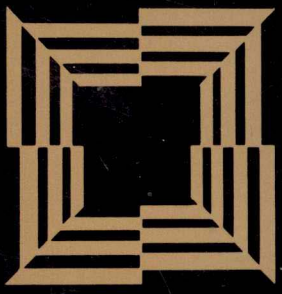
THE HANDBOOK OF PROBLEM SOLVING



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An Analytical Methodology

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Preface

ANALYTICAL PROBLEMS of all shapes and sizes surround every analyst, decision-maker, and manager. Yet the methods by which solutions are developed and applied to such problems tend to be static. In fact, analytical problems of all natures are generally approached with routinized and familiar methodologies—regardless of how applicable to the problem at hand they might be. Indeed, methodological myopia is even exacerbated by office proximity, where the location of an analyst's office vis-a-vis his colleague's can determine the number and kind of methodologies considered.

Yet another problem has to do with the time lag connected with the "discovery" and refinement of analytical methods and their introduction into the "field." Too often new methods are conceived and tested in academic or other non-mainstream laboratories and never find their way into the field, or do so only after years have passed. Relatedly, decision-makers seldom have the time or opportunity to learn about new analytical methods on their own and, unfortunately, organizations—be they private or public—infrequently create self-study incentives or offer on-the-job refresher seminars or training courses in analytical methodology.

Finally, there are organizational and situational issues which hover in and around the problem-solving process which are almost always discounted by problem-solvers. Such issues, including problem definition, urgency, and complexity, are generally the most critical to successful problem-solving because they necessarily determine the correct selection and use of competing analytical methodologies. For example, if a problem must be solved in two days by two individuals, how should those individuals select and reject alternative methodologies? Ideally, they would do so based upon situational (in this case, short time and short staff) constraints and related methodological strengths and weaknesses. Unