PROBLEM-SOLVING SKILL IN THE SOCIAL SCIENCES

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I. Introduction

In recent years problem solving has been studied in the context of particular subject matter domains such as physics (e.g., Larkin, McDermott,
Simon, & Simon, 1980), geometry (e.g., Greeno, 1978), and software design (e.g., Jeffries, Turner, Polson, & Atwood, 1981). The present research is concerned with problem solving in yet another domain, social sciences.

There are a number of reasons for studying social science problem solving. One is to examine how recent theoretical developments in problem solving may be extended to the social sciences. A second and related reason is that problems of the social sciences tend to be ill structured, and the study of solving such problems has received relatively little attention (cf. Reitman, 1965; Simon, 1973). Finally, many problems of everyday life, for example, economic and political, are in the social sciences, and a better understanding of problem solving in such domains may help to improve instruction in these areas.

Within the social sciences, we have concentrated on problems in political science, and especially on problems related to the Soviet Union. While we have employed a number of different problems, our most extensive analyses have been conducted upon the Soviet agriculture problem. In this problem we indicate that Soviet crop productivity is not able to meet the country's needs, and we ask the solver what he or she would do to increase agricultural productivity in the Soviet Union, given that the solver is the Head of the USSR Ministry of Agriculture. The methodology that we have employed is protocol analysis, collecting the protocols from individuals varying in training and experience.

The organization of this article is as follows. The present research was conducted within the framework of the general information processing model of problem solving, and the model is briefly described (cf. Newell & Simon, 1972; Simon, 1978). Next, there is a discussion of some characteristics of social science problems. Subsequently we present a description of the more specific model of the solving process we have developed as a result of this research, and this is followed by a summary of the protocols that we have collected. The final sections present some ideas regarding how social science problem-solving skill is acquired and how the present work is related more generally to problem-solving research.

II. The Information-Processing Model

A. Task Environment

The task environment is the problem statement and the context in which the statement is presented, that is, the “objective” statement of the problem as found under particular conditions.

B. Problem Space

When presented with a problem, the solver establishes a problem space that consists of the information known or potentially available to the solver that may be useful in solving the problem. This information typically includes the problem goal and subgoals, as well as the possible states of the problem that may occur as the problem solver moves toward the solution. In addition, the problem space contains operators which enable the individual to move from state to state. Finally, the problem space contains the solver's knowledge of the constraints under which a problem is to be solved. Thus, the solver is assumed to begin at an initial problem state and move along a solution path from state to state until the goal state is reached (Simon, 1978). Furthermore, this movement is assumed to be constrained by the short-term memory limitations of the individual. Such limitations are assumed to limit the number of problem components that the solver is able to consider at any point in the solving process.

C. Problem Representation

When presented with a problem, the individual develops a problem representation which, in a sense, is the solver's interpretation of the problem statement. For a number of problem classes, for example, puzzle problems (Greeno, 1974; Simon, 1975), the solver's representation consists of little more than an understanding of the problem statement. However, as shown by Larkin et al. (1980), problem representation is generally more complex for physics problems. In this case, the solver must interpret the problem statement by studying the features of the problem and their interrelations. Thus, a novice tends to use the problem's surface information to form a representation, while the expert's representation is usually based upon the conceptual relations underlying the surface statement (cf. Chi, Feldovich, & Glaser, 1981). Moreover, the expert's representation may include classifying the problem, for example, as one of “mechanics.” Thus, the expert is able to represent the problem appropriately because of the knowledge and experience in dealing with that particular type of problem.

D. Problem Solution Activity

While general problem solving may be viewed as stepwise movement toward a goal, a more complete understanding of the solving process must include an understanding of the more specific strategies that may be employed. Sacerdotti (1977), for example, developed a model that consists of decomposition of the problem into a number of subproblems, and solutions are sought for the subproblems. The decomposition occurs via a top-down.
breadth-first process, in the sense that the individual specifies the major subproblems and subsequently solves them. The solver may work on the subproblems iteratively, refining the subproblem solutions with each iteration (cf. Jeffries et al., 1981; Sacerdoti, 1977).

Other descriptions of problem solving strategies have been developed by Hayes-Roth and Hayes-Roth (1979) and Stefik (1981). The primary issue of concern in these models is subproblem interaction. The concept of opportunistic solving has been offered by Hayes-Roth and Hayes-Roth, and a somewhat similar notion, constraint posting, has been suggested by Stefik. Opportunistic solving refers to taking the opportunity of solving one subproblem while the solver is in the process of solving another subproblem. Similarly, constraint posting refers to not solving a subproblem until it becomes necessary to deal with a constraint during the course of solving the subproblem.

E. Evaluation

In the information-processing framework, evaluation of the steps taken during the solving process is often assumed to take place via means-ends analysis. In this method, a step is evaluated in terms of whether it moves the solver closer to the goal. Indeed, the solver may look at the difference between the current state and the goal and then try to select which step reduces this difference. Hence, this process is sometimes referred to as working backwards. Another form of evaluation is the generate-test process in which the solver may generate a number of solutions and evaluate (test) the solution via the application of some criterion. On the other hand, Larkin et al. (1980) have shown that once physics experts are able to classify a problem, they go through the solution steps in a routine manner. Because the solution is reasonably stereotypical and does not usually require evaluation, the process is referred to as working forward.

In summary, for relatively complex problems, the solver develops a problem representation and then offers a solution to the problem and a number of strategies have been proposed to describe how this takes place. Moreover, as the solution activity is taking place, the steps taken are often evaluated, except in cases where working out the solution is a routine process.

III. Social Science Problems and Their Solutions

A. General Characteristics of Social Science Problems

Many social science problems, including those employed in the present research, involve the existence of an undesirable state of affairs (the problem) that requires improvement (the solution). Thus, a high crime rate requires reduction, an excessive inflation rate should be decreased, agricultural productivity is below the nation's needs and must be increased, etc. This type of problem may also be found, of course, in other fields such as medicine. In general, solving such problems consists of isolating the cause(s) of the problem and eliminating or at least reducing the effects. In social sciences, however, solving such problems is often made quite difficult by two factors, namely, the lack of agreed-upon solutions and delay in implementing solutions.

1. The Lack of Agreed-upon Solutions

While virtually all problems used thus far in problem-solving research have one or more known solutions, social science problems seldom have solutions about which experts are in complete agreement. An effect of such lack of agreement is that the solver must provide arguments supporting why the particular proposed solution should be adopted. Indeed, as shown later in this article, such argument development is a major part of social science problem solving, especially for experts.

2. The Delay of Implementation

In most social science problem solving there is a relatively long delay from the time a solution is proposed and accepted to when it is fully implemented; for example, an economic policy designed to reduce inflation may take years to implement. Moreover, the effects of such implementation delay are indeed profound. First, relatively few solutions may be tried for any given problem because of time, cost, and other factors. Second, the opportunity to try so few solutions contributes to the relatively slow development of the data base of social sciences. Third, the conditions existing when the solution is proposed may change during the course of implementation. Naturally, a good solution anticipates changes in conditions, but anticipation can be quite difficult. Finally, implementation delay affects solution evaluation, a point discussed in more detail in the next few pages.

B. Specific Considerations of Social Science Problems

1. The Goal

The goal of many social science problems is often vaguely stated, for example, "reduce the crime rate," "decrease inflation," and "improve crop productivity." Moreover, what constitutes an "acceptable" goal, for example, how much inflation may be reduced in order to consider the
problem “solved,” can be a point of considerable controversy (and a political football).

2. Causes, Constraints, and Subproblems

As previously noted, solving the type of problem employed in the present work typically involves isolating cause(s) of the problem, and this strategy raises questions about causation that are beyond the scope of this article. For our purposes, however, causes are viewed as factors that play a role in producing the problem, and these factors are taken to be subproblems and constraints.

Subproblems are typically regarded as problems that are subordinate to a more general problem. Constraints, on the other hand, are typically regarded as factors assumed to be invariant over the course of solving a particular problem that in some way restrict the range of solutions. In the present research, for example, the lack of peasant knowledge regarding how to use technical farm equipment is typically viewed as a subproblem that could be solved by education. Soviet ideology, on the other hand, is viewed as a constraint because solving the Soviet Union's agricultural problem must be done within the framework of the Soviet system, and it is generally assumed that there is no chance of changing that system. However, a factor identified as constraint early in a protocol may be converted to a subproblem if the subject attempts to provide a solution. In principle then, while one factor may be assumed to be invariant over the course of solving the problem, it is possible that any constraint could be subsequently interpreted as a subproblem. (Soviet ideology could be attacked via shifts toward capitalism or even revolution.) The distinction of subproblem and constraint in social sciences thus appears to be less definite than in other areas. For example, the operation of physical laws can only serve as constraints in physics problem solving. Finally, we note that in social sciences constraints and subproblems are usually not given in the problem statement, and the solver must rely upon his or her knowledge of the field to identify these factors.

3. Evaluation

The previously mentioned implementation delay found in social science problem solving has an important influence upon the evaluation process. Specifically, after proposing a solution, the solver (especially the expert): (1) may provide support for the proposed solution, (2) may isolate subproblems that need to be considered in order for the proposed solution to be implemented and may offer solutions to these subproblems, and (3) may evaluate any of the solutions, with one or more constraints serving as the evaluation criterion. Thus, social science problem solving includes argument development which involves “building a case” for a proposed solution.

The account presented thus far suggests that social science problem solving is an integration of two processes, problem solving and verbal reasoning. In an early attempt to describe the solving process, Voss, Tyler, and Yengo (1983) used an extension of a model of argument, that is, a jurisprudence model (Toulmin, 1958; Toulmin, Rieke, & Janik, 1979). The model described by Voss and his co-workers had deficiencies, however, the most serious of which was the lack of a problem-solving control structure. The model presented in this article takes this deficiency into account by assuming two structures, a problem-solving control structure and a reasoning structure, each with its own set of operators.

IV. The Problem-Solving-Reasoning Model

The model consists of a problem-solving control structure (G) and a reasoning structure (R). Here, G is viewed as a goal structure which controls the problem-solving process. It consists of operators that act upon the individual knowledge base and generate the problem solution. The G operators are presented in Table I.

The first operator is State Constraint (GCON). This operator is applied when a solver explicitly or implicitly indicates a problem constraint. The second operator is State Subproblem (GSUB), applied when the solver indicates that a particular factor is being used as a subproblem. The third operator, State Solution (GSOL), is applied when the solver states a solution, either to the given problem or to a subproblem, explicitly or implicitly expressed. The three operators stated thus far constitute the “hard-core” operators, which in some form or another may be found in most descriptions of problem solving. The remaining four G structure operators are

<table>
<thead>
<tr>
<th>TABLE I</th>
</tr>
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<tbody>
<tr>
<td><strong>G STRUCTURE OPERATORS</strong></td>
</tr>
<tr>
<td>GCON</td>
</tr>
<tr>
<td>GSUB</td>
</tr>
<tr>
<td>GSOL</td>
</tr>
<tr>
<td>GIPS</td>
</tr>
<tr>
<td>GSUP</td>
</tr>
<tr>
<td>GEVA</td>
</tr>
<tr>
<td>GSUM</td>
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supportive to these three operators and are used in conjunction with Reasoning Structure operators.

The operator Interpret Problem Statement (GIPS) is applied when the solver considers how the problem is to be interpreted. The Provide Support operator (GSUP), for reasons described below, is applied only when the solver is using some type of argument to support the existence of a subproblem or constraint. The Evaluate (GEVA) operator is applied when (1) the solver develops an argument that supports or rejects a solution, and (2) when the solver evaluates a solution in relation to a particular constraint. Thus, GEVA is used in the first case rather than GSUP because evaluation is provided which is not necessarily supportive. Furthermore, to distinguish support from positive evaluation under such circumstances is virtually impossible. Therefore, we used GSUP only when supportive evidence is stated for the existence of a subproblem or constraint and GEVA when an evaluation of a solution occurs.

The Summarize (GSUM) operator is applied when the solver presents a summary of a relatively large portion of the protocol. It seems that GSUM has an integrative function in that the solver is stating, "Here is where I am so far."

The R Structure operators are listed in Table II. These operators are applied in conjunction with the GIPS, GSUP, GEVA, and GSUM operators. Typically, the application of the R structure begins with an argument made by the solver, that is, the application of the RARG operator of Table II. Subsequently, a combination of the remaining operators is applied in the argument development.

The State Assertion operator (RSAS) is applied when the solver refers to a constraint, subproblem or solution, but the factors referred to are not in the goal structure of the solution process. This occurs primarily when the solver refers to one of these factors as part of argument development, not actually dealing with the factor as part of his or her proposed solution. The State Fact (RFAC) operator is used when the solver supports another statement via the statement of a fact. The Present Specific Case (RPSC) operator is used for stating a specific case or example which demonstrates the contents of a previous statement. The State Reason (RREA) operator is applied when the individual states a reason for a previous statement. This operator often involves use of terms such as "because." The State Outcome (ROUT) operator is applied when the solver states an outcome of a previous statement. The Compare and/or Contrast (RCOM) operator is applied when the solver compares a previous statement with some other entity related to the statement. The Elaborate and/or Clarify (RELA) operator is used when the solver attempts to elaborate or clarify a previous statement while essentially not adding anything new. The State Conclusion (RCON) operator is employed when a concluding statement is provided after a series of previous statements. It typically terminates a line of argument and is more specific than the GSUM operator. The State Qualification (RQUA) operator involves the use of a statement to restrict the range of application of the previous statement.

Finally, we would note that if one were to develop a simulation model involving the use of the G and R structure operators, it would be necessary to derive a much more precise statement for the input and output operator conditions. Our analysis, however, had as its goal a reasonable exposition of the solving processes found in the protocols.

V. Protocol Collection and Analyses

A. PARTICIPANTS

Six experts and ten novices participated in the study. The experts included five faculty members of the University of Pittsburgh and one person finishing his dissertation who is now on the Ohio State University faculty. Six of the novices were individuals in a course on Soviet domestic policy. These individuals were given the Soviet agriculture problem both at the beginning and at the conclusion of the course, the latter responses being referred to as postnovice protocols. The purpose of repeating the protocol collection was to get an idea of what effect the course may have had upon the solving process. Four additional novice protocols were obtained from individuals attending another section of the same course.

In research using the constrastive method, experts and novices typically differ in a number of ways in addition to their acknowledged differences in expertise. In an effort to gather data that would help to "unconfound" some of the expert-novice differences, we obtained protocols from three first or second year graduate students in political science whose field of
interest was the Soviet Union. We also obtained protocols from four advanced political science graduate students whose field of expertise was Latin and/or South America. We obtained three protocols from faculty whose field of expertise was Latin America or American Government and Policy and we also obtained four protocols from faculty of the Chemistry Department. Finally, we obtained one protocol from a foreign service officer of the State Department whose service is in South America and one protocol from a visiting scholar of an Eastern European country. With these protocols we thus were able to compare not only expert and novice performance, but were able to compare protocols of: (1) experts on the Soviet Union with individuals who were not experts on the Soviet Union but whose field of expertise was in the same general discipline, (2) experts on the Soviet Union to that of experts of a different discipline (chemistry), and (3) undergraduate, graduate, and faculty within a given discipline, and thereby use a cross-sectional approach to develop some ideas regarding how expertise develops.

B. THE COLLECTION OF PROTOCOLS

Except where noted, the problem given to the participants was the previously stated Soviet agricultural problem. There were two variations of the problem. One version was as follows: "Suppose you were the Minister of Agriculture in the Soviet Union and assume that crop productivity has been low over the past several years. You have the responsibility to increase crop production. How would you go about solving this problem?" The second added that because of political reasons, "productivity had to be increased as soon as possible." In addition one expert, the foreign service officer, and the European scholar received probes during the course of generating the protocol. This procedure was used to determine whether they knew more problem-related information than they utilized during the generation of the protocol.

Individuals were instructed to "think out loud" while generating their solution, being encouraged to state "whatever comes into their head." A tape recorder was started and the participant was given the problem on a sheet of paper. In some cases individuals were allowed to use pencil and paper to make notes, but in only one case was there significant use of these materials.

C. PROTOCOL ANALYSIS

The first group of protocols we gathered, which included four experts and the six novice-postnovices, were initially divided into idea units. Typ-

ically, a unit was a sentence, but on occasion it was of clause length or a number of sentences. The interrater reliability of segmenting units was in excess of .90. For the remaining protocols, we used a more "top-down" method, analyzing the protocols in relation to the previously mentioned G and R structures, but again segmenting the protocols in relation to assertions germane to the problem solving process. When the first group of protocols was analyzed in the same manner, the two methods led to equivalent segmentation. Finally, in analyzing protocols, every effort was made to stay close to the protocol contents, and contents were discarded only rarely and only when they were not related to the solution process.

D. EXPERT PROTOCOLS

Expert A began with an explicit statement of constraints:

I think that as Minister of Agriculture, one has to start out with the realization that there are certain kinds of special agriculture constraints within which you are going to work. The first one, the most obvious one, is that by almost every count only ten percent of the land in the Soviet Union is arable. This is normally what is called the Blackland in the Ukraine and surrounding areas. And secondly, even in that arable ten percent of the total land surface, you still have climate for instance, problems over which you have no direct control. Okay, so that is sort of the overall parameter in which we are working.

Subsequently, Expert A analyzed the problem from a historical perspective, concluding that inadequate technological modernization is a major factor in low productivity, thus representing the problem as technological. Table III presents the historical analysis in relation to the R structure.

Immediately thereafter Expert A stated his basic solution, greater capital investment in agriculture:

I think as a starting point as Minister of Agriculture, my first aim would be to get monies to invest in this further mechanization and further application of scientific techniques of agriculture, to agriculture situations.

This statement was followed by argument supporting the solution. The argument is focused upon specific problems that by implication would be solved by greater investment:

Even though we have mechanized to some extent, it has been a rather crude form of mechanization, it has been rather low-level, it is not coherent, it is not consistent. We have the same old problem that we've had. If we develop tractors or we produce tractors, we produce a thousand tractors, we have no parts to service them when they break down. We don't have adequate transportation supplies or transportation networks to carry the produce we do have to the urban markets. We have been woefully lacking in a methodical application of fertilizers to our agricultural sectors in society. We are much more like a third world than an industrial world in terms of the way, the lack of use of
TABLE III

EXPERT A'S R STRUCTURE FOR HISTORICAL ANALYSIS SEGMENT

<table>
<thead>
<tr>
<th>(GIPS)</th>
<th>Interpret problem statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RARG)</td>
<td>Historically, agriculture has been a problem in the Soviet Union</td>
</tr>
<tr>
<td>(RFAC)</td>
<td>Problem had been inherited from the time the czars freed the serfs</td>
</tr>
<tr>
<td>(RFAC)</td>
<td>Agricultural production was low even before then</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Historically, the serfdom had no need to feed for itself</td>
</tr>
<tr>
<td>(RCON)</td>
<td>Was not like English aristocracy</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Never introduced modern methods of fertilization</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Never went to enclosures or consolidation of land</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Never experimented with crop rotation</td>
</tr>
<tr>
<td>(RFAC)</td>
<td>Agriculture problem was passed onto peasants so they could do what they willed with the land</td>
</tr>
<tr>
<td>(ROUT)</td>
<td>They responded with old, inefficient ways</td>
</tr>
<tr>
<td>(RFAC)</td>
<td>USSR had three different policies to increase agricultural production</td>
</tr>
<tr>
<td>(REL)</td>
<td>Exhortation</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Campaign for more effort on the part of the peasants</td>
</tr>
<tr>
<td>(RCON)</td>
<td>Was waste of time and energy</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Only gave the party a sense of false importance</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Apparent use by the party to develop these campaigns (but they haven't paid off)</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Party believes that ideological policies can overcome objective limitations</td>
</tr>
<tr>
<td>(RCON)</td>
<td>1 would not use exhortation</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Reorganization</td>
</tr>
<tr>
<td>(ROUT)</td>
<td>Leads to confusion, mismanagement, makes peasants laid back</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Reorganized collective state farms, machine tractor stations</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Now have agrarian industrial complexes, reducing number of collectives and making farmer a wage earner</td>
</tr>
<tr>
<td>(RQUA)</td>
<td>Have always allowed private crop to exist</td>
</tr>
<tr>
<td>(RQUA)</td>
<td>Except in stringent ideological periods</td>
</tr>
<tr>
<td>(REL)</td>
<td>Is taken to be a more primitive form of production</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Private crops account for 40% of food staples</td>
</tr>
<tr>
<td>(RPSC)</td>
<td>Mechanization</td>
</tr>
<tr>
<td>(RCON)</td>
<td>This is where I would start my solution</td>
</tr>
<tr>
<td>(REL)</td>
<td>Have tried to mechanize agricultural production more</td>
</tr>
</tbody>
</table>

fertilization. We still don't have very scientific management in terms of crop rotation and because of all this, we still have a rather labor intensive agricultural production system and therefore, production per unit is very marginal.

An important point is that the subproblems, for example, inadequate transportation system and poor management of crop rotation, are regarded as subordinate to the more general lack of technological development, and it is further implied that these problems can be resolved by the solution of capital investment. As such, the subproblems are not basic in the solution structure. Instead, the solution to these subproblems is being used by Expert A to support his more abstract solution. This is a type of reasoning commonly employed by experts, that is, showing how a more general solution will act to solve a number of subordinate subproblems.

In the next part of the protocol, Expert A stated a subproblem that he would encounter, namely, there would be a need to reorder financial priorities and this would mean interacting with other agencies. The primary line of argument used by Expert A is to convince those in power to reorder priorities so that agricultural development will lead to less dependency on the West and a more stable regime:

I would have to fight very strongly in the party and the government to redirect the investment ratio going to agriculture over heavy industry, and even light industry from the way it has been in the past. Though we have in the last ten years shifted investment policies so that more and more is coming into agriculture and away from industrial production per se, it still is not anywhere near the break even point even though for both international, political and domestic reasons, agriculture is our "Achilles Heel." If we simply don't produce enough we will become more and more vulnerable to dependency upon the West for agricultural production, and we will, if we don't have enough food, stuffs internally, we will develop a more unstable regime. There will be lack of support. We have developed a program where the support from the people is going to come at least in some basic way from demand satisfaction and yet we haven't been able to satisfy a lot of the basic food demands of large parts of our population. So, I would first have to fight in the decision-making circles to once and for all, recognize that the construction of socialism is the construction of an entire society that is self-sufficient and does not have to depend upon, especially potential adversaries, for all parts of its basic resources. That means that we have a high enough industrial base, we have the war technology equivalent to the West, we must now redirect in a major way, our investment policy toward agriculture, toward mechanization, toward the infrastructure around mechanization, toward the transportation program, toward the plastic bag program so that whenever the damn fertilizer is packaged it doesn't sit out in the lot as it does. We lose one-half of our fertilizers because it rains on paper packages. What I mean by infrastructure, there is a whole series of secondary enterprises that we have to make.

Finally, Expert A defined a number of subproblems that should be considered in relation to the proposed solution. These include the need for education, the need to improve wages and incentives, the need to make private plots a more integral part of the economy, and the need for a modified market mechanism. A solution is provided for each of these issues and each solution also involves agreement to support it.

Figure 1 presents a diagram of Expert A's G structure. Brackets indicate that the protocol contained R structure information which was used to support the contents of the node having the brackets. As shown, Expert A's protocol contained extensive reasoning to support various phases of the problem solving activity. Also, a dashed line depicts an implied subprob-
lem, for example, Expert A's statement, "We will need to educate the peasants," implies that lack of peasant knowledge is a subproblem.

We note the following additional points regarding Expert A's protocol:

1. In discussing increased wages he made the statement "ideology aside" and discussed the need for agricultural workers to receive the same benefits as industrial workers. However, he did not fully explore how he may be violating the ideology constraint in his solutions involving an increase in wages, making the private plot a greater part of the system, and modifying the market mechanism.

2. Expert A provided an example of converting a constraint into a subproblem when initially he stated limited arable land as a constraint but later considered increasing the amount of arable land via irrigation.

3. Expert A's protocol depicts a problem-solving strategy in which the given problem was converted into a problem for which a solution may be offered; that is, the stated problem was converted to inadequate technological development and the solution proposed was greater agricultural investment.

Expert B began with a strong statement of the political constraint:

I think the most difficult part of this sort of problem for a Soviet leader is that the objective is not as clear as your question hints, because solving the productivity of agriculture in technical terms, even in economic terms, is no big problem, given that you can get the land fertile and can rotate it. But in the Soviet Union all these economic problems are political issues and so the objectives are not at all clear because you cannot raise agriculture productivity in the most simple fashion without damaging certain political priorities that you will not be able to ignore.

Subsequently, Expert B, in a quite interesting manner, suggested a number of solutions to the problem that could be offered, if it were not for the political constraint. (Among these is Expert A's solution, which Expert B rejected.) Table IV presents a description of the R structure of this analysis.

From this analysis, Expert B developed his problem representation, which was stated immediately after the conclusion of the Table IV contents:

So our problem is really not technological, but it is social—how to make labor work harder on the collective, as opposed to the private plot.

A general solution is subsequently proposed, followed by a statement of support:

Maybe one way we could do it is to make the incentives in the collective really competitive with the incentives on the private plot. As it is now, people on the private plot
TABLE IV. SAMPLE OF EXPERT B'S R STRUCTURE

<table>
<thead>
<tr>
<th>(GIPS)</th>
<th>Interpret problem statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RARG)</td>
<td>Agriculture problem would be easy to solve if it were not for politics involved</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Could demand finances for agriculture</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Could use money for technology</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Fertilizer</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Machinery</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Heaters</td>
</tr>
<tr>
<td>(RCON)</td>
<td>These solutions are technically okay, but politically bad</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Therefore, cannot use them</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Could use money to industrialize agriculture</td>
</tr>
<tr>
<td>(ROUT)</td>
<td>Would kill off jobs, creating unemployment</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Force people to move to the city</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Cities can't absorb the people</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Need to keep labor in countryside</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Cities can't absorb them</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Not enough industry jobs</td>
</tr>
<tr>
<td>(ROUT)</td>
<td>Create large unemployed mass</td>
</tr>
<tr>
<td>(RREA)</td>
<td>This is alright for country like Turkey</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Can't absorb them</td>
</tr>
<tr>
<td>(ROUT)</td>
<td>Create large unemployed mass</td>
</tr>
<tr>
<td>(RREA)</td>
<td>This is alright for country like Turkey</td>
</tr>
<tr>
<td>(RREA)</td>
<td>We can't do that</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Nationalism too strong</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Can't ignore peasants</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Already have high unemployment</td>
</tr>
<tr>
<td>(RQUA)</td>
<td>Invisible though</td>
</tr>
<tr>
<td>(RREA)</td>
<td>People lose another jobs</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Doesn't want to drive it up higher</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Cities overwork</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Can't build cities</td>
</tr>
<tr>
<td>(RCON)</td>
<td>This is why we have tried to build up industrial base to sales</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Could allow for incentive system</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Would have to prevent capital accumulation</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Increased incentives allow some to get rich</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Few people needed in countryside if agrarian exist</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Creates serfdom and poor</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Could allow incentives on collectives only</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Would increase incentives on collectives only</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Have problem of where to get resources for incentives</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Can't raise price of food</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Tenet of socialist system to provide food for everyone so there is no starvation</td>
</tr>
<tr>
<td>(RFAC)</td>
<td>Real achievement of our system</td>
</tr>
<tr>
<td>(RREA)</td>
<td>Need to increase incentives, but not raise food prices</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>This private plot become more important source of agricultural output</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Have some problem of allowing some to get very rich</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Undermines effort to make collectives the area of real productivity</td>
</tr>
<tr>
<td>(RFAC)</td>
<td>Private plot doesn't take advantage of economies of scale</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Take advantage of labor and keep it on the farm</td>
</tr>
<tr>
<td>(GIPS)</td>
<td>Interpreted solutions</td>
</tr>
</tbody>
</table>

Problem-Solving Skill in Social Sciences

...can take their goods and sell them at the bazaars around the countryside and sell them at much, much higher prices than the collective earns and therefore make much more money. Therefore, it is in their interest to not work too hard on the collective to keep the supply of food down so that the food that comes off their private plots can be sold at a higher price. We have got to provide them with an incentive on the collective which equals the incentive on the private plot and actually attracts them away from the private plot and to the collective, which simply means much higher incentives.

As illustrated by Expert B's G structure found in Fig. 2, the remainder of the protocol is concerned with how to implement the proposed solution. Expert B first considered raising food prices, rejected this, and then proposed education and subsidization:

To do that the obvious way would be to raise prices of food, which would allow the collectives to sell at a higher price and therefore reap a greater profit and pour it back into the collective. But we can't do that. We can't allow prices of food to rise very much. Maybe minimally, but otherwise it would be socially unacceptable. People already are at a minimal level of wages. So the way it seems we will have to do it is to take the money that we would like to put into technological efficiency and instead pour it into the labor force. Pour into the labor force in two ways: (1) education, but (2) even more importantly, into simple subsidies for the collective to allow the prices to stay low.

A brief argument of support followed the solution, which in turn was followed by a statement of a problem that may arise, namely, the accumulation of capital or wealth. The remainder of the protocol is then directed toward how to prevent such accumulation, which of course is in opposition to the ideology. Expert B indicated that preventing accumulation may be accomplished by forced reinvestment, limiting options with respect to how money may be spent, for example, not permitting the purchase of land. He also argued that accumulation may also be prevented by the development of consumer products and indicated that in the short run such products would need to be imported, but in the long run they may be domestically manufactured and thus help to develop the industrial base of the economy.

In summary, Expert B developed a problem representation via analysis of solutions that would not work because of ideology, the representation being "social," and dealing with the lack of productivity on collectives, compared to private plots. Expert B thus converted the problem in a manner similar to Expert A. Expert B's solution was general, and the bulk of his protocol was concerned with how it could be implemented, that is, solving a major subproblem generated by the solution.

Expert C provided the longest protocol, although the G structure presented in Fig. 3, is relatively brief. After beginning with a constraint clarification, Expert C stated that research needed to be done to study productivity in various parts of the country, in order to determine whether...
productivity is near its potential. If it is not, then it must be determined why the productivity is low. Expert C then presented a number of examples pertaining to various parts of the country and discussed how different solutions could be developed to the problems in various geographical regions. Expert C also pointed out that this work should be done by the staff of the Ministry of Agriculture:

Once we identify those levels that are less productive than other levels, or less productive than their potential at least, then we have to figure out why. Now, hopefully all this has been done by the myriad of staff which surround the Ministry of Agriculture. (This is followed by specific hypothetical examples.)

Expert C subsequently shifted to a second issue, namely, that the issues go beyond the Ministry of Agriculture:

But those are issues which the Ministry of Agriculture itself wouldn't have the final word on. That would involve other people as well. It would involve people who would be involved in what we would call marketing and so on, but is something which would be pursued for sure.

This statement was followed by a lengthy set of arguments showing how agriculture issues go beyond the Ministry of Agriculture. But subsequently Expert C reduced the problem of working with other agencies to the first person level:

There is the whole political angle. That is, how does the Minister of Agriculture actualize whatever he sees as problem areas involved with other agencies. To a certain extent that is going to depend on how powerful he is, or I am, it is going to depend on how much pull he has. What kind of committees does he have that can kind of help him along within the Central Committee? What kind of access does he have to the Politburo? What kind of access does he have to not only the heads of ministries, which he would not just have on a formal basis, but personal access to them? What kind of favors do they owe each other? So there is the whole political thing.

Expert C, to this point, thus decomposed the problem into two subproblems. The first was the need to conduct extensive productivity analyses which then could be used to improve productivity in areas that were producing below their potential. This would be done by the ministry staff. The second was the problem the Ministry Head faces in dealing with other agencies. Furthermore, Expert C refined this subproblem by defining it as a first person political problem. Expert C thus represented the problem for the Ministry Head as political.

Expert C subsequently proposed a solution that was especially oriented for the short-run aspects of the problem, namely, since the problem is political, the solution consists of the Minister of Agriculture making sure his voice is heard. This statement was followed by an extensive discussion of how the Ministry Head may do this.

The subsequent portions of the protocol were dominated by the political theme. Expert C returned to his initial concern of having the agency staff analyze productivity geographically, but this time Expert C emphasized how improving productivity in these areas would involve political interaction. He further provided examples regarding this matter as well as how one might deal with peasants in implementing policies. Finally, he considered another issue that could arise geographically, namely, the shifting population of the Soviet Union may require decentralization of agriculture control and this would have political ramifications.

Expert C's solution strategy differed from the strategies of Experts A and B. While the latter converted the given problem into a problem for which a solution could be proposed, Expert C decomposed the problem into two subproblems, focusing especially on the second, which yielded a political representation of the problem. Expert C's solution was concerned primarily with the Ministry Head needing to act politically to implement the agricultural policies which presumably were to be developed without saying much at all about the policies themselves. Then Expert C supported his solution by showing how political skill would operate in relation to the analysis of agricultural problems by the ministry staff and this way brought his solution to bear on the solution to the first subproblem; that is, he discussed what one must do politically in various geographical regions in order to implement the policies for increasing productivity in the respective regions. Finally, we note that Expert C gave lengthy examples of specific cases which illustrated his respective points.

Experts D and E employed the strategy of problem decomposition. They differ, however, in the extent to which they provided solutions. The G structure of Expert D is presented in Fig. 4.3 This expert was the only person to use notes in any serious way, using them as a reminder to comment on something later. These comments were not included in our analyses.

Expert D decomposed the problem into five components: two constraints, ideology and elements, and three subproblems, bureaucracy, peasant mentality, and lack of infrastructure. A relatively long initial section of Expert D's protocol is presented because it shows first, a historical analysis which helps to decompose the problem, and second, a quite explicit

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3 The reader is asked to note that numbers refer to the solver's returning to issues. Basically, the G structure runs left to right in a temporal order, but when the solver returns to deal specifically with a particular issue, a number is placed at that point in the order and a jagged line followed by the number denotes the issue. Statements not analyzed are included in parentheses.
Problem-Solving Skill in Social Sciences

The problem of Soviet agriculture is a nagging and historical one which has plagued the Soviet Union virtually since its founding. By way of thinking through possible solutions, let me review what I remember of various Soviet attempts to deal with this problem (as I sit in my office surveying the tundra, and deciding). Lenin came to power with the promise of bread, peace, and land and promptly tried to requisition grain from the peasants, that is to say, to force them to give their grain to the state. That didn’t work, and it was forced on them mostly by the contingencies of World War I and the Civil War. That failed, and Lenin had the foresight to replace it with what he called the tax in kind, that is, peasants could give a certain amount of their grain to the state, and then after they were able to grow anything they wanted, sell it and dispose of it as they wished. In fact, at one point in time a member of the government even said “enrich yourselves.” He said to the peasants, “make a lot of money.” Grain production improved, more grain was delivered to the cities, but it wasn’t, it wasn’t, of course socialism. It was by no stretch of the imagination Communism, it was socialism, but it wasn’t even what you’d call pure socialism. Essentially what he was creating was, or what he was accused of creating, was a class of little rich private farmers, something that a socialist revolutionary government would presumably not want.

Stalin changed all that at the end of the twenties and the beginning of the thirties by forced collectivization, actually forcing people to yield their land up to collective farms, or state farms, in which people worked for the state or for the collective farms, much as a factory worker, and received a salary. This was pure socialism, but it also created a tremendous havoc in the countryside, produced revolution, peasants slaughtered their livestock, burned their crops, and resisted as long as they could. It is estimated that in the course of this process, perhaps 10 million people were killed or deported, or in some way deprived of either their livelihood or their life, for the greater good of Socialism and moving the country forward. That has remained the practice in the Soviet Union through the War until the middle of the fifties. And, what has also remained has been a consistent lack of efficient production and delivery. (So I’m making a note to myself that I should also comment on the fact that it is not only the system, but also natural aspects, whether infrastructure, weather, traditions, so I’m making the note to myself not to blame it all on government policy.)

Well, in the fifties as the Soviet Union attempted to bring a better life to its people, especially under the leadership of Khrushchev, and pursue what was known as the New Course in the Soviet Union, a shifting away from consistent investment in heavy hand of the state on all aspects of the economy, including agriculture, Khrushchev came up with a number of plans to try to solve this problem, and one of which is known as the Virgin Lands Plan (which I usually joke to my students is a plan by which the fields are cultivated by 13 year old girls). In fact it was a program to bring into production land that had not been used before. It failed. Agricultural production improved, but not dramatically over the course of Khrushchev’s time and Khrushchev was, among other things when he fell, attacked for producing what were known as harebrained schemes, among them the Virgin Lands Plan. There is probably no greater problem that has persisted in the Soviet Union, that has nagged the system and its governing body, than what to do about agriculture.

Now, in addition to the problems of trying to reconcile a Socialist policy with the need for production and, I hesitate to say man’s instinct because, let’s confine it to peasants, that the peasants’ instinct seems to be, across countries in history, forborne, for his
own land and for some share in his own production. That conflicts with a collective notion of some sort of government control in production, at least, making sure that people get fed. If grain is produced in the countryside, and people live in the cities, some method has to be found to get that grain into the cities, and a reasonable cost, if reasonable proportion, or otherwise, there will be chains, or even revolution and civil war, the cities of Russia emptied out as people desperate for grain left the cities in a desperate attempt to get grain. The peasant can be encouraged to grow, but will he sell, will he sell what he makes to the government? Or will he simply hoard the grain, knowing that the grain has a value itself beyond whatever he might be paid for it? Let me leave the government policy for a moment and talk about other things that affect agriculture.

First, as I’ve indicated, or sort of hinted at, there is the peasant’s own frame of mind. It’s a traditional frame of mind. The peasant is typically a very religious person, very close to his land, his family, his village, and his church. He’s very suspicious about outsiders. This is also clear throughout Russian history, when various movements would arise. Go to the People was one of them, by the sort of Russian populists, known as the Udruviks, in the nineteenth century. Go to the People, and bring them the New World, or the new revolutionary mode. I forget exactly what they were supposed to be brought, most of them never had the chance, because the peasants simply killed many of the people who came to them, certainly the tax collector, any government agent is always suspicious. So that’s problem number one. The peasantry is not only suspicious of the government, but any new methods, any new introduction of new ways of producing agriculture, he would always grow enough for himself and for his family, and, if motivated properly, might grow enough to feed other people. The question is how to motivate him properly and retain some of the Socialist principles upon which our government is based. But there are problems as well, which are less malleable, I think, and less the fault of mismanagement of the government.

One is the fact that agriculture is a particularly difficult business because of questions of weather, of soil development, of soil erosion. The Soviet Union is, for example, two and one half times the size of the United States, roughly one-seventh of the earth’s surface and yet, in terms of arable land, it roughly has about the same as the United States and less than a country like Australia, for example. So there is a problem simply of the elements, how to deal with that, in an effective way. Third, there is the problem of once the grain is grown, how to get it to the markets. The Soviet Union is a vast country with roughly, three hundred thousand miles of paved road, on a country two and one half times the size of the United States. The United States, just by contrast, has roughly some three million miles of paved road. So there’s a significant difference. When you have one railroad line going to Siberia and back, you recognize the size of the problem. There’s a similar disparity in terms of rail passage. The country covers thirteen time zones. Delivering, getting grain from the farm to the land, to the people who need it is a significant problem, even if there were not other problems of government mismanagement.

Finally, this sort of gets back to the question of Socialist principles. This is a command economy in which the government makes a plan and it’s carried out by way of decisions, that are determined by the government, how much is to be grown, how much is to be invested which is crucial in terms of agriculture, how much is to go into fertilizers, how much is to go into tractors, how much is to go into every aspect of the agricultural question. That produces an enormous sluggishness, an inflexibility to the market and to the needs of the country.

So, if I were just to review the four sets of problems (and I’m making a note to help me to remember what I just said) there’s a question of the elements, there’s a question of the peasants’, let’s say, culture (and by that I don’t mean arts and sciences, I mean his orientation to the world, his frame of mind) and finally, there’s the question of well, two finallys, one, the question of infrastructure, that is, getting to market, railroad cars, the roads, provisions, infrastructure and let me go back to point one, that is, the principles of Socialism, let’s call it the principles of Socialism management, meaning that there is a question of ideology, and question of management, that is, of plans, solving them, the plan, a problem of bureaucratic management.

The decomposition is followed by an interesting solution process. Although the next excerpt is also lengthy, the reader is asked to note how Expert D began his solution by stating that he would first deal with the peasants’ frame of mind, and then stopped and said, “I’ve changed my mind.” He then switched to the topic of what the Minister of Agriculture would “push for” politically. However, as the protocol continued, the expert brought in bureaucracy and infrastructure, and finally returned to the peasants’ frame of mind. Indeed, this section of the solution is a fascinating example of interaction among the solutions being provided to three sub-problems:

Let me begin with the peasants’ frame of mind. The peasant is a suspicious person. This is, of course, a stereotype, but we’ll operate on the basis of it to begin with, and, like all stereotypes it contains a kernel of truth. If we can assume, let’s say, that the peasant is suspicious of the government, suspicious of government actions, what needs to be done is to provide him with some sense of security. In our system, we allow peasants to have a certain amount of private land, in addition to the collective land on which he works. In fact, if it were not for that amount of private land, and it’s a small amount, that the peasant is allowed to have usually behind his house, or something like that, that he can cultivate. If we were not for that, our system would be in much worse shape, we would not be able to provide even the level that we do, which is, incidentally, better than it was ten years ago, and much better than it was twenty years ago, but still, by modern standards, poor. And, more importantly than that, volatile. 200 million tons of wheat harvest one year, and then 180 million tons the next year, a vulnerable, volatile system.

I changed my mind. I won’t start with the peasants’ frame of mind. Let’s start at the top with the question of policy. Since I’m the Minister of Agriculture, what kinds of things can I begin to push for? By saying that, I mean to indicate that I can’t make any of these decisions by flat, by simply deciding on them myself. I can only lobby, and try to get the Government and the Politburo to go along. I think that’s likely to happen because I think that everybody recognizes the seriousness and the vulnerability of the problem. Things that I would push for are greater investment in agriculture. There must be more of the state budget, which is, after all, decided by the Party, put into agriculture, put into investment, into machines, tractors, fertilizer. If the peasantry will misappropriate that and use it for their private plots, well, we have to wink at that. It seems to me that we have to look the other way. But there has to be more of that so that agriculture becomes more modern. We have missiles, we have satellites, we have extraordinary advances in computers and other technologies. There’s no reason that we can’t have the same, just in terms of the nuts and bolts, of farming in our country. So, point one would be greater investment in agriculture. Point two, point one-b, probably would be greater investment in the things that would allow the supplies, once grown, to make it to the cities. Greater investment in infrastructure, paving the roads to the countryside, certainly electrification where it doesn’t already exist, railroad cars, trucks, specifically
for the purpose of agriculture. Getting things that are grown in the land to the cities.

Okay... (I'm making a note to myself that this means taking it from somewhere else and that I'm writing down the word budget to remind myself to talk about the politics of the budget.)

The question is how to simply encourage people. Suppose we have all this investment, and railroad cars, and tractors and fertilizer, we still can't get people to use it, to pour it into the farms, especially in the state and collective farms. How can we get them to use it in an efficient, effective way and encourage people to make efficient use and productive use of resources rather than wasteful use of resources or no use of resources at all? We have to, well, I think, allow for incentives. This is under what I've written down as private enterprise, but that's not really what I mean. Well, what I mean is, private incentives which allow greater proportions, let's say, of the crops grown on the collective farm to be retained, or to be sold. Maybe make collective farms self-governing enterprises or, that's not what I mean enterprises whose profit and loss is a function of their own success, and to suggest to them that if they can grow more and they can sell more at a profit, then they can keep a certain amount and distribute it among themselves. To provide what might be called by someone else, certainly not me in the Ministry of Agriculture, capitalist incentives, incentives to increase production. To go along with offering people medals of Hero Socialist Labor if they'll produce more, we need to offer people real incentives that encourage that.

At the same time, we must recognize that the peasants' production on his own private plot is crucial to our element, if it doesn't get out of hand and people don't start becoming rich landowners, and speculators in currency, and completely destroying social strata. Then I think that we should tolerate a greater degree of profit and initiative on the part of the private plots. We should allow use of state equipment on the private plots, and lower what taxes there are on the sale of things, to allow, what in America would be called rent to farmers, to bring in goods to the cities more efficiently, more easily, even perhaps to encourage that. Along these lines, a somewhat more radical proposal, which might be a couple of more years down the road, would be to allow for the formation of genuine cooperatives. A cooperative is different than a collective farm in that it presumes the voluntary association of the farmers, their voluntary input and some degree of self-governing of their entities, genuine determination by themselves of how much they're going to make and how much they're going to invest. I think that we should begin along that... to happen, perhaps in an experimental area of the country, to see if it works. It's being done in China, it's being done in Yugoslavia, with some success. I think we ought to allow that to happen too. While being careful, of course, that this doesn't lead to a run on the collective farms and people leaving those in droves, but to see if it works, and if it increases production, and if it does, then reconsider to see if we might want to do it on a broader scale. This is related to the third point, which is the one about the peasants' orientation, the peasants' feeling of security, the farmers' feeling of security. One of the reasons, in Poland, for example, that the farms, although private, although owned by families, though also small and inefficient, have not produced as much as they might, is the constant feeling that the government might sooner or later take away what the peasant has invested. So that the peasant, for example, who makes a lot of money by selling his grain, is loathe to reinvest into the farm, and into equipment, because he's afraid—why should he do that?—because the government will take it away. Why should he raise livestock beyond what he needs, or what he can sell for a few dollars, or a few doly because there's no point in that because the government might come along and take it away. That same sense of insecurity, I think, needs to be assuaged in our country probably by the measures that I indicated before, encouraging the use of private plots, making it easier. By making a series of reassuring policy decisions, which may involve making changes in the Ministry of Agriculture where people who are more inclined to reassure the private farmer, any of the peasants, that their production goals will be achieved, that they can invest some of their money, that they will have a feeling that the government will not be there to take away the fruits of their labor (I'm beginning to sound like Ronald Reagan). But there is no place, perhaps, that the government is more involved in the people's lives than here in the Soviet Union, and if we have to ease up on that, while being assured of course that norms of socialist legality are adhered to, it might reassure the farmers, and it will take years to do so, but I think the steps have to be taken so that the peasant's feeling of insecurity will be lessened.

The G structure of Expert E, found in Figure 5, indicates that two subproblems were delineated, one involving the need to deal with issues beyond the Ministry of Agriculture per se and the other with issues of domestic and international interpretation. Following this, Expert E delineated a number of subproblems which have existed historically, and he refined some of these into more specific problems. Finally, when the issue of budget was considered as a subproblem, Expert E stated a solution which essentially consisted of presenting a plan to the Politburo. However, he pointed out in the evaluation of this solution that acceptance of the plan is quite related to the overall Politburo policies regarding investment and international relations. Expert E then proposed to try to do something to help solve the various subproblems, but he recognized that he had not really given a solution and instead had shown how extensive and involved the problem is. Expert E thus decomposed the problem into a number of subproblems, but was not able to specify a general solution.

The protocol of Expert F is not discussed in detail. The mode of solution was to decompose the problem into two subproblems, one dealing with geography and the other with worker incentives.

Particular aspects of the expert protocols are now presented, including some that were not discussed in relation to the specific protocols.

1. Experts did not articulate their highest level plans. While an expert may have mentioned the need to consider constraints, no expert spoke of a general strategy or plan to be used to solve the problem.

2. During the initial phases of protocol generation, experts showed no evidence of having a well-developed solution plan. Instead, they tended to do some type of review of the problem (three used a historical approach) from which they developed a general representation of the problem. Under what conditions experts would have a well-articulated plan is discussed later in the article.

3. As previously noted, the solution strategy to problems such as the Soviet Union agricultural problem is to isolate one or more of the factors producing the problem and to solve the problem by eliminating the effects
of the factors. While this strategy was used by everyone, two more specific problem solving strategies were employed. Problem conversion was used by Experts A and B and, in a sense, by Expert C in that Expert C converted the problem into a first person political issue. The other strategy employed was problem decomposition, used by Experts C, D, E, and F. (How consistently a particular expert would use the same strategy for a number of problems is a question of interest, but it is beyond the scope of this contribution.)

4. Experts generated subproblems in two ways; they either stated a subproblem as part of a decomposition process or they “encountered” subproblems when they were exploring the implications of a proposed solution. This is an important distinction, for it is primarily the experts that generated subproblems via the second mechanism.

5. A large proportion of the contents of expert protocols consisted of R structure information. Possible reasons for this were discussed earlier in the article, but the protocols make it abundantly clear that the expert frequently explores the ramifications of the proposed solutions and provides extensive supportive argument.

6. The nature of the solutions offered by experts, regardless of strategy, is to find one general solution which is able to solve the problem as it had been represented. Indeed, one expert, E, indicated that he was unable to provide a solution when he could not come up with this type of general statement even though he suggested that subproblems could be handled on an individual basis.

E. NOVICE AND POSTNOVICE PROTOCOLS

Novice protocols are characterized by problem decomposition in which solutions are proposed for a number of relatively low-level subproblems, for example, need more fertilizer, need more tractors. This decomposition, on occasion, even takes the form of a listing. Figure 6 presents the G structure of the least developed novice protocol, while Fig. 7 presents the G structure for one of the most developed novice protocols.

With respect to the R structure, novice protocols are characterized by a lack of argument. While some novices provided support for their solutions, the support was generally weak. Furthermore, novices quite typically did not evaluate solutions in terms of ideology or some other constraint and they did not specify subproblems that could be encountered when proposed solutions were implemented. The protocol for the novice whose G structure is presented in Fig. 6 had no R structure, while the R structure for the novice of Fig. 7 is presented in Table V.

As previously mentioned, six novices received the Soviet agriculture prob-
lem both at the beginning and the end of a course on Soviet domestic policy. An interesting finding is that there was relatively little difference in the form and contents of the protocols.

F. GRADUATE STUDENT PROTOCOLS

The protocols of the three first- and second-year graduate students form an interesting transition between novice and expert performance. While the graduate student protocols involved problem decomposition in a manner similar to the novices, the subproblems were more abstract than those of the novices but not as abstract as those of the experts. For example, while novices suggested the need for tractors, and the experts suggested the need for infrastructure development, graduate students stated the need for better machinery, better transportation, and more money for agricultural development. Figure 8 presents the G structure for one of the graduate student protocols.
An aspect of the graduate student protocols is that, on occasion, when a solution was proposed, implications of the solutions were considered, including subproblem development. However, while graduate students examined such implications, they provided nowhere near the argument development found in expert protocols. Table VI presents one of the more extensively developed graduate student arguments.

Briefly stated, the picture that emerges regarding the protocols discussed thus far is that, with the training and experience involved, the path to expertise includes: (1) isolating more abstract or general problems as being the primary factors producing the given problem, and in so doing, making lower level problems subordinate to the more abstract problem, (2) in a related way, stating a general or abstract solution which also solves subordinate problems rather than stating, as solutions, the solutions to more specific problems, and (3) developing much greater skill in examining the implications of stated solutions, especially in providing support for particular solutions, stating what subproblems may emerge in relation to the solutions, and evaluating solutions in relation to constraints.

G. **Nonexpert Expert Protocols**

This category of participants refers to four advanced graduate students and two faculty members who are in political science but whose field of expertise was not the Soviet Union. Figure 9 presents the most developed
TABLE V

SAMPLE OF NOVICE R STRUCTURE

<table>
<thead>
<tr>
<th>(RARG)</th>
<th>Would have to use nationalistic incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>(REA)</td>
<td>Personal incentives are capitalistic, not communist</td>
</tr>
<tr>
<td>(REL)</td>
<td>Nationalistic incentives—for the better of the people and the USSR</td>
</tr>
<tr>
<td>(REL)</td>
<td>Convince people to work harder for more growth of the USSR</td>
</tr>
</tbody>
</table>

G structure of an advanced graduate student. His area of specialization is Latin America. The protocol indicates the following:

1. Problem decomposition occurred, with solutions offered to the subproblems. There is, however, no general solution as found in expert protocols.
2. The subproblems are more general than those defined by novices and resemble more those defined by experts.
3. There is a larger argument development than found in novice or beginning graduate student protocols, including some argument by analogy. Furthermore, the argument development sometimes refers to general political issues.

An example of this person's R structure is found in Table VII.

Figure 10 presents the G structure of one of the faculty. This person's area of expertise involved domestic policies such as taxation. As shown, this solver has a relatively undeveloped protocol, emphasizing the ideology constraint and what solutions may be proposed while working within that constraint. The solutions are of a general political nature. Argument development is relatively weak, as shown by an R structure presented in Table VIII.

TABLE VI

SAMPLE OF GRADUATE STUDENT R STRUCTURE

<table>
<thead>
<tr>
<th>(GSUP)</th>
<th>Support that subproblem of opposition exists</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RARG)</td>
<td>There is going to be a lot of opposition</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Can increase incentives, but against the socialist system</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Measures I might propose might be rejected by Politburo</td>
</tr>
<tr>
<td>(RSAS)</td>
<td>Kieryenka might reject measures</td>
</tr>
</tbody>
</table>
We also gave this solver a problem in her own area of expertise, a problem involving income tax. Figure 11 presents the G structure for the obtained protocol. While the form of the G structure is similar to that shown in Figure 10, the contents are more abstract in the individual's own area of expertise. There is a top-down, breadth-first decomposition defining two problem areas termed "horizontal equity" and "vertical equity." The solver then indicated what could be done to solve problems related to both of these areas. Furthermore, there is a much more developed R structure than found in this person's Soviet agriculture protocol, as shown by the account presented in Table IX.

Comparing the two protocols generated by this individual provided some interesting information. First, a general problem-solving strategy was applied in both problems. However, the subproblems and solutions are quite generally political for the Soviet problem, and little more than a superficial knowledge is demonstrated with respect to subproblems and solutions and R structure contents. In contrast, the G structure contents in the person's area of expertise are more specifically related to the issues, even though they are stated in an abstract manner similar to that of Soviet experts. In addition, the R structure development, including issues of support, evaluation, and subproblem development are also highly similar to the Soviet experts' protocols.

H. CHEMIST PROTOCOLS

Of the four protocols of chemists, three strongly resembled those of novices, especially in relation to the level of problem and solution considered as well as to the lack of exploring solution implications. The fourth chemist provided a much more developed protocol, which, while not demonstrating an extensive knowledge of the Soviet Union, nevertheless demonstrated a
sensitivity to bureaucracy. Figure 12 presents the G structure of this protocol. With respect to the R structure, this solver at times demonstrated evaluation based upon ideology and government bureaucracy.

I. MISCELLANEOUS PROTOCOLS

The protocol of the foreign service officer was quite pragmatic in that he indicated what would be done if the Ministry Head was a technocrat. This person also stressed the need for more information. As to structure, the foreign service officer isolated a few subproblems, and these are presented in Fig. 13. In addition, there was relatively extensive argument development concerning why particular steps could not be taken.

The Eastern European scholar made a strong statement regarding the ideology constraint, isolated the problems of infrastructure and incentive, and then proposed the interesting solution of funding two “think tanks,” one to deal with technological issues and the other to deal with socio-psychological problems. This person’s G structure is presented in Fig. 14. The R structure of this person showed supportive argument and evaluation, but it was not developed as extensively as experts.

VI. The Acquisition of Social Science Problem-Solving Skill

The question considered in this section is what the present research suggests regarding how social science problem-solving skill develops. Before
TABLE VIII
SAMPLE OF DOMESTIC POLICY EXPERT R STRUCTURE
(AGRICULTURE PROBLEM)

(GIPS) Interpret problem statement
(RARG) Would have to assume that I am a Communist Party loyalist
(RSAS) I have been brainwashed for years and years with Marxist–Leninist
(RPSC) Certain options would be available in other countries, but not USSR
(RPSG) Private incentives
(RSAS) Payments to farmers
(RELA) Subsidies to encourage individual effort
(RSAS) I know our balance in payments is screwed up
(RREA) Because we have to import so much
(RREA) I am not allowed to do anything about it though
(RREA) Because I would be shot down

Getting into this issue, however, we consider which components of such skill appear to be domain specific and which are more general.

The present research suggests that two aspects of the skill are general. One is the individual's knowledge of the physical and social world, which may be assumed to constitute a database common to all individuals. The other is knowledge of and ability to use quite general problem-solving strategies. Thus, all participants tried to isolate one or more factors producing the agriculture problem, and they did this in a reasonably straightforward manner.

The exception is the experts whose method of isolating the primary factor(s) usually included a rather extensive problem analysis.

On the other hand, one component taken to be domain specific is knowledge of the subject matter, that is, declarative knowledge (Anderson, 1982; Ryle, 1949) related to the Soviet Union. A second domain-specific component consists of problem-solving strategies that tend to be used within a particular subject matter domain. Furthermore, two types of such strategies may be discerned. The first involves strategies that are not content specific, but nevertheless tend to be used in particular subject matter areas. Problem conversion is one such strategy, and is demonstrated by some of the Soviet experts. Thus, while problem conversion is no doubt used in many domains, the present research suggests that the more sophisticated individuals working within the social science domain may use this strategy while the less sophisticated do not. In this sense the use of the strategy is taken to be a function of experience working in the domain. The second class of strategies that is taken to be domain specific consists of those modes of problem analysis found in particular domains, an example being the historical analysis of the experts on the Soviet Union. Other domain-specific strategies would include how to set up proofs in geometry (Greeno, 1978) and how to decompose a software design problem in computer programming (Jeffries et al., 1981). Thus, while the "world" information and general prob-

![Fig. 14. G structure of East European scholar.](image-url)
Problem-solving strategies may be acquired from a number of sources; domain-related information and strategies are assumed to be acquired within the domain via experiences which provide opportunities to utilize and organize the information. Such experiences no doubt include reading, writing, listening, and solving problems within the particular domain. We now turn to a cross-sectional type of analysis of the current findings in order to present some ideas regarding the acquisition of social science problem-solving skill.

The novices of the present research had some knowledge of the Soviet Union but were not effective in using it in the problem-solving context. Moreover, their knowledge seemed to consist of "bits and pieces" of information that were not well integrated. The postnovice protocols were not appreciably different from those of the novices, a finding which suggests that, although the individuals acquired information related to the agriculture problem during the academic course, they were not successful in utilizing this information when given the problem at the end of the course. We would suggest that this result occurred because the course provided little opportunity to organize information in relation to issues such as agricultural productivity.

Compared to the novices, first- and second-year graduate students showed three changes, although these did not apparently occur as well-defined stages. First, some knowledge of subproblem interaction was shown, even though the various subproblems were described in a manner similar to novices. Second, the subproblems were stated at a little more abstract level than those stated by the novices and postnovices. Third, more reasoning was shown, in the sense of support and evaluation.

The three changes suggest that learning within the domain includes the use of declarative knowledge to construct three types of structures. First, conceptual networks are constructed and continually expanded. This construction provides the individual with increasing knowledge of relations among concepts, facts, principles, etc. Second, in a related way, the individual constructs causal relations among these factors which provides the knowledge of the interdependencies that exist within a domain. It is this knowledge, moreover, that enables the individual to develop argumentation. Third, the individual develops hierarchical structures, a finding of particular interest because such development is quite clearly an important aspect of expert performance. (A possible reason for developing hierarchical structures is to handle the magnitude of information one is arguing; cf. Simon, 1969.) Thus, the expert sees the lack of fertilizer, lack of repair parts, lack of infrastructure, etc. as elements related to a more abstract concept, lack of capital investment. Furthermore, the hierarchical organization in all likelihood enhances the ability to retrieve information.

The performance of graduate students and faculty with expertise in social science areas other than the Soviet Union and the performance of chemists also suggests some points regarding the acquisition process. First, when expertise is acquired in a field such as political science, it may be assumed that one acquires domain-related strategies and a data base within one's field of expertise. However, when confronted with a political science problem outside of one's specialization, and for which one does not have a substantial data base, the individual tends to fall back upon more general knowledge of the field and of the topic in question when utilizing the domain-related strategies. Furthermore, while the social scientists demonstrated the use of solution strategies but lacked a Soviet Union data base, the chemists apparently lacked both the data base and the domain-related strategies. However, we do not know of course whether the chemists "really" lacked the strategies or whether the lack of the data base did not provide them with the opportunity to utilize the strategies.

Turning now to the experts, in addition to the components of skill development discussed thus far, the most obvious factor contributing to expertise is the varied exposure to issues and problems of the particular field. Such experiences, it may be assumed, provide multiple patterns of organization that are constructed and stored. Furthermore, these patterns are probably highly context dependent. For example, let us assume that the experts of the present study had never really considered specifically why agricultural productivity was low in the Soviet Union and that the protocols generated represent what happens. The expert typically performs an analysis of the problem, for example, an historical analysis, and the expert presents a solution, combined with an examination of the implications of the solution. But now assume that the expert is asked repeatedly how agricultural productivity in the Soviet Union could be increased. In all likelihood, an expert's answer would become less variable with repetition; whereas the first time that the expert was confronted with the problem it was necessary to conduct an "organized search," this becomes less necessary with repetition, and whenever the issue of Soviet agriculture comes up, the expert has readily accessible organized information. Thus, as the expert considers more issues such as the agricultural problem, the expert organizes information according to the problem context. Finally, the patterns of organization also give the expert an added advantage, for if the expert acquires new information about a particular issue, it is quite likely that the information is stored in relation to the existing structure and thus is also readily accessible when that issue arises again.

The experiences that enhance the expert's knowledge organization no doubt cover a wide range of issues and problems, and the expert thus develops a highly flexible information-processing system. It is flexible in the
sense that domain-related information, whatever it is, may be readily interpreted in terms of existing structures, and new information may be assimilated into the appropriate structures. In a general sense then, the expert social science problem solver thus begins to resemble the chess expert (Chew & Simon, 1973) in that experience provides for the development of a large number of patterns which the expert may identify. (If the reader wishes to assume the expert has many Soviet Union-related schemata, we have no objection. We do, however, feel that the schema concept and especially the script concept have come to connote more rigidity than actually found with expertise.)

Our discussion of skill development has been at a global level. The more detailed mechanisms by which the structures are developed and knowledge is organized are not considered here. However, we would note that mechanisms such as those proposed by Anderson (1982) are compatible with the notions expressed in this paper. For example, in Anderson's model, the proceduralization mechanism involves converting declarative knowledge into procedural knowledge. What we referred to as patterns of organization developed by the experts' application of strategies would in Anderson's model be regarded as procedural knowledge in that the knowledge is employed as a set of procedures to solve particular problems.

VII. General Considerations

A. Task Environment

Two interesting statements were made by one of our participants not mentioned previously. He is a Latin American expert who has frequently appeared on television and radio interviews discussing such issues as the policies of the United States in El Salvador. The problem that he was given was as follows: "Assume that you were a high-ranking State Department official and were asked by the President to suggest how the United States should change its policies toward El Salvador. What would you suggest?"

Contrary to the protocols generated by all other experts, this individual immediately stated his solution, which was relatively abstract, and which emphasized the need to assemble the leaders of various political factions and enter into negotiations. For our purposes, the important point is that this individual later indicated that the wording of the question made it unnecessary for him to go through a preliminary development of what the situation in El Salvador was, how it had developed historically, and what the current United States policy is and why it is not working. The solver indicated that the fact that the problem stated a new policy was needed presuming this. Furthermore, this individual indicated that he had been thinking about this issue for a long time and that he knew what he felt the solution should be and he therefore was able to state it without hesitation. This supports our notion that when an issue has been considered often, a solution is readily accessible.

Another interesting observation is that this solver indicated that in giving his protocol he was, in the context in which the protocol was given, not hesitant to make statements which would suggest his own political inclinations. However, he indicated that if he were in a public interview, he would only make statements which he would be able to support by argument and he would try not to show his own political preferences.

In a similar vein, at a recent conference held at the University of Pittsburgh, a State Department official, in replying to a question pointed out how problem solving is influenced by what the next in command would accept or reject. (This factor is no doubt highly significant in government and industry problem solving, but of course not in academia.)

These observations are highly instructive. They suggest that experts need not develop extensive problem representations when (1) the wording of the problem suggests that this is not necessary, and (2) when the solver already has a solution in mind. Also, the observations indicate how the surroundings in which the problem is presented may provide constraints and influence what the individual states. Indeed, there apparently are "audience effects" in social science problem solving just as in writing and speaking. We might add that the bulk of our research has been conducted in a relatively "open" atmosphere and the solver is aware that anonymity will be preserved. In this respect constraints were hopefully reduced.

B. Problem Space

The problem spaces established by novices and postnovices appear to be quite limited, while those of the more experienced solvers are of course much more filled with information. Furthermore, there is some evidence that the problem space may expand as the expert solver advances his or her solution. This occurs when the solver comes to issues that were not part of the original representation.

C. Problem Representation

The issue of problem representation is central to the solving process, especially for experts. The following additional finding is of interest with respect to this matter.

We presented experts and novices with an international problem in which we asked that one assume herself or himself to be a high-ranking U.S. State
Department official who is asked to formulate a workable foreign policy with respect to the Soviet Union. However, in so doing, the individual was asked to take into account a large number of factors, including Eastern European countries, Western European countries, one's own political party, popular opinion, position on SALT, cultural exchange, etc. Without exception, novices went down the list of things to consider and indicated what should be done with respect to each item. Experts, on the other hand, spent considerable time on problem representation. One expert (Expert B in the present research) gave a highly instructive protocol. He initially indicated that the policy will depend upon one's perception of the actions and motives of the Soviet Union and whether one thinks that the Soviet Union is basically aggressive or reactive (political science distinction). This person said that he felt that the Soviet Union is basically reactive and provided extensive argument for why he thought this to be the case, using primarily examples of Soviet actions. Only after much argument development did this solver get to specific issues which in his protocol were subordinate to one's attitude toward the Soviet Union.

This protocol and those of other experts illustrate a point which could not be demonstrated in the Soviet agriculture problem solutions, namely, that the problem representation and what follows can be highly influenced by one's attitudes and motivations. Indeed, one has the idea that government policy development is apparently quite influenced in this way.

D. Solution Activity

While decomposition was clearly the predilection of the less experienced solvers, this strategy was also found in expert protocols. Thus, while decomposition may be assumed to be a quite general problem-solving strategy, which is used for the "something is wrong, do something about it" problem, the experience of social science experts, as previously noted, provides the experts with strategies that may be used effectively in their domain. Furthermore, the faculty member having United States policy expertise demonstrated a top-down, breadth-first strategy for a problem with which she was highly familiar. Finally, we note that it was primarily the experts who showed evidence of opportunistic solving and constraint posting. This finding is reasonable because only experts examined the implications of their solutions, and therefore had an opportunity to encounter a subproblem or constraint. In these instances, the experts handled the new subproblem or constraint before proceeding further with the argument.

One of the major findings of the present research is that experts spend a large amount of time on argumentation. At first glance, one may conclude that natural sciences and social sciences may be fundamentally different in this regard, with little argumentation found in natural sciences. However, this is not really the case. Our view is that the major factor producing the social science and natural science differences in solving activity is that, as noted earlier in this article, problems in fields such as physics have been well worked out. This is particularly true for those problems used in problem-solving research, (e.g., Larkin et al., 1980). On the other hand, few social science problems have agreed upon solutions. While we are not aware of any research on the problem-solving activity of a scientist when trying to solve a problem that has not been worked out, some interesting work by Tweney (1981) is germane. Tweney has studied the notebooks of Michael Faraday, especially in reference to Faraday's process of confirming or rejecting hypotheses. The interesting observation in the present context is that in studying the (previously unsolved) problem of electromagnetic induction, Faraday apparently proposed one or possibly two basic solutions and studied the implications of these solutions. Faraday's notebooks thus apparently portray a solving process similar to the present work. A difference, however, is that Faraday developed arguments which led to experimental tests that could be conducted and refined within a short period of time in his laboratory. Testing hypotheses in social sciences, however, tends to be a much more protracted process. Thus, the relatively large amount of argumentation found in social sciences may be attributed to the fact that the problems do not have agreed upon solutions, whereas the problems studied thus far in natural sciences have well-formulated solutions.

E. Evaluation

Evaluation was employed in the present research primarily by the solvers who had more domain-related experience. There was little evidence of a straightforward means-ends analysis. The evaluation process more closely resembled a generate-test method, although the solutions were generated in a highly developed way. The evaluation process occurred via two mechanisms: direct, that is, evaluating a solution in relation to a constraint, and indirect, that is, providing support for a solution by exploring its implications with respect to what it would accomplish. In a sense then, evaluation is a jurisprudence process in that a person builds a case for a particular solution.

VIII. Concluding Remarks

We close this article with three brief comments. First, while this work is exploratory, it nevertheless does demonstrate that the solving of complex
and ill-defined as well as "real-world" problems is amenable to study. Second, the research provided information concerning protocol analysis as a method, and suggested some ways in which protocol contents may be influenced. Third, the research provided a sketch of the processes involved in learning the skill of social science problem solving, emphasizing the importance of experience in providing ways of organizing information so that it subsequently may be utilized in further processing.

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