U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1618

Early Decisions and Concurrent Option Comparison in Problem Solving Groups

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U.S. Army Research Institute

May 1992

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

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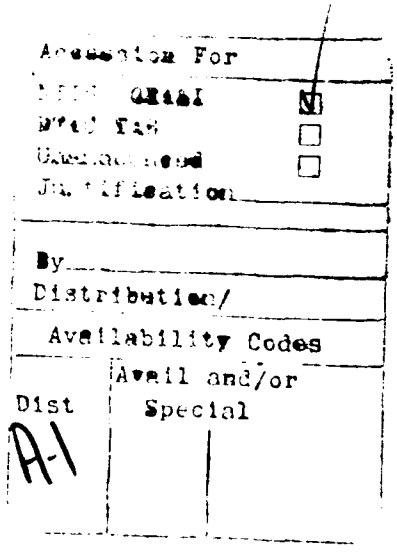

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	1992, May	Final Jul 89 - Jul 91

4. TITLE AND SUBTITLE
Early Decisions and Concurrent Option Comparison in Problem Solving Groups

5. FUNDING NUMBERS
62785A
791
1301
H01

6. AUTHOR(S)
Lussier, James W.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Institute for the Behavioral and Social Sciences
Fort Leavenworth Field Unit
Fort Leavenworth, KS 66027-0347

8. PERFORMING ORGANIZATION REPORT NUMBER
ARI Research Report 1618

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
--

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
--

11. SUPPLEMENTARY NOTES
--

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE
--

13. ABSTRACT *(Maximum 200 words)*

For this project, groups of Army captains were tested in a problem solving exercise called VARWARS. Normally in VARWARS exercises, groups use a naturalistic problem solving process characterized by sequential elaboration and development of possible solutions, rather than a concurrent comparison of options. In the first experiment, an attempt was made to induce some groups to use a concurrent option comparison method. It proved possible to increase the likelihood of groups using the method; however, this did not result in an improvement in solution quality. In the second experiment, groups were induced to use a different method, called Early Decision, in which the groups were compelled to select a single candidate solution much sooner than they normally would. The Early Decision process resulted in a significant and substantial improvement in the quality of solutions, compared with both naturalistic and concurrent comparison methods.

Situations that favor use of the Early Decision method are those involving "planning" problems in which the solutions are fairly detailed or complex plans of

(Continued)

14. SUBJECT TERMS
Problem solving
Command group training
Group decision making
Decision-making process
VARWARS
Group performance measurement

15. NUMBER OF PAGES
23

16. PRICE CODE
--

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

13. ABSTRACT (Continued)

action, as opposed to "decision-making" problems in which the options are easily specifiable. The Early Decision method should also be favored in situations where errors play a significant role in determining the outcome, such as when the planning and problem solving tasks are distributed among team members. When there is a desire to limit problem solving time and effort, then Early Decision may also be a good choice.

Research Report 1618

Early Decisions and Concurrent Option Comparison in Problem Solving Groups

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Department of the Army

May 1992

Army Project Number
2Q162785A791

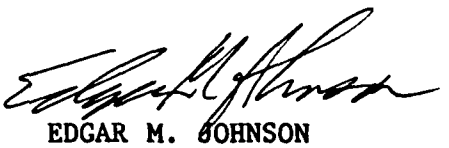
Manpower, Personnel, and Training

FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Leavenworth Field Unit, conducts a systems and training research program in support of the Combined Arms Center (CAC). The Field Unit has been involved for several years in research to assess and improve decision making in command groups. Studies have been conducted in the field, in the classroom, and in the laboratory.

The research described in this paper identifies a structured group problem solving process called "Early Decision." The Early Decision process is very important because, in some circumstances, it is greatly superior to the doctrinally prescribed concurrent comparison process. Military problem solving groups commonly find themselves in situations in which use of the Early Decision method will be beneficial.

This effort was performed with the support of the Combined Arms and Services Staff School.



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EARLY DECISIONS AND CONCURRENT OPTION COMPARISON IN PROBLEM SOLVING GROUPS

EXECUTIVE SUMMARY

Requirement:

Army doctrine prescribes that a concurrent option comparison method of decision making be used in both tactical and nontactical staff decision-making situations. Research is required to determine under what conditions this method should and should not be used and how and when it should be modified. The Combined Arms and Services Staff School (CAS^3) is responsible for teaching group problem solving. The school must determine what methods to recommend in various situations and also must devise good exercises for training methods of planning and problem solving. Previous U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) studies developed an exercise called VARWARS, which is used as a full-day exercise at CAS^3. These previous studies also showed that CAS^3 students tend not to use a concurrent option comparison method in VARWARS, even after being trained at CAS^3 to do so. Instead, they tend to use a "naturalistic" process characterized by successive elaboration of a single course of action.

Procedure:

In the context of the VARWARS portion of the CAS^3 course, problem solving groups were induced to use one of three methods: concurrent option comparison, the naturalistic process, and an "Early Decision" method characterized by striving to quickly select a candidate solution. Researchers wanted to discover whether groups could be induced to use the doctrinal concurrent comparison method in VARWARS and if its use would promote better solutions.

Findings:

Experiment 1 showed that the likelihood of using the concurrent method could be increased somewhat but that this did not improve solution quality. In Experiment 2 the Early Decision method was found to produce much better solutions than either the naturalistic or concurrent problem solving methods. Situations that may favor use of the Early Decision method are those involving "planning" problems in which the solutions are fairly detailed or complex plans of action, as opposed to "decision-making" problems in which the options are generally easily specifiable. Use of the Early Decision method should also be favored in situations where errors play a significant role in determining the outcome, such as when planning

and problem solving tasks are distributed among team members. When there is a desire to limit problem solving time and effort, then Early Decision may also be a good choice.

Utilization of Findings:

CAS^3 has modified its curriculum and now trains students to use the Early Decision procedure during the VARWARS exercise.

EARLY DECISIONS AND CONCURRENT OPTION COMPARISON IN PROBLEM SOLVING GROUPS

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EARLY DECISIONS AND CONCURRENT OPTION COMPARISON IN PROBLEM SOLVING GROUPS

Introduction

Group problem solving situations vary widely on a host of important characteristics, including time available for devising and evaluating options, expertise available in the group, how certain, well structured, and quantifiable problem elements are, and the social, motivational, and structural features of the group. Given the diversity of problem solving situations, it is obvious that no single group process can be recommended without regard to the characteristics of the situation. Instead, one needs to ask how should a particular problem solving process be tailored to fit the situation and when should one process be abandoned in favor of another.

Many theorists (e.g., Raiffa, 1968; Kenney, 1983; Fishburn, 1972) propose processes that can be classified as decision analytic methods. When using a decision analytic methodology, problem solvers list all possible courses of action, identify all possible outcomes for each course of action, assign probability and utility values to each outcome, calculate expected values for the courses of action, and select the option with the greatest expected value. The logic of the decision analytic methods is their greatest strength. If one can accurately follow the steps, the process can often guarantee an optimal solution. The two chief drawbacks are that the process may require too much time or effort, and that it may not be likely that the solvers will follow the steps accurately.

Problems involving the first of these drawbacks, lack of time, have been studied by Klein using firefighting commanders (Klein, Calderwood, & Clinton-Cirocco, 1988) and nurses monitoring very premature infants (Klein, 1990). In both cases, decisions must be made rapidly in situation that are becoming worse with the passage of time, i.e., the fire is growing or the infant's infection is spreading. Klein claims that, in such situations, people do not make even a hasty attempt to generate and compare options but instead adopt a sequential process, which he terms "recognition-primed decision making" (Klein & MacGregor, 1988). In this process, the problem solvers first attempt to "recognize" the situation as one that is familiar to them and that has a previously formulated solution. They may implement this solution immediately or, when time is not so critical, may mentally evaluate the applicability of the solution to the particular situation. If the candidate solution is judged to be "good enough," it is implemented. If not, the solution is modified until it achieves criterion for implementation or eventually is rejected. After rejection, a second solution is either recalled or devised and subjected to similar tests as the first.

Two aspects of the recognition-primed decision making process are particularly noteworthy. The first is the emphasis on recognizing situations and using known "stock" solutions rather than generating new options creatively. The second is the readiness of the solver to implement the first solution that meets some criterion rather than searching for better solutions. Both aspects are appropriate to time-pressured decisions in worsening situations. Also, Klein often studied domain experts who would have the knowledge required to recognize a variety of situation-action pairs and would also presumably have an intuitive feel for what outcomes are achievable in a situation, an ability that is important for establishing a good criterion for implementation.

A nine-week school for U.S. Army captains, the Combined Arms and Services Staff School (CAS^3), teaches a six-step problem solving method. The steps are identify the problem, gather information, list alternative courses of action (COAs), analyze the COAs, select the best COA, and implement the solution. Analysis of the COAs proceeds by developing criteria, weighting the criteria, evaluating each COA on each criterion, and

summing the weighted scores. Some criteria may be identified as screening criteria which eliminate the COA from consideration if it fails to pass on this measure. This six-step process, termed the concurrent option comparison method, is clearly in the decision analytic tradition.

At CAS^3, use of the six-step method is advised for virtually all problem situations. If time is short, fewer alternatives may be considered and the analysis becomes rougher, ignoring relatively unimportant criteria, scoring the COAs as simply +, 0, or - on each criterion, and dropping the weighting. The concurrent option comparison method is also doctrinally prescribed by the U.S. Army for wartime situations at various planning echelons (US Army FM 101-5, 1984). Alternative tactical plans are devised and concurrently evaluated by staff members who are experts at various military specialties, e.g., logistics and artillery.

In a previous study (Lussier, Solick, and Keene, 1991, In preparation), CAS^3 students were tested in a 7-person, 3-hour problem solving exercise called VARWARS (Lussier, 1990). Groups of students entering the course, midway through the course, and near the end of the course were tested. It was found that none of the groups used the concurrent option comparison method on this problem, despite the fact that (except for the entrants), they had been trained to do so. Instead, all the groups adopted sequential processes, resembling the process described by Klein, in which a single solution was developed and modified incrementally. Unlike the situations studied by Klein, this was not a worsening situation in which an early decision was especially desirable, and the 3-hour time limit was sufficient so that use of the concurrent option comparison method was not precluded. Also, unlike many of Klein's studies, these students did not have any particular expertise in the VARWARS problem and so could not "prime" their decisions with recognition to any great extent.

The failure of the students to apply the concurrent option comparison method can probably be ascribed to the nature of the VARWARS problem. The VARWARS group, working with a fixed budget, must plan to buy some training devices, locate them around the country, hire operators and managers to run them, determine how to distribute the training among Army units, and allocate funds for maintaining the training devices. Thus, they must construct a workable plan that coordinates the various factors and does not waste too much of the budget. In VARWARS, construction of a candidate solution requires considerable effort. When CAS^3 students are given an exercise that better fits the concurrent option comparison method, they show no hesitancy or difficulty in applying the method. One such problem is Al Khabari, in which they must recommend the purchase of one of six armored vehicles which differ in various specifications. In the Al Khabari problem, the alternatives are simple, easily specifiable, limited in number, and, in fact, are given as part of the problem, i.e., buy vehicle 1, buy vehicle 2, etc. VARWARS and similar tasks are more aptly described as planning problems. In planning problems, as well as math proofs, and social or moral problems, devising possible solutions is usually a major part of the problem solving effort. Problem solving in all of these cases involves primarily creative, or at least constructive, activity. Such problems can be contrasted with gaming and decision making situations such as Al Khabari, which have clearly and easily specifiable options and the primary activity is evaluative. Of course, many situations will involve both planning and decision making behaviors in various proportions.

In the above study (Lussier et al., 1991, In preparation), VARWARS exercises were run with groups at Day 0, Day 18, Day 30, and Day 40 of the course. It was found that the later in the course groups were tested, the poorer the solution produced, with groups of arriving students scoring the highest. Because group process did not seem to differ, it was unclear if the deficits were the results of trying to apply methods which did not fit the problem or if the losses were due to some form of progressive fatigue or to social, or motivational

factors. Although motivation appeared high for all groups, the tendency for groups to make major errors was greater for groups with more time in the course. It was also found that intact groups (composed of students from the same class section) scored substantially lower than mixed groups (composed of one student from each of seven different sections).

Since none of the groups used the concurrent option comparison process, it was not possible to tell if its use would have promoted better solutions. Further, even if some of the groups had used the process, interpretation of a correlation between use of the process and solution quality would have been unclear because the CAS^3 course urged use of the process. It could be argued that the more motivated and competent groups would both be more likely to use the process and to produce better solutions.

Experiment 1 in the present study attempts to control use of the concurrent option comparison method in the VARWARS problem to see if use of the process can improve solution quality. The answer seems to be no - its use may even reduce quality. Experiment 2 addresses whether there is a structured process which can improve solution quality above that shown in the processes which groups naturally evolve. The answer to that appears to be yes, an "Early Decision" process. Aspects of the VARWARS problem solving situation which tend to make the Early Decision process a good choice are discussed.

Experiment 1

Methods

Problem solving groups comprise 11 U.S. Army Captains, attending the 9-week Combined Arms and Services Staff School (CAS^3). In the course, the students are divided into 12 person sections and taught by a single Lieutenant Colonel instructor. Individuals remain in the same section throughout the 9-week course. The goals of the course are to improve the students' written, oral, and group communication skills and their problem solving abilities. The groups solve the VARWARS problem as part of the course curriculum, on Day 8 of the course. Prior to the Day 8 VARWARS exercise the students have received training and practice on the six-step (concurrent comparison) problem solving process.

VARWARS is a group planning and resource allocation exercise which is set in the context of acquiring, staffing and employing a new, hypothetical, training device. The VARWARS problem was developed such that:

1. The quality of the group solution is numerically scorable in an objective manner.

2. The subproblems exhibit considerable dependency, including sharing of a common pool of resources.

3. There is not a single correct answer, for example, as in a math problem. There are many good answers.

4. The presentation by the group of their solution is very simplified so that group score depends on the quality of the problem solving rather than the presentation of the solution.

5. All solutions are scorable, even "defective" solutions.

6. Problem elements are straightforward so that group success depends more on the ability of the group to share information, make decisions, integrate the subsolutions and otherwise function effectively than it does upon the creativity or insight of a single member.

For the VARWARS exercise, the instructor assigned group roles of a leader, 3 three-person teams (budget, training, and personnel) and a process monitor. Additionally, the 12th class member served as an observer but did not assist in solving the problem. The observer kept a log of group activity, paying particular attention to aspects of the six-step, problem-solving process, for example, COA generation, evaluation and selection. The instructor was told to first assign a "forceful student with a good understanding of the problem solving process" to the role of process monitor, and then to choose the most conscientious student to be the observer.

Although previous research with the VARWARs problem used a strict 3-hour time limit, the time limit for this experiment was extended to a loose, 5-hour limit. It was loose in that the instructors, at their discretion, might give groups that needed additional time up to an extra hour. Three hours is probably sufficient time to employ a process involving concurrent consideration of multiple COAs in the VARWARS problem. However, some instructors thought that the reason no groups did employ this process in previous experiments was that the groups abandoned the process because of a perceived time pressure rather than because of either an inability to perform the process or an irresistable preference for a sequential process.

Groups were randomly assigned to one of four conditions which differed only in the instructions given to the Process Monitor. The intent of the conditions was to produce varying amounts of "process-following" with respect to the six-step problem solving process. The conditions were:

1. No-Help. The process monitor received no instructions. If the groups behaved as in the previously observed 3-hour exercises, then few or no groups were expected to employ a process involving generation and comparison of multiple COAs.

2. Low-Help. The process monitor received written instructions assigning him or her the mission of enforcing the six-step process. The instructions also contained a brief description of the steps (Although all students were, by this time in this course, very familiar with the six steps). The six steps are: recognize the problem, gather information, list possible solutions, test possible solutions, select the best solution, and implement the solution. For step three, the process monitor was told to make sure that "at least 2 COAs are proposed so that the entire group definitely knows what the COAs are. The group should also know what analysis and estimates they will have to make in order to select one of the COAs." For step four, the process monitor was told to make sure that "the group actually carries out the planned analysis and does not get sidetracked." The process monitor was warned that steps 3 and 4 might be difficult to accomplish and that the group might feel they should solve the problem by some different method. The process monitor was given the authority to enforce the process.

3. Medium-Help. The process monitor received the same sheet of instructions as the low-help group monitor and additionally received detailed instructions on how to follow the process. The extra instructions included advice on holding group meetings, on timelines, on devising COAs, and on error checking.

4. High-Help. The process monitor received the same instructions as the medium-help monitor and also received content specific information on the VARWARS problem including a good problem statement, analysis of problem dimensions, description of

several workable COAs, suggested criteria for evaluating COAs, and some error checking information.

Eighty groups (20 in each condition) were scheduled to participate; however, some groups did not actually participate in the VARWARS exercise and the data from other groups were unavailable or unusable. In all, data were collected from 19 groups each in the no-, medium- and high-help conditions and 16 groups in the low-help condition.

Results

The mean VARWARS scores, number of groups, standard errors, and standard deviations for the four conditions are shown in Table 1. Values are rounded to the nearest point.

Table 1

VARWARS Scores for All Conditions

	No-Help	Low-Help	Medium-Help	High-Help	All Groups
Mean	345	296	320	275	309
n	19	16	19	19	73
SE	39	39	36	40	19
SD	171	155	159	173	164

Since the no-help condition produced the highest average score, it is clear that "help" did not lead to increases in the VARWARS scores. The differences between conditions were not statistically significant , F (3, 69) = .65.

The process observers (a different individual for each group) kept records of the process. They had been instructed to note when COAs were identified and to describe briefly the COAs. Observers would probably find it difficult to identify specific multiple COAs in groups that followed a sequential process, continually modifying a single solution. Groups were scored as having followed the concurrent process (termed a "Yes") when the observer record identified two or more COAs as being under consideration. If the observer only referred to COAs but did not identify them or if the observer described a clearly sequential process the group was classified as a "No". Quality and distinctness of the COAs were not evaluated. Table 2 shows the distribution of scores on this measure of "process-following". (Observer notes were not available for one of the medium-help groups.)

Consistent with previous research, groups in the no-help condition rarely chose to follow the concurrent comparison process of generating multiple COAs, evaluating them and selecting one. In fact, they rarely got as far as proposing the alternatives. Assigning the process monitor the job of enforcing a concurrent option comparison process raised the probability of the group at least getting to the stage of proposing multiple courses of action, X^2 (3, N = 72) = 14.58, $p < .01$, although about half of the help groups apparently did not even get to this stage. Combining the 3 help conditions (low, medium, and high), there were 27 "Yes" groups and 26 "No" groups.

Table 2

Number of Groups Rated as Yes and No for Concurrently Considering Multiple COAs

	No-Help	Low-Help	Medium-Help	High-Help	All Groups
Yes	1	8	7	12	28
No	18	8	11	7	44

Since the average scores (Table 1) and the percentage of "No" groups (Table 2) follow the same pattern (no-help was highest, followed by medium-, low-, then high-help), one might guess that the process-following ("Yes") groups tended to reduce the scores. This was not true. Overall, the "Yes" groups outscored the "No" groups. Table 3 shows the mean VARWARS scores for each of the help conditions, separated into "Yes" groups and "No" groups. The difference between "Yes" and "No" groups was significant only for the high-help condition, in which the 7 "No" groups scored particularly low, t (17) = 2.723, $p < .01$.

Table 3

VARWARS Scores for Groups Rated as Yes and No for Concurrently Considering Multiple COAs. Standard errors are in parentheses.

	Low-Help Mean (SE)	Medium-Help Mean (SE)	High-Help Mean (SE)	All Help Groups Mean (SE)
Yes	326 (46)	285 (65)	346 (42)	324 (28)
No	266 (64)	330 (47)	154 (58)	263 (34)

In the VARWARS exercise, it is theoretically possible to score a 0, however solutions which are complete "busts" and accomplish no training tend to cluster at scores of 88 or slightly below. Table 4 shows the distribution of busts (scores of 88 or below) and "non-busts" for help conditions. (The no-help condition had 2 busts and 17 non-busts.)

Combining the three help conditions, the "No" groups (groups that did not even start to follow a multiple comparison process) were significantly more likely to "bust" than the "Yes" groups, X^2 (1, N = 53) = 4.44, $p < .05$[1]. The bust-rate was fairly small for the low-help and medium-help conditions so it is possible that the effect is actually only due to the high-help condition, which when analyzed separately also shows a significantly greater tendency for "No" groups to bust ($p < .01$, Fisher exact test).

[1] Kendall-Stuart continuity correction was used. This is appropriate for contingency tables in which the marginals are not fixed. (Conover, 1974).

Table 4.

Numbers of Groups Scoring at 88 or Below (busts) and Groups Scoring above 88 (non-busts).

	Low-Help		Medium-Help		High-Help		All Help Groups	
	Bust	Non-Bust	Bust	Non-Bust	Bust	Non-Bust	Bust	Non-Bust
Yes	0	8	1	6	1	11	2	25
No	2	6	1	10	5	2	8	18

Superficially, the results in Tables 3 and 4 seem to indicate that following a concurrent option comparison process led to higher scores. This conclusion, however, is erroneous. A comparison of the no-help condition with the help conditions indicates that help did indeed lead to increased process following; however, this did not result in higher VARWARS scores. In fact, the no-help condition, in which only one group followed a concurrent process, had an average VARWARS score which was almost identical to the average of the highest scoring of the "Yes" subgroups, the high-help. Thus, it is clear that following a concurrent option comparison process *per se* did not produce higher scoring solutions. Within the various conditions, however, groups self-selected whether they were a "Yes" or "No" group, Some of the groups could be expected to be less competent than others for a variety of reasons, intellectual, social, or motivational. Since all groups had been trained to follow a concurrent process, and the help groups had increased pressure to do so, then the least competent groups could be expected to be more likely to fail at both their process and product goals. This would be particularly true for groups in the high-help condition who received considerable guidance in following the process, especially regarding the formulation of alternative COAs. Failure to generate multiple COAs in a high-help condition might be a good indicator of group dysfunction but becomes less indicative in the lower help groups and no indicator at all in the no-help groups where failure to generate multiple COAs is almost universal.

For all 28 "Yes" groups, the observer notes showed that the mean time when multiple COAs were determined was 2 hours and 37 minutes after the exercise began, with a standard deviation of 37 minutes (standard error of 7 minutes). The mean time, according to observer notes, that one of the options had been selected was 4 hours and 2 minutes after the exercise began, with a standard deviation of 36 minutes (standard error of 7 minutes).

It is interesting to compare the average VARWARS scores in this experiment with the scores from previous experiments (Lussier et al., 1991, In preparation). The group members in the previous experiments were also Army captains in the CAS^3 course, so they and the participants in this experiment represent a fairly homogeneous group in terms of age, education, and occupation. Procedures in the present experiment differ in four ways from previous experiments.

1. The problem solving sessions were changed from a strict 3-hour time limit to a more loosely enforced 5-hour limit. The problem is complex enough so that a group could continue to improve their solution over a period of weeks or months if allowed and most groups show a high activity level throughout the exercise, whether 3 or 5 hours. Thus, it is very possible that the extra time could allow better solutions (i.e., higher scores).

2. The exercise was now conducted as part of the class curriculum rather than as an adjunct. Therefore, the groups were motivated not only by personal pride but also by the

desire for success in the course. In the previous exercises motivation of the groups appeared to be generally high, so the effect of making the exercise part of the curriculum might be minor.

3. The group size was raised from seven (a leader, and three 2-person teams) to eleven (a leader, three 3-person teams and a process monitor). The addition of a person to each team could be significant. The VARWARS exercise is organized such that the problem is divided among the three teams that work on interdependent subproblems. Commonly two of the teams perform adequately but the mistakes from one team reduce the group score drastically, i.e., scoring is most influenced by the weakest link. Thus the extra person per team might reduce the possibility of a single individual making an undetected error.

4. In the present experiment, the instructor selected the group leader based on his knowledge of the individuals after seven class days. Previously, a leader was assigned based on seniority. As typically all members were the same rank, the leader was the captain who had the earliest date of rank and was therefore roughly random as far as leadership abilities. Instructor selected leaders might be better, causing an increase in scores.

None of the four variables above are experimentally separated; however, their combined effect, if any, would probably be to raise overall scores. Two variables which were previously found to affect VARWARS scores are length of time in the course and intact versus mixed groups. An intact group takes all its members from a single class section; therefore, the members are acquainted and have worked together in other group projects. A mixed group takes one member each from different class sections so the members are generally strangers, with occasional exceptions. Table 5 shows VARWARS scores by these two variables. The present experiment results are the Day 8-Intact result of 309 which is the average of all 73 groups.

Table 5

Comparison of VARWARS Scores in Present Experiment with Averages from Previous Experiments.

Day of Course	Mixed	Intact
0	465	-
8	-	309[a]
18	440	-
30	410	285
40	356	-

a . The value 309 is from the present experiment. All other values in Table 5 are from previous experiments with VARWARS.

It seems clear that very little argument can be made for the four procedural variables listed above having any positive effect on the scores. The 309 average is also well below what would be predicted, by interpolation, for a mixed group at Day 8. Therefore it would appear that the large and significant mixed versus intact difference previously found at Day 30 is an effect which appears fairly early in the course.

The results of Experiment 1 indicate that there is little reason to recommend use of a process involving concurrent comparison of multiple options in situations resembling the VARWARS exercise. It could be argued that, among the three help conditions, half of the groups may not have reached the stage of generating alternatives, and many of the half that did reach this stage may not have progressed adequately through the analysis and selection phases of the process. Perhaps if they had, those help conditions and therefore, the concurrent process, would have shown solutions superior to those that resulted from a sequential process. Even if this were so, the difficulty of applying the process adequately would recommend against it. The members of the groups studied here were, without exception, college graduates who had received considerable training in use of the concurrent process and were, for the most part, well motivated to succeed. The difficulty of identifying and describing reasonable courses of action and the lack of an easily applied metric for comparing the value of COAs make the concurrent process difficult to apply in the VARWARS problem. This and the fairly major impact of mistakes on VARWARS scores reduce the value of attempts to apply a concurrent process. Further characteristics of the VARWARS problem which make it a poor candidate for the concurrent process are discussed later in this report.

The previously found intact versus mixed difference, which received some support in this experiment, is interesting. It is curious and, at first thought, counterintuitive that taking the groups tested in this experiment and shuffling their members to produce groups of strangers would probably have greatly increased the quality of the solutions produced. When comparing the performance of existing teams and ad hoc teams it is probably quite important to distinguish between teams being measured on a task which they had performed and trained on together and teams performing a new and different task. For new tasks, the major elements of value are those related to group cohesion, cooperation, and reinforced motivation. The students at CAS^3 have much in common with one another, such as rank, age, education, and occupation. Further, the U.S. Army is an organization characterized by esprit de corps. Thus, groups of unacquainted Army captains tend to work together in an atmosphere of mutual respect and cooperativeness and quickly establish a positive group motivation. Given this high baseline, it may not be unlikely that as they come to know one another, and work together in a somewhat competitive environment, frictions develop which outweigh the friendships which also develop. Although no measurements were made, casual observation of the intact groups evinced a tendency for blaming one another, recriminations, and other forms of bickering which, while not rife, had been completely absent in the mixed groups previously observed. Faced with the complexity of the VARWARS problem virtually all groups experience periods of frustration. Nonetheless, if this is the cause of the mixed versus intact effect, then it is surprising how dramatically social factors in the group may affect the quality of the solutions.

In Experiment 2, yet another attempt is made to improve VARWARS scores by manipulating problem solving process. In this case, however, the attempt is successful.

Experiment 2

Methods

Procedures in this experiment were similar to those of Experiment 1 in that intact groups of students in the CAS^3 course participated in the VARWARS exercise at Day 8 of the course. There was no process monitor; groups comprised a leader and three 3-person teams.

The instructor required the group to develop 3 courses of action and to select one. The group was given 1 hour and 30 minutes to do this. A COA was defined for the group as a skeletal plan, i.e., the group had to identify what type of VARWARS device they would purchase, how many of the devices they would purchase, and where they would locate them in the country. After 1 hour and 30 minutes had elapsed, the group made an oral presentation to the instructor which identified the three COAs they had considered and gave reasons for recommending one of the COAs. The instructor accepted whatever COA they recommended. If the group did not give a clear recommendation containing the 3 required elements (model of devices, number of devices, and location of devices), the instructor forced them to come to an immediate decision. The instructor then gave the group two hours to continue to develop the plan. The instructor encouraged them to retain the selected COA as much as possible, however, authorized them to make minor modifications based on their continued assessment. They were told not to make major modifications unless such modifications were deemed to be absolutely necessary. The terms "major" and "minor" were not defined. After the further two hours had elapsed, the group made another presentation of their completed solution. The instructor told the group to spend approximately 30 more minutes looking over their solution trying to find errors. This essentially ended the procedure. (In the class, the group went on to enter their solution on a computer, score it, and have an after-action review, critiquing their performance.)

The overall exercise time was the same as that of the Experiment 1 procedure. Here, the schedule was: COA development and selection phase (90 minutes), presentation (15 minutes), planning phase (120 minutes), presentation (15 minutes), error-checking phase (30 minutes) and entry of information onto the computer for scoring (30 minutes) for a total of 5 hours. In Experiment 1 there was no structured schedule but the group prepared a presentation similar to those given by the groups in Experiment 2 and also spent approximately the last 30 minutes entering their solution on a computer for scoring. The Experiment 1 groups had more time in general because (a) it was sometimes necessary to give them additional time because they had not completed entry of their solution on the computer, and (b) their presentations were made after the 5 hour session, not during it.

The process described above can be termed an "Early Decision" process. Recall that in the "Yes" groups of Experiment 1, the COAs were identified, on average, 2 hours and 37 minutes after the exercise began, and one was selected, on average, at the 4 hour and 2 minute mark. The Early Decision process forces the group to identify COAs and reach a decision after only 1 and 1/2 hours (as well as prepare a presentation during this period). Actually, the decision of the "Yes" groups at the 4 hour mark is much more of a final decision, as these groups must still spend some time on the details of their selected COA and enter information into the computer; major changes at this time would be very difficult to effect. The Early Decision process decision at 1 and 1/2 hours is much more of a tentative, "starting point" decision, which will probably undergo many modifications before becoming final. Imposing an Early Decision requirement forces the groups to select a definite COA sooner than they normally would; imposing a concurrent comparison requirement delays COA selection.

Thirty-three problem solving groups were tested in Experiment 2.

Results

The 33 groups had a mean VARWARS score of 434 with a standard error of 23 points and a standard deviation of 132 points. This represented a significant improvement ($t=3.80$, $p<.01$) over the groups tested in Experiment 1 taken as a whole, and also a significant improvement ($t=2.07$, $p<.05$) over the highest scoring condition, no-help. Figure 1 shows all of groups tested in Experiments 1 and 2. The Early Decision procedure

seemed especially to reduce the relative frequency of low-scoring groups; the "bust-rate" went from 16.4% for the Experiment 1 groups to 0% for the Early Decision groups, which represents a significant reduction (Fisher Exact Test, $p < .01$).

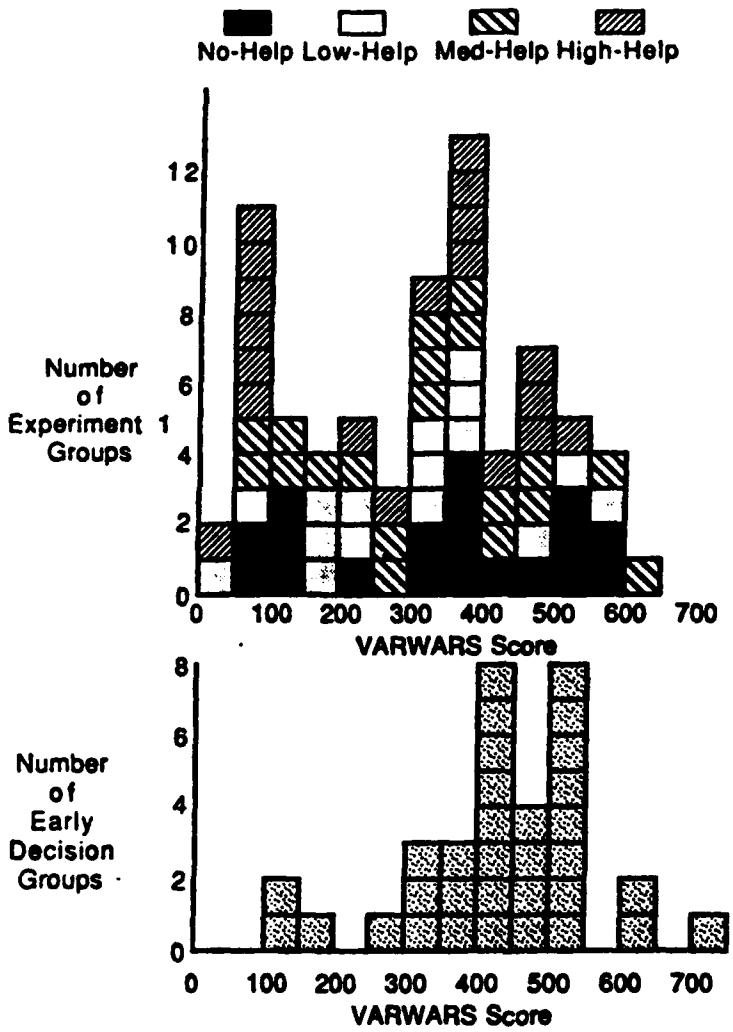

Figure 1. VARWARS scores from all groups tested in Experiments 1 and 2.

Discussion

Groups working on the VARWARS problem tend to prefer to use a naturalistic process. The term "naturalistic" is used by Klein and Klinger (1991) to identify a process characterized by: (a) serial generation and evaluation of options, not concurrent evaluation; (b) satisficing, not optimizing; (c) evaluation through mental simulation, not multiattribute utility analysis, decision analysis or Bayesian statistics and; (d) a focus on elaborating and improving options, not choosing among options. Attempting to sway groups from this process toward a decision analytic process involving concurrent comparison of options proved to be quite difficult to accomplish and did not result in better solutions even when groups did adopt a concurrent process. In contrast, the Early Decision process was both simple to effect and did lead to a fairly large improvement in solutions.

