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SIMULATION GAMING APPLIED TO CONTROVERSIAL FACILITY PLANNING: EXPERIMENTAL RESULTS

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ABSTRACT

The article relates the experimental results of the use of a computer simulation as a gaming tool for resolving interest group conflicts over alternative airport plans. The experiments involve students, professional planners, and citizens. The simulation itself uses an interactive mode at meetings with experimental groups.

The major portion of the article identifies human factors affected by the involvement of participants in the use of the simulation versus involvement in a public hearing format (with no simulation model present). Results show a difference in the understanding of underlying issues, confidence in technical information presented, and perception of acceptable plan solution.

The design and use of simulation games in the field of education has been widely accepted in spite of the scarcity of scientifically conducted comparisons with other learning techniques. Those dealing with urban development issues enjoy special favor as teaching aids. The interaction of complex social and economic relationships provides great fascination for model builders, teachers, and game players alike. The basis of the appeal of urban development games is in some part due to a general familiarity with role characterizations and development issues typically confronted.

It is a natural extension of the belief in the educational value of urban simulations that they should also be able to serve as a vehicle for demonstrating to citizens the decision trade-offs for alternative solutions to an urban problem [1, 2]. It is further theorized that the

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gaming aspect of simulations can cause players to systematically reconsider their attitudes toward various social processes and values [3]. Thus the game is a possible instrument of reducing conflict between opposing roles. Experimentation in the field of political science has supported this theory [4], and even suggested that the game does not need to be related to the crisis at hand for the cooperative spirit to emerge [5].

Three questions serve as the focus of this article with respect to the potential usefulness of simulation games as a citizen participation vehicle. First, is a man-machine interaction simulation more or less effective than group interaction alone in modifying role attitudes, values, and behavior? Secondly, does the game design affect the controversiality of the issue confronted as well as engender a cooperative spirit among participants? Finally, how is the educational value of a game related to cooperative spirit and issue controversiality?

In the research reported here the significance of the answers to these questions lie in their application to the problem of citizen opposition to the location and improvement of controversial public facilities, such as highways and airports. Such projects have increasingly had to face strong protest from affected groups causing implementation costs to go up, delays, concessions, vetos and other completion risks [6]. The use of a man-machine simulation as a communication medium with a non-technically oriented public has been suggested as a way to engender constructive participatory planning on controversial topics [7].

Such projects are highly technological by virtue of the forecasting method used to determine future public needs as well as the engineering design specifications. Public opposition to controversial facilities is rooted in the technological mystification inherent in the planning design process. Given the purpose of demystifying that process, it is logical to hypothesize that providing a computer-based evaluation simulation to citizen groups will affect their perceived capability of speaking on a technological plane [8].

This article reports on the findings of a series of man-machine simulation gaming sessions systematically compared with a gaming session that depends on personal interaction alone. The ideal subject group for this set of experiments would have been the actual parties engaged in the controversy being modeled. The political situation would not permit such a study design. As a result, special subject groups were brought together to participate in the experiments described here.

To overcome the lack of direct personal involvement motivation, orientation sessions were conducted on the specific controversy being studied. It should be noted, however, that the early stages of citizen involvement with controversial facility planning is characterized by an intensive questioning and information seeking, not unlike the orientation session conducted here. It is not until proposals are clearly formulated that citizens take a position [9]. At worst, the limitations of the experimental design indicate that the findings relate primarily to the early planning stages of an actual design process.

Airport Planning

The environmental and economic issues surrounding airport planning qualify it as a subject of intense local citizen interest. The traditional planning process, in the case of making airport plans, is to hold public hearings or other public informational meetings at which a package of improvement proposals under consideration are presented and discussed. The "discussion" aspect of the hearing format is considered by the Federal Aviation Administration to be the forum in which citizens can lodge protest against or support for part or all of the proposals presented [10]. Case study investigations of airport planning in practice reveal a high degree of frustration on the part of interest groups expecting to gain an understanding of the impacts involved and/or to influence final decisions made [9, p. 46].

Against a backdrop of increasing population growth in metropolitan areas and the expanding volume of air traffic and related activity an environmental planning problem is waged: How to meet the higher level of air transport demand while at the same time respecting the potential noise disturbance and other pollution factors imposed on surrounding neighborhoods? To meet the expanding air transport demand as well as maintain and modernize existing public airport facilities the FAA makes funds available to public airport authorities across the country. The amount of monies earmarked for these improvements is substantial, some $750 million annually, through the Airport and Airway Development Act of 1970. This figure greatly understates the total annual capital investment in U. S. airport development since it does not take into account FAA administrative costs, local airport tax subsidies, and direct state and local contributions as well as militarily financed improvements.

Part of the planning process for airports requires localities — large and small — to prepare airport master plans describing the anticipated improvements needed for five, ten, or twenty years into the future. It is on the basis of these plans that specific improvements, expansion or modernization are eventually implemented, usually by a combination of financing sources. Airport master plans, by FAA definition, describe the airports' "ultimate development" in relation to surrounding land uses in the immediate environs of the airport property. "The overall objective of the airport master plan is to provide guidelines for future development which will satisfy aviation demand and be compatible with the environment, community development, and other modes of transportation." [11]

It remains to be seen how successful the master planning process is in achieving the objectives stated in FAA guidelines. Indications are that the process breaks down because it occurs in isolation from the community base which has the greatest stake in the environmental impacts which are likely to occur. "Only limited opportunity in formal hearings has been provided for community input in the Airport Master Plans of the past." [12] Such statements indicate the importance of researching citizen involvement techniques that will provide the opportunity for meaningful social and environmental review.

Experimental Design

A computer-based simulation model had been developed by the author in an effort to forecast various impacts of alternative airport facility improvements and operational changes. The model itself was derived from the analysis of air traffic and facility data from thirty public airports in upper New York State. The results of the forecast model proved to have a high measure of reliability that could be applied to any particular social/environmental situation at one of the New York airports. A selection of an airport undergoing master plan consideration was selected for application. These circumstances permitted the conduct of an experiment comparing the benefits of citizen involvement using the computer model as a part of the participatory planning process with a control group engaged in a traditional public hearing format.

An experimental testing procedure was designed to accomplish the comparison. It involved the random selection of a control and treatment group to participate in the two planning processes. The "control group" was brought together to be engaged in a public hearing about the airport plan. (The plan presented in the hearing format consisted of the actual airport master plan done for Schenectady County Airport, New York, 1970.) The "treatment" group was engaged in the conduct of the simulation as well as in a role playing exercise using the computer model described above. The test sessions were conducted with college students, interested citizens and professional planners. In each case the participants assumed randomly assigned role identities of "real world" interest groups as drawn from case study research on the events and personalities emerging from airport planning controversies observed.

A set of evaluation criteria was set down before conducting the sessions as a basis for comparing the two involvement approaches. They were as follows:

Understanding of Relevant Issues

1. Perception of the effect of various actions toward offsetting county operating losses.

Confidence in Technical Information Presented

2. Perception as to the objectivity of answers to technical questions raised.
3. Perception as to the attention given to all technical questions raised.
4. Perception as to the adequate substantiation of assumptions made in answering technical questions.

Acceptability of Specific Relevant Proposals

5. The rating of facility improvements, operational changes and land use modifications to the surrounding neighborhoods.

Design Structure

The total experiment consisted of four 3-part meetings and involved between ten and forty-six participants each, not including special observers or the moderator. The first session took place at Rensselaer Polytechnic Institute, Troy, New York, where forty-six engineering students were presented a one-hour orientation slide conference which included general information on airport planning issues and the specific information about the situation at the modeled airport. At the conclusion of the orientation meeting a "before treatment" questionnaire was administered. Upon completion of questionnaires the audience was randomly subdivided into two equal halves to form the actual experimental groups. Each of the two subdivided groups were scheduled separately to take part in a subsequent meeting and told that the second session would demonstrate the airport planning process in detail, and that they would be given the opportunity of evaluating that process.

