Mean: 4.7
 
</td></tr>
<tr><td colspan="2">Measure of Confidence in Ability: The control group had a significantly higher mean score than the experimental group (p = 0.001) relating their confidence that they had identified the best approach for LA to take when striving for zero waste.</td></tr>
<tr><td>Control Group Mean: 3.79
 
</td><td>Experimental Group Mean: 3.39
 
</td></tr>
</table>

Discussion of Results Related to Hypothesis 2: Greater Focus

The questions testing the second hypothesis examined the level of participant focus on the relevant information. The idea behind this hypothesis was that the facilitation method more aligned with the ideal classical decision making practices should be better able to keep its participants focused on the relevant information presented so that they would be better able to make more fully-informed decisions. It was relatively easy to code the post-intervention responses to the question asking

participants to list the best things LA should do to achieve zero waste. Responses that exactly matched the presented materials, meaning they quoted or used the same words and/or phrases as the presented materials, or responses that demonstrated a clear understanding of the content of those materials were coded higher than those that did not. There was a significant difference between groups ($p = 0.005$) with the experimental group scoring higher than the control group in making more references to the materials.

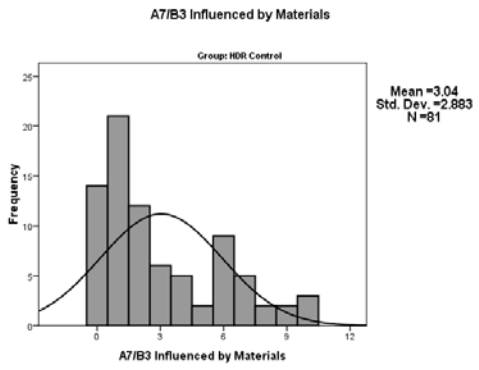
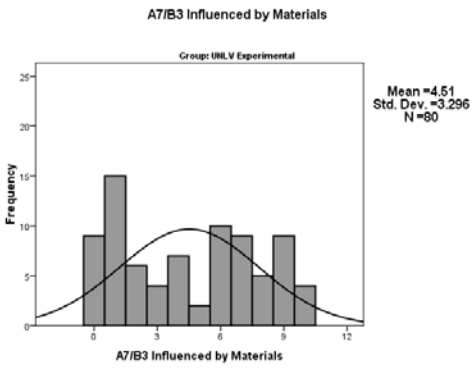
Two additional questions were asked to examine whether participants felt they had learned anything new or whether they had changed their views about the issue. There was no significant difference between the two groups' responses for either question.

The group facilitated with the system dynamics method was more focused on the presented materials than the group facilitated with standard methods. These results are important because the more a group of lay stakeholders are focused on relevant information, the less likely they will be to go off on tangents that will distract participants' attention away from the core issues. By focusing on the relevant information, it is also more likely that the participants will be able to improve their general level of understanding of the issues, be better able to improve incomplete or incorrect mental models. By keeping a group of diverse participants focused on a common set of relevant facts, it also helps the facilitator to be able to productively address and resolve any conflicts that may exist among participants. Finally, the more focused participants are on relevant information on the causes and effects of the problem, the better they will be at making more fully-informed decisions on the best solutions to the problem. Figure 3 illustrates the difference in level of focus between groups.

Figure 3.

Measure of Focus: The experimental group had a significantly higher mean score ($p = 0.005$) than the control group on the coding for the influence of the presented materials on participants' suggestions for the best things LA could do to achieve zero waste.

Influenced by Materials (Post-intervention Only) Control Group

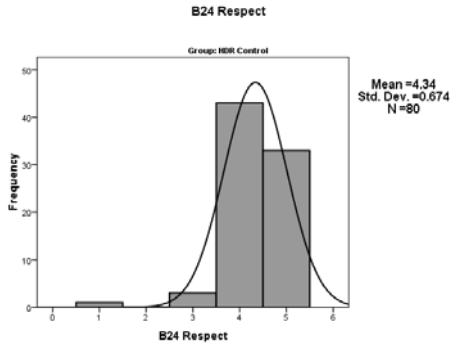
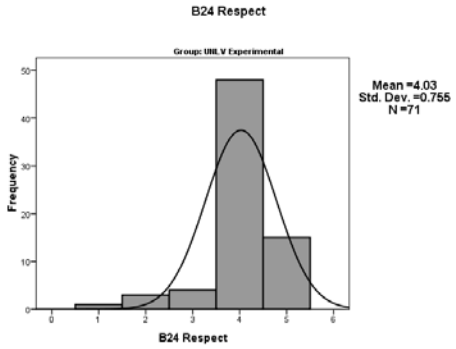
Control Group Mean: 3.04	Experimental Group Mean: 4.51
	

