

# Developments in Business Simulation & Experiential Learning, Volume 11, 1984

## A STUDY OF COMPARATIVE EFFECTIVENESS OF PROBLEM-SOLVING TECHNOLOGIES

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### ABSTRACT

Increased complexity of modern organizations and rapid changes in economic, social and political environments have created conditions for which the concepts of decision making and problem-solving become critical. With the increased level of openness, business and administrative organizations have grown in size and complexity. These developments have led to the creation of more complex forms of organization necessitating the need for effective problem-solving technologies. This paper describes an empirical investigation into the comparative effectiveness of four problem-solving technologies: Dialectical Problem-Solving Technology (DPST), Devil's Advocate Problem-Solving Technology, Nominal Group Technique (NGT), and Modified Delphi (Delphi).

### INTRODUCTION

In a recently published article entitled "Is Problem-Solving America's Lost Art?", Malcolm W. Brown wrote:

Are we Americans becoming a nation of ignoramuses, and if so, is there anything we can do about it? Scientists, teachers and America's managers are complaining that on the whole our people no longer seem to solve problems very well. The complaints cite precipitous declines in school and college test scores, the statistical increase in functional illiteracy and the growing difficulty of filling jobs requiring problem-solving abilities. . . if the slide continues our country could eventually find itself a member of the deprived 'Third World' without engineers or the other problem-solvers who created American civilization (2).

This citation epitomizes the realization of the critical need for new ways and techniques of problem-solving in the increasingly changing environment of modern business and government. For a long time attempts were made to improve the quality of decision-making by developing new techniques and formats of problem-solving. A substantial body of literature and research on these problem-solving technologies, such as brainstorming, Nominal Group Technique and Delphi, has been generated in the last 20 years (1, 4, 17, 18, 23, 26, 32, 42, 44). Examination of the traditional problem-solving technologies indicates that the majority of these technologies reflect the "consensus" or "harmony" period in the development of organizational theory. Only recently a few problem-solving technologies have made explicit use of the conflict concept in their constructs (6, 7, 20, 28, 30).

Some researchers recognized conflict as a dialectical and natural phenomenon, which is derived from Hegelian and dialectical materialism (7, 9, 10, 11, 28, 29). These researchers utilized the dialectical concept of conflict as an integral part of a number of models designed to facilitate problem-solving in strategic

planning and policy formulation. The concept of conflict is not only accepted as inevitable, necessary and even desirable under specific organizational and environmental conditions but also it is assumed that moderate levels of conflict can facilitate individual performance and ability to adjust to uncertainties of the changing environment. In contrast to existing planning methodologies, where conflict is regarded as destructive and unproductive, these dialectical planning models are built on explicit recognition of the positive role of systematic or controlled conflict, with continuous commitment of an organization's opposing parties to their positions.

The theoretical claims about the advantages in strategic decision-making of using such dialectical planning models such as Dialectical Inquiry Problem-Solving Technology (DIPST), Strategic Assumption Making Methodology (SANM), Assumption Making Methodology (AMK), and Strategic Assumption Surfacing and Testing has been supported by a number of uncontrolled field studies, undertaken by Mitroff, Mason and their associates (21, 27, 28, 29, 30, 33, 35). However, these studies were conducted without controlled samples, no statistical data were reported and the researchers stated that subjective opinions of participants and/or researchers were utilized as measures of success of dialectical models in the studies.

Cosier and his associates, though supporting the positive view of conflict, have questioned the validity of the dialectical approach, and strongly criticized the methodology, results and claims made by Mitroff and his colleagues. A number of controlled laboratory studies were conducted by Cosier and his colleagues to show that dialectical inquiry models are inferior or, at best no more effective than the DA or the traditional 'Planning Expert' approach (10, 12, 13, 14, 15, 37, 38, 39). The findings of these studies suggest that the Devil's Advocate Approach is better suited to strategic planning and policy formulation. Contrary to the findings of Cosier and his colleagues, Chanin (7) and Chanin and Shapiro (8, 9) found that DPST is a more effective planning tool as compared to DAPST.

Examination of studies on conflict-oriented problem-solving technologies have failed to provide us with conclusive evidence and support for specific problem-solving technologies. The major problems in this area stem from methodological problems and different interpretations and/or rationalization of dialectic. In addition, it is methodologically questionable to compare decision-making based on group conflict in studies by Mitroff and his colleagues with cognitive, individual conflict in studies by Cosier and his associates.

A similar situation exists in the research on non-conflict oriented problem-solving technologies. There is a considerable body of empirical research comparing brainstorming, interacting groups, pooled-individual groups, NGT and Delphi (3, 5, 9, 16, 17, 18, 22, 24, 34, 36, 40, 41, 42, 44). Our analysis of the existing research indicates that NGT tends to outperform interacting and Delphi problem-solving technology. However, the advantage of NGT is statistically significant in only a few studies.

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An extensive literature review revealed no comparative studies between conflict-oriented problem-solving technologies, such as DAPST or DPST, and non-conflict-oriented problem-solving technologies, such as NGT and Delphi.

Recently Chanin (6) found a strong and statistically significant difference between DPST technology groups and groups utilizing NGT technology. The DPST groups out-performed the NGT group on such performance variables as Industry Rank, ROI, Cost per Unit, Profit in Dollars, and Sales in Units. However, the limited scope and exploratory nature of this study did not allow broader generalizations. The absence of comparative studies dealing with a larger number of problem-solving technologies stimulated the present research.

## METHODOLOGY

### Subjects

The subject pool consisted of 94 senior undergraduate students enrolled in four sections of the business policy course at Baruch College of the City University of New York. A total of twenty four teams, representing individual firms, were assigned to four different problem-solving technologies: six teams to DPST, six teams to DAPST, six teams to NGT and six teams to Delphi. The composition of teams was heterogeneous and well-balanced in terms of the students' major in each team. The assignment of different problem-solving technologies to individual teams was made randomly.

### Research Design

The present study was conducted in the context of the Executive Game (25). The 24 experimental firms were divided into three independently operating industries. Each industry had eight teams (two of each problem solving technologies) competing in production and sale of a single medium-technology product. The performance of individual firms was evaluated by the firm's rank in the industry and selected economic indicators. The Executive Game is known as one of the first games and thus is rather simplistic compared with other more recently developed Business games. Nevertheless, it still offers a dynamic business case, whose outcome is determined by the group-dynamics and decisions made within the firm, competition with other teams in an industry, and prevailing economic factors affecting the industry market potential. Although the game's computer program is essentially deterministic, the game itself involves a high degree of uncertainty, which develops not only from imperfect predictions of economic factors and inability to foresee decisions made by competing teams, but also from the quite often erratic behavior of competing firms.

All teams were asked to develop a strategic plan with a time horizon of three years, medium-range plans with a time horizon of one year and to submit three annual and final reports. Operational decisions were made every quarter with 12 quarters (3 years) of simulated business activity. All experimental firms were allowed to revise their plans at the end of the first and second years.

To facilitate operations and the implementation of long-range policies in each firm a special organizational structure consisting of a president and three vice presidents was created. If desired, at the end of the first and second years, firms were allowed to

change their organizational structure (e.g., select a new president, reassign executive functions).

### Experimental Conditions

Four different treatments - problem-solving technologies were utilized in this study; DPST, DAPST, NGT and Delphi.

DPST was developed and applied along the theoretical framework of the Dialectical Materialism Inquiry System (7, 9). DPST, designed to facilitate the decision-making for strategic and operational planning, is a three- step decision-making process:

1. Development of individual (conflicting) plans
2. Structured debate
3. Synthesis - development of a final group plan

A detailed description of DPST is presented in Chanin (7) and in Chanin and Shapiro (8).

The operationalization of DAPST is similar to Mason's (28) interpretation of the Devil's Advocate Approach. DAPST involves a four-step problem-solving technology:

1. Development of strategic and operational plans by the planning group
2. Plan presentation at the management briefing session
3. Management critique of the plan, and
4. Development of a final plan

The NGT was developed and introduced by Van de Ven and Delbecq (42, 43, 44). NGT was operationalized as a six step problem-solving technology:

1. Individual generation of forecasts and decisions
2. Round-Robin recording of decisions
3. Serial discussion of decision variables
4. Preliminary vote
5. Final vote - if necessary
6. Team decision

A more extensive description of NGT steps is presented in Chanin (6).

The Delphi technique, developed at the Rand Corporation by Dalkey and his associates, is one of the most popular and well-researched problem-solving technologies (16). Though there are many variations in the process of administering the Delphi procedure, the basic approach involves two iterations of questionnaires and feedback report. Because of time constraints and logistic difficulties in the present operationalization of Delphi we have used only one iteration. The operationalization of Delphi involved a two stage decision-making process:

### Stage 1

- a. Development of individual strategic and operational plans
- b. Submission of the individual plans to the Game Administrator

### Stage 2

- a. Preparation of the feedback report by the Game Administrator
- b. Return of the feedback report, consisting basically of enumeration and a summary of different statements for qualitative plans and means and standard deviations for each quantitative decision variable

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DPST and DAPST can be classified as conflict-oriented problem-solving technologies, where conflict is stimulated through the workings of the problem-solving technology. NGT and Delphi are non-conflict oriented problem-solving technologies, where the very design minimizes the possibilities for conflict to occur. DPST, DAPST and NGT are interactive and Delphi is a non-interactive decision-making process.

### Independent and Dependent Variables

In the present study the independent variables are four problem-solving technologies: DPST, DAPST, NGT and Delphi. The independent variables are introduced into the research design by setting up differential starting positions-different problem-solving technologies for teams involved in the study. Compliance of the subjects with specific problem-solving technologies was constantly reinforced by regular observation of each team's decision-making process by outside observers and usage of a 12 point (1 point per decision) reward system.

Dependent variables utilized in this study were objective performance variables such as rank, ROI, profit, sales, etc. An additional dependent variable was the total score on business game tests.

### Hypothesis

- H1: DPST group will tend to outperform DPST, NGT and Delphi groups in economic performance.
- H2: DAPST groups will tend to have higher levels of performance as compared to NGT and Delphi groups. -:
- H3: NGT groups will have higher economic performance than Delphi groups.
- H4: Because application of DPST increases awareness and understanding of economic and planning problems and issues, the DPST subjects will outperform the remaining problem-solving technologies in scoring on business game tests (an indirect measure of performance).

### RESULTS

Hypothesis Hi stated that DPST will exhibit superior performance as compared to other problem-solving technologies. In order to identify which problem-solving technology has higher performance, we dichotomized all teams into high- and low-performance teams, using the Industry rank for each firm. Firms ranked as 1 to 4 were designated as high performance teams.

Table 1 presents the number of teams falling into each category after three years of simulated business operations.

Table 1  
High and Low Performance Teams  
According Industry Rank

Level of Performance	Problem-Solving Technology	Number of Teams
High	DPST	6
	DAPST	3
	NGT	2
	Delphi	1
Low	DPST	0
	DAPST	3
	NGT	4
	Delphi	5

From the results in Table 1 we may classify DPST as a high performance problem-solving technology and NGT and Delphi basically as low performance problem-solving technologies.

Distribution of teams into high and low levels of performance has a relative interest, but it does not indicate whether the differences in comparative effectiveness is statistically significant.

The superiority of DPST technology is also supported by information contained in Table 2. Examination of data in this table indicates that DPST firms have the highest rank, return on investment, net profit, and market share. DPST groups significantly outperformed DAPST on all five variables and also outperformed NGT and Delphi on three out of five variables. Thus, hypothesis Hi is overwhelmingly supported.

Table 2  
Comparison  
of Problem-Solving Technologies  
for Selected Performance Variables

Performance Variable	Means and Stand. Deviations				Comparative t-value and significance level					
	DPST	DAPST	NGT	Delphi	DPST vs DAPST	DPST vs NGT	DPST vs Delphi	DAPST vs NGT	DAPST vs Delphi	NGT vs Delphi
Rank	2.2 (2.3)	4.3 (2.1)	4.7 (2.2)	6.8 (1.2)	-2.16 (.028)	-2.41 (.018)	-6.46 (.000)	-1.27 (.395)	-2.58 (.013)	-2.16 (.028)
ROI (%)	16.13 (1.72)	13.76 (1.30)	13.63 (1.55)	9.37 (4.75)	2.70 (.011)	2.65 (0.12)	3.28 (.004)	0.15 (.441)	2.18 (.027)	2.09 (.031)
Net Profit (\$000)	363 (88)	240 (98)	218 (125)	83 (161)	2.29 (.078)	2.32 (.155)	6.37 (.224)	0.34 (.381)	3.33 (.206)	2.37 (.211)
Mkt. Share (%)	13.8 (.85)	12.7 (1.56)	13.2 (1.68)	10.7 (1.82)	1.56 (.074)	0.87 (.203)	3.79 (.002)	-0.50 (.314)	2.02 (.035)	2.42 (.018)
Sales	21332 (1687)	18662 (2348)	19532 (2336)	24085 (22176)	2.26 (.023)	1.53 (.078)	-0.30 (.384)	-0.64 (.297)	-0.60 (.287)	-0.50 (.314)

\*Rank 1 is the highest and Rank 8 is the lowest.

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Basically Hypothesis H2 should be rejected because we found no statistically significant difference between DAPST and NGT groups, though DAPST groups outperform Delphi on three out of five variables.

Hypothesis H3 is statistically supported by three out of five variables: rank, ROI and market share.

In Hypothesis H4 we stated that the very nature of DPST increases awareness and understanding of the problem through the structured debate and critical evaluation of various alternatives and underlying assumptions. Table 3 contains information on means, standard deviations, t-values and significance levels derived from business game tests.

Analysis of this table indicates that only students using DPST significantly outperformed their peers in remaining problem-solving technologies. We found no significant differences between DAPST, NGT and Delphi. Thus hypothesis 4 is supported.

Table 3  
Performance Means, Standard Deviations and  
t-value for Problem Solving Technologies

Prob.-Solv. Technologies	Mean	St. Deviation	t-value	Sig. Level
DPST Vs DAPST	<u>15.44</u> 13.07	<u>2.82</u> 4.37	2.23	.015
DPST Vs NGT	<u>15.44</u> 14.03	<u>2.82</u> 4.48	1.3	.099
DPST vs Delphi	<u>15.44</u> 14.14	<u>2.82</u> 3.24	1.45	.077
DAPST vs NGT	<u>13.07</u> 14.03	<u>4.37</u> 4.48	-.75	.228
DAPST vs Delphi	<u>13.07</u> 14.14	<u>4.37</u> 3.24	-.94	.177
NGT vs Delphi	<u>14.03</u> 14.14	<u>4.48</u> 3.24	-.10	.462

### DISCUSSIONS AND CONCLUSIONS

The findings of this study indicate a strong and statistically significant difference in comparative performance between DPST and the other three technologies: DAPST, NGT, and Delphi. We also may infer that teams using conflict-oriented problem-solving technologies generally perform better than those using non-conflict-oriented problem-solving technologies. However, though the results are not statistically significant, DAPST had slightly higher values in Ranking, ROI and Net Profit. The poor performance of Delphi teams may be explained by the absence of social interactive decision processes. In the absence of the ability to discuss possible alternative strategic or operational plans, the subjects in Delphi groups felt frustrated and angry with the decisions of their unknown teammates.

The subjects were asked to rank the 5 most important positive and the 5 most important negative aspects of the problem-solving technology they used. The responses were clustered into the 9 following factors: usefulness, social interaction, impact on planning and decision-making, independent thinking, conflict, time demand, analytical power, structure of technology, and feedback. The examination of the responses using these 9 factors indicated that positive responses exceeded negative responses by 1.6 to 1 for DPST, 1.1 to 1 for DAPST and 1.7 to 1 for NGT. In the case of the Delphi technique there were 2.6 negative responses for each positive response. Students utilizing the Delphi technique cited the following major shortcomings: absence of social interaction, negative impact on planning and decision-making, and poor feedback.

In a number of studies above, Cosier and his associates claimed that dialectical models may be inferior to alternative problem-solving technologies, especially the Devil's Advocate approach. Our research results are contrary to the findings of Cosier; DPST teams considerably outperformed DAPST teams. Nevertheless, we have to be careful making generalized and far-reaching conclusions. First, 'The Executive Game' may not be sufficiently complex to provide the necessary environment and conditions for strategic and operational decision-making. Second, the study is limited in scope and population size (six teams for each problem-solving technology).

One of the major conclusions that we arrived at in this study is that more extensive and diversified research is needed to establish comparative advantages or disadvantages of specific problem-solving process. In addition, conditions should be created to control for the impact of such variables as personality traits, individual beliefs, motives and needs, as well as group norms and roles, and leadership styles.

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