The control group meeting was comprised of thirty students, twenty-three selected randomly as described above, plus seven others who could not attend the treatment session at the time arranged. Participants were randomly assigned the following interest group roles:

- (1) local pilots' association representative;
- (1) elected county representative;
- (1) business/industrial community representative;
- (1) fixed base operator representative; and
- (26) residents from neighborhoods surrounding the airport.

Fact sheets were provided to each interest group relating to statistics and general information of special concern to each respective role. The fact sheets were designed to be utilized by each participant to ask questions about the proposed airport plan as presented by the moderator. The moderator, in turn, assumed the role of the airport planning consultant in a step-by-step review of the contents of the proposed airport plan.

The public hearing was run as close as possible to the format of a real public hearing. A series of thirty view graphs were used for visual display of pertinent graphics and engineering drawings; the language of the actual layout plan narrative was used as much as possible by the moderator. In the case of the neighborhood resident roles the fact sheets consisted of the recorded testimony which took place at the actual public hearings conducted on the *Schenectady County Airport Layout Plan.* At the conclusion of the hearing demonstration a follow-up questionnaire was distributed to record the reactions and value perceptions of what had taken place.

The treatment group meeting was comprised of the balance of the original forty-six students not attending the public hearing demonstration, sixteen in all. Treatment group participants were randomly assigned the same roles as the control group with twelve neighborhood residents. The same fact sheets were distributed to each individual according to the designated role. In addition each participant was given a player's manual pertaining to the rules and limitations of the simulation model at their disposal. The moderator once again identified himself as the airport planning consultant and proceeded to direct the simulation demonstration for as many five-year cycles as could be covered in two and a half hours. Full documentation of the internal mathematical relationships and modeling assumptions was available for participants to consult any time during the demonstration. Upon completion of the treatment group exercise the same follow-up questionnaire as used for the control group was distributed to all present.

Two additional simulation demonstrations were conducted under separate arrangements with specially drawn audiences. One audience group consisted of citizens, environmentalists and other interested parties upon mailed invitation and newspaper notice. The final audience group consisted of professional planners also drawn by mailed invitation. In both cases the special audience groups participated in the very same simulation demonstration sequence as the student treatment group. In each case, identical questionnaires were administered after the initial orientation and again at the conclusion of the simulation demonstration itself.

The primary means of experimental evaluation is based on the responses to the "before and after" questionnaires as mentioned above. In addition, two qualified individuals attended the entire sequence of meetings, including orientation, hearing demonstration, and simulation model demonstration. These individuals were given instructions to record events and make comments during the conduct of each meeting and to answer a series of post-evaluation questions according to their personal observations, comparing the relative merits of the two planning processes as demonstrated.

Educational Value

One of the most important expectations of citizen groups in participating in public hearings on airport plans is "understanding the impact of alternative plans." Actual public hearings observed in case studies were found not to adequately contribute to the understanding of impact questions, according to the participants contacted [9, p. 46]. The hypothesis tested here is that the treatment group had a better understanding of the issues than the control group (Criteria 1).

Educational value of the involvement process can be evaluated to some extent by a comparison of perception of technical information adequacy (Criteria 2, 3, and 4). The concept of understanding has another dimension which can only be measured by participants demonstrating their knowledge of the subject at hand. This is accomplished in conventional academic settings by means of factual and/or essay examinations. A similar approach was incorporated into the "before and after" questionnaire design in these experiments. A series of ten factual questions were asked during the orientation phase of each of the experimental sessions; the same ten questions were included in the post experiment questionnaire.

The questions used for this portion of the evaluation pertained to the two primary areas of impact concern, economics and noise. Five questions pertained to the effects of alternative actions on the operating expenses of the airport and five questions pertained to future airport noise impacts. The rationale was to compare the per cent of questions answered correctly before exposure to the hearing or simulation model with the per cent answered correctly after exposure. Table 1 presents these percentages for each question by experimental group. In this analysis a question is considered incorrect if the participant answers "unable to answer," a wrong answer is chosen, or it is left blank.

In four instances out of thirty in the control group, fewer persons answered a question correctly after the hearing than before it. Among the treatment groups this phenomenon occurred only once. In all other cases understanding was increased or stayed the same for both control and treatment groups. The control group showed the least net change in total questions answered correctly before and after exposure. While the citizen treatment group shows only a slightly better total net change in the average number of correctly answered questions, the before treatment understanding is 10 per cent

Table 1. Level of Understanding Evaluation

	Experimental Groups[a] *% Correct Before / % Correct After*			
Question	*HRG*	*STU*	*CIT*	*PRO*
1	66.7/63.3	43.8/81.3	70.0/ 90.0	40.0/70.0
2	40.0/63.3	6.3/87.5	70.0/ 80.0	60.0/90.0
3	80.0/63.3	62.5/93.8	60.0/ 80.0	70.0/90.0
4	16.7/36.7	18.8/56.3	30.0/ 40.0	40.0/65.0
5	70.0/76.7	62.5/87.5	70.0/ 70.0	65.0/70.0
6	80.0/96.7	81.3/93.8	90.0/100.0	95.0/95.0
7	16.7/60.0	12.5/50.0	50.0/ 60.0	50.0/85.0
8	56.7/76.7	87.5/75.0	60.0/ 80.0	45.0/70.0
9	10.0/ 6.7	12.5/12.5	20.0/ 40.0	15.0/45.0
10	50.0/46.7	56.3/75.0	70.0/ 70.0	65.0/80.0
Total	48.7/60.0	44.4/71.3	59.0/ 71.0	54.4/76.0
Avg. % Change				
Within Groups	11.3	26.9	12.0	21.5
Across Groups	9.3	20.6	20.3	25.3

[a] (HRG) is the hearing control group, sample = 30.
(STU) is the student treatment group, sample = 16.
(CIT) is the citizen treatment group, sample = 10.
(PRO) is the professional treatment group, sample = 20.
(NHRG) is the combined treatment groups, sample = 46.

greater than the control group. In fact, the citizens exhibited the highest level of pretreatment understanding of any of the groups tested. The difficulty of achieving successively higher levels of total correct answers appears to be a limiting factor in the case of the citizen treatment group. For this reason a cross-comparison with the combined groups' per cent of correct answers before exposure is a fairer means of comparison.

On the basis of cross-comparisons, Table 1 shows that the total expected increase in the number of correct answers before and after the hearing session is 9.3 per cent. In contrast, the treatment groups show a net increase in correct answers of 20.6, 20.3 and 25.3 per cent for the student, citizen and professional groups respectively. On the basis of this comparison, the expected net increase in correct answers for simulation model exposure is more than twice that for the public hearing. A test of significance across groups of different sample sizes yields a level of significance less than .05.

Technical Information Adequacy

The post-experiment questionnaire attempted to measure the relative confidence of participants in the adequacy of technical information presented. Three separate criteria were used, as already indicated: objectivity, comprehensiveness, and substantiation. The confidence ranges of scores for control and treatment groups are presented in Table 2 for each of the information adequacy factors, the null hypothesis being that treatment group mean scores equal control group mean scores.

The 90 per cent confidence intervals for each factor provide a basis for rejecting the null hypothesis for the citizen and professional treatment groups, but not for the student treatment group. This disparity can only be explained by an apparent bias on the part of the students tested as being more skeptical of technical information in general. The students used in the experiment were primarily junior and senior engineering majors, presumably well acquainted with technical problem solving and quantitative design specifications. That background is a probable explanation for the bias noted above, especially in light of the fact that the highest mean scores consistently came from the citizen treatment group which one would expect to be the least technically oriented.

The problem with technical bias on the part of the students used in this series of experiments effectively negates any conclusion that might otherwise have been able to be made as to the advantage of a simulation model session over a public hearing on the basis of

Table 2. Technical Information Adequacy Confidence Intervals

Groups	*Means*	*Standard Deviations*	*90% Interval Range*[a]
Objectivity			
(HRG)	46.667	19.268	40.697 – 52.637
(STU)	48.750	17.935	40.921 – 56.579
(CIT)	62.000	15.494	53.122 – 70.878
(PRO)	60.000	17.244	53.348 – 66.652
(NHRG)	56.522	17.118	52.282 – 60.762
Comprehensiveness			
(HRG)	33.500	18.761	27.687 – 39.313
(STU)	35.625	17.877	27.822 – 43.428
(CIT)	56.000	15.055	47.373 – 64.627
(PRO)	45.750	16.958	39.209 – 52.291
(NHRG)	44.456	16.854	40.281 – 48.631
Substantiation			
(HRG)	40.167	15.838	35.260 – 45.074
(STU)	43.437	22.265	33.718 – 53.156
(CIT)	58.500	23.576	44.990 – 72.010
(PRO)	57.250	21.733	48.867 – 65.633
(NHRG)	52.717	22.319	47.188 – 58.246

[a] Students' t Distribution.

perceived technical information adequacy. It must be concluded that the bias which caused the student treatment group to score its session low on technical information objectivity, comprehensiveness and substantiation also caused the students in the control group to do the same. Therefore, the population of the experimental groups significantly influenced the mean scores, to the point of obscuring the treatment cause. It is some consolation, however, that population composition alone does not explain the difference between treatment group scores. Only in one instance (under "technical comprehensiveness") is there a case where two treatment groups are outside the 90 per cent confidence interval of each other. It should also be noted that control group mean scores are lower than student treatment group mean scores for each factor analyzed. Finally, the citizen treatment group's high mean scores are an indication of the simulation model's effectiveness with that group in particular.

Acceptability of Specific Proposals

A variety of specific planning proposals were presented in both the public hearing and the simulation modeling groups. Each test group had as one of its objectives the enlightenment of participants as to the impacts of actions under consideration. Questions were asked at the conclusion of each session regarding the acceptability of ten such actions. In analyzing the results of these ten questions two points of view are taken. The most obvious point of interest is the relative acceptability scores for each action. In addition, the wording of the question provides for a neutral response, i.e., an answer which neither strongly favors nor opposes the action proposed. Therefore, it is possible to look at the audience ambivalence for control and treatment groups as well as relative acceptability.

Considering the concept of audience apathy or ambivalence, the control group had the lowest absolute mean value score in five out of ten instances, i.e., showing the most ambivalent attitude more times than any of the treatment groups. This finding is worth noting considering the "before treatment" mental set of various participant groups. That is, initial interest in coming to the demonstration sessions in the first place may be assumed to be the result of intellectual curiousity rather than personal crisis, as it would be when a "real life" airport plan is being faced.

Greater ambivalence toward proposed actions for the control group may be attributed to one of three factors:

1. a compromising attitude promoted by participation in the hearing demonstration;
2. a lack of clarity on the nature and extent of impacts associated with each action; or
3. a general lack of stimulation on the part of the hearing format to inspire thought and opinion formulation.

Judging from the comments of the observers present during the hearing demonstration, the latter two factors are the principal cause for the ambivalent control group responses. In the record of the hearing session, observers commented:

> Participants appear bewildered, asking questions aimlessly and on various topics. Many participants are conversing among themselves and doing other things . . . segments of the audience are not attentive to the speaker although a few are very interested.

A second observer contrasted the two planning process experiments by saying:

> The simulation model exercise allowed participants to become actively

Table 3. Planning Process Satisfaction Confidence Intervals

Groups	Means	Standard Deviations	95% Interval Range[a]
(HRG)	22.00	17.15	15.61 – 28.39
(STU)	37.81	17.32	28.63 – 46.99
(CIT)	50.00	26.67	31.21 – 68.79
(PRO)	49.50	20.64	39.87 – 59.13
(NHRG)	48.26	20.12	42.28 – 54.24

[a] Students' t Distribution.

involved in the planning process, acting out their respective roles according to their perspectives and interests. In contrast, the public hearing demonstration reduced the participants' role to primarily observing a technical dissertation in defense of a proposed package.