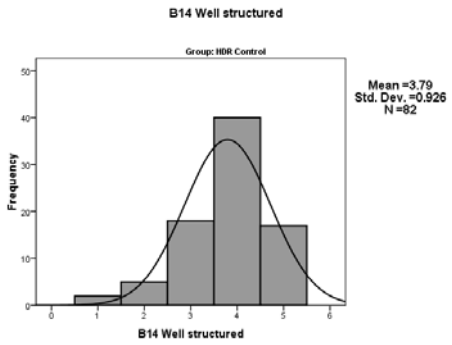
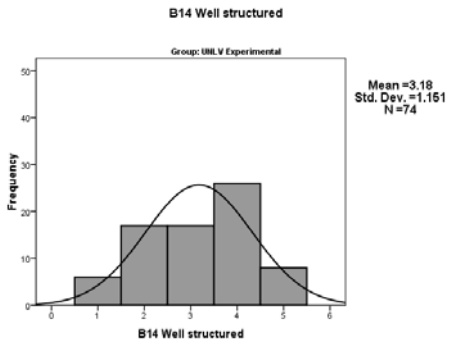
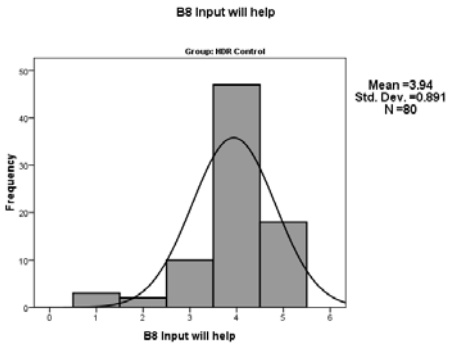
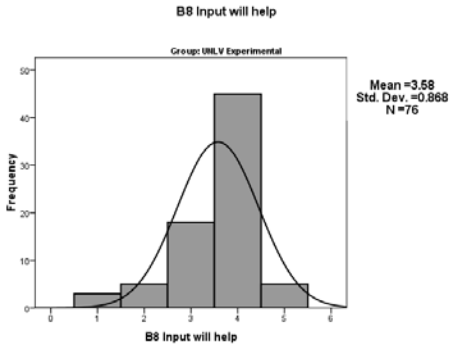
Discussion of Results Related to Hypothesis 3: Greater Procedural Satisfaction

The responses to questions measuring the level of procedural satisfaction of participants showed that the group facilitated with standard methods had a higher level of procedural satisfaction than participants in the system dynamics group. That is, participants in the traditionally facilitated group were more satisfied with the overall experience than were the participants of the system dynamics group.

The questions designed to test procedural satisfaction were divided into three areas. The first measured satisfaction with interpersonal dynamics, the second set of questions measured satisfaction with process, and the final set measured the level of support for the outcome and the zero waste initiative. In each of these areas a significant difference was observed, and in each case of significance the control group had a higher mean score than the experimental group. Figure 4 provides a sampling of the findings related to procedural satisfaction.

Figure 4.

<table>
<tr><td colspan="2">Measure of Interpersonal Dynamics: The control group had a significantly higher mean score than the experimental group (p = 0.022) relating to their satisfaction with others respecting their views during the session.</td></tr>
<tr><td>Control Group Mean: 4.34</td><td>Experimental Group Mean: 4.03</td></tr>
<tr><td> 
</td><td> 
</td></tr>
</table>

<table>
<tr><td colspan="2">Measure of Process: The control group had a significantly higher mean score than the experimental group (p = 0.001) relating to their satisfaction that the discussion was well structured during the work session.</td></tr>
<tr><td>Control Group Mean: 3.79
 
</td><td>Experimental Group Mean: 3.18
 
</td></tr>
<tr><td colspan="2">Measure of Support for Outcome: The control group had a significantly higher mean score than the experimental group (p = 0.003) relating to their satisfaction that their input will help LA in its planning efforts to achieve zero waste.</td></tr>
<tr><td>Control Group Mean: 3.94
 
</td><td>Experimental Group Mean: 3.58
 
</td></tr>
</table>

While system dynamics-based facilitation can sometimes cause participants to feel discouraged if their intuitions are proven wrong, in our experience, we have seen participants feel empowered by the new knowledge they experience in the inherent "ah ha" moments system dynamics modeling tends to promote. As such, we were surprised to find that the experimental group did not have a significantly higher mean score than the control group in response to the questions designed to measure procedural satisfaction. We also thought that because the experimental groups' performance was

better, that they would feel a higher level of satisfaction related to a stronger sense of accomplishment. Instead, the findings indicate that the experimental group had a lower level of satisfaction.

It is possible that the lower level of satisfaction among experimental group participants was in fact, related to the discouragement in learning their intuitions were incorrect. It is also possible that the time constraints related to the 90-minute work session prevented participants from fully understanding and trusting the model, and limited the participants' ability to discuss and challenge the output. This lack of sufficient processing time could have left participants unsure of or uneasy with the results of the modeling process.

From another perspective, the control groups' higher satisfaction level could be due to the fact that the standard facilitation processes tend to promote creativity and work to positively reinforce and/or avoid correcting participants' intuition. Such standard techniques stress the basic rule of brainstorming that "no idea is a bad idea" and thus tend to frown on negative evaluation of participant comments. This focus on creating an environment of positive reinforcement, and avoidance of evaluation/ correction of comments, could have contributed to the control groups' higher level of satisfaction with the process. In addition, the fact that the control groups' facilitators used a SWOT analysis, a process familiar to most participants, instead of having to train the participants in a more complex, and unfamiliar facilitation process such as system dynamics modeling, could have also contributed to the control groups higher level of procedural satisfaction.

While the differences in satisfaction level among groups is interesting, perhaps the more interesting finding is that there was an inverse relationship between satisfaction and performance. The experimental group had a higher level of performance in identifying better solutions for the problem at hand, yet they had lower level of self confidence and satisfaction. The control group had a lower level of performance in identifying better solutions, yet they had a higher level self confidence and satisfaction. These findings provide an important caution for both standard and system dynamics-based group facilitators. If the process produces good solutions but does not yield sufficient support and satisfaction, the results will be difficult to implement. Conversely, if the process does not produce good solutions, but does yield sufficient support and satisfaction, the results may be easy to implement but they will likely fail to sufficiently solve the problem or may even make things worse. If the goal of such efforts is to identify and implement effective solutions, standard and system dynamics-based facilitators should strive to promote a rational decision analysis for finding the most effective solutions, while also attending to issues associated with participants' procedural satisfaction with the process and outcome.

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