Interestingly, the VARWARS situation is quite unlike the situations studied by Klein. Klein and Klinger (1991) list ten features of naturalistic decision making for which classical (decision analytic) approaches to decision making are "limited in their ability to encompass" (Klein and Klinger, 1991, p. 1). These ten features are (a) ill-defined goals and ill-structured tasks, (b) uncertainty, ambiguity, and missing data, (c) shifting and competing goals, (d) dynamic and continually changing conditions, (e) action-feedback loops (real-time reactions t o changing conditions), (f) time stress, (g) high stakes, (h) multiple players, (i) organizational goals and norms and (j) experienced decision makers. None of these features is present in the VARWARS problem solving situations studied in this paper except multiple players.

The major effect of imposing an Early Decision requirement is to force the group to "fix" on a definite, that is to say, specified option much earlier than they normally would. In the VARWARS problem about one hour is required just to begin to comprehend all the problem elements and requirements. The group is therefore, forced (in the Early Decision Method) to identify rapidly some possible solutions and, after only a brief analysis, make a selection. The Early Decision process may at first sight appear to be a concurrent process because several options are generated initially. In fact, it impels the group into a sequential (and naturalistic) mode by giving them a definite, although possibly inadequate option early and allowing the bulk of the time to be spent elaborating and improving it. VARWARS groups could be characterized as low-experience decision makers (in the VARWARS situation) and, when not faced with the Early Decision requirement, typically do not feel strong time pressure during the first few hours of the problem. The imposition of an Early Decision requirement makes them behave more like Klein's experts under time pressure, i.e., they generate a candidate solution rapidly, and then, as time permits, test and improve it.

While the Early Decision strategy seems beneficial in the VARWARS situation, there are undoubtedly many situations in which it would not be. What factors should one consider when deciding whether to use this method? Consider that using this method involves forcing the group to propose a candidate solution at a time when they probably feel they have not given enough consideration to the alternatives.

Several possible factors are:

Relationship between COA selection and outcome. Sometimes selecting the right COA is only part of the whole job. It is possible to choose the best COA and still have an unfavorable outcome, especially when the selected COA requires further development, for example, into a detailed plan. An early decision tends to increase the time and effort available for development and implementation of the COA. In other situations the relationship between COA selection and outcome may be strong in that a favorable outcome may be virtually assured by choosing the best COA and a relative failure assured by not choosing the best COA. Such situations as the latter would be less likely to benefit from early decisions.

Availability of good solutions. In some problem solving situations there are likely to be several good, workable solutions. A successful result involves finding one and making it work well. Early Decision probably works best when there are a number of acceptable solutions. At other times, finding a key or best solution is important or there may be many trails that are superficially attractive but contain flaws that make them unworkable. Here, more attention should probably be paid to various options before any option is explored in detail.

Likelihood and effect of mistakes in implementation. In some situations, it is virtually impossible to execute the COA without making a number of small or major errors, each of which will result in decreased effectiveness. Therefore, careful attention to a detailed implementation plan will more than compensate for selection of a suboptimal COA. This is especially a characteristic of plans that are

devised and executed by groups working as teams, i.e., with interdependent subtasks planned and performed by group members or sections. The effect of individual mistakes is much more significant in such groups than it is in groups organized so that all members work on the overall problem as a whole, for example, a jury.

Level of expertise. Greater levels of expertise would probably favor use of an Early Decision method. It is useful to be able to make a judgment on what levels of outcome are achievable in a situation, therefore allowing one to judge the adequacy of a particular COA without formally comparing it to other COAs. Novices in the problem area would be more likely to benefit from extended consideration of alternative solutions.

Ability to compare and discriminate between COAs. The value of methods that emphasize generation and comparison of multiple COAs is enhanced when such comparisons are clear and easy. When comparison of COAs is difficult and relies heavily upon subjective judgement, there is not much payoff in expending a great effort trying to discriminate between two COAs that are close in value. However, if there is a clear, objective bottom line so that a solution that is even slightly better will be clearly seen to be an improvement, then greater exploration of options becomes a more favorable course.

Time and effort constraints. Early Decision methods are, of course, most favorable when time and effort are limited. In such situations, time and effort put into deciding upon a COA will necessarily reduce the time and effort put into development of implementation details, or other planning and rehearsal activities. If the group has the time and determination to work all phases of the problem thoroughly, then it is well worth the expenditure to improve the chance that they arrive at the best of all possible COAs through broad consideration of COAs.

The time and effort constraints of a situation may not always be readily apparent. For example, an organization is to present a one-week training seminar for some of its employees. A committee meets months in advance to plan the seminar. Enthusiasm for the project and optimism about the amount of effort that will be expended are initially high. The group may spend considerable time and effort engaged in the fairly interesting job of selecting a topic for the training. As the deadline approaches, however, the group begins to feel that more effort than merited has already been put in the project and the planning becomes less thoughtful. Finally, the group is pressured to fill the seminar week with some specific instruction, and they become very uncritical of this material. Without expending more energy, the group could have chosen any of a large number of topics and presented a good seminar but instead, they presented a poor seminar about a great topic.

Much advice given about problem solving focuses on broadening consideration of options, increasing creativity with brainstorming, and systematizing the evaluation of options beyond people's natural inclination. In VARWARS-like situations, however, it is better to do the opposite and curb people's tendencies for option generation and evaluation.

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