Considering the actions rated negative by both the control and treatment groups, only the most obvious "high impact" alternatives were perceived as such in the hearing session; for example, "instituting new airline service" was judged unacceptable by all participants. In the case of land use alternatives and operational changes, such as establishing a system of runway priority approaches, the simulation group was better able to foresee the environmental and economic effects. The recognition of impacts appears to be further related to the particular treatment session conducted. Thus, if one group instituted zoning changes in one of the flight paths, the mean acceptability score for zoning would deviate significantly from another gaming session where that action had not been taken. In nine out of ten questions the gaming session participants rated actions more severely than the hearing group.

Other Factors Affecting Participant Reactions

Confidence intervals were constructed for determining relative differences for mean satisfaction scores. The result of this comparison indicates that in each case the treatment group's perception of the fairness and completeness with which all points of view were considered was higher than for the control group. Table 3 lists the statistical details of this conclusion. It should be noted that in all cases the 95 per cent confidence range of the control group was completely outside that of each treatment group range. Furthermore, no such distinction is found between treatment groups which indicates that the three samples may be considered to be drawn from the same population for this particular question.

Table 4. Acceptability of Proposed Plan

Groups	*Yes*	*No*
(HRG)	7	23
(STU)	8	8
(CIT)	4	6
(PRO)	9	11
(NHRG)	21	25

Groups	*Probability of "No"*	*Standard Deviations*	*95% Interval Range*[a]
(HRG)	0.767	0.0719	0.740 – 0.794
(STU)	0.500	0.1250	0.434 – 0.566
(CIT)	0.600	0.1549	0.491 – 0.709
(PRO)	0.550	0.1117	0.498 – 0.602
(NHRG)	0.543	0.0735	0.521 – 0.565

[a] Students' t Distribution.

The final question in the post experiment questionnaire called for a "yes" or "no" judgement on the part of participants as to the acceptability of a specific airport plan. That plan included the total package of improvements contained in the 1970 *Schenectady County Airport Layout Plan.*

Acceptability responses are listed in Table 4 for each experimental group. Also shown is the result of a hypothesis test for determining the treatment effects in influencing a "no" vote. This analysis rejects the null hypothesis that the difference in "no" vote responses for treatment groups versus the control group is due to random occurrence. It is therefore concluded that the simulation model treatment influenced participants to view the same set of proposed airport improvements more favorably than would otherwise be the case, i.e., as the result of a public hearing only. This conclusion bears significantly on the value of the simulation model as an approach to involving citizens in the airport planning process.

Conclusion

On the basis of this experiment the value of simulation gaming as a participation technique is affirmed: citizen satisfaction is higher for participating in a simulation gaming model than in a public hearing. The importance of this conclusion is apparent from what is implied in the practical advantages of the simulation approach:

1. better plans, for having considered the sociological dimension of plan evaluation;
2. greater likelihood of plan implementation, for having involved affected parties in the decision process; and
3. continuity of design solution, for building decisions on prior levels of understanding rather than the political exigencies of the time.

Hopefully, this work will contribute to the eventual realization of an improved planning process that considers the perceived values of all affected parties, allowing them to compare for themselves alternative actions on the basis of the best technical information available.

With the advantages noted above, the simulation model involvement technique bears considering as an alternative to the public hearing. One observer pointed out that an additional orientation meeting prior to working with the computer model would be a further help. That advice appears well considered since it could provide an opportunity to present the technical basis of the model construction to prospective participants. As conducted, confidence in technical information underlying predicted impacts and projections was no greater for the treatment group than for the control group. It is further believed that more than one meeting experience using the model would also increase the effectiveness of this approach. The computer model is designed for individual manipulation of inputs. Although no tests were performed on this model, it is logical to hypothesize that the greater anxiety of some individuals may be satisfied by repeated experiences with the model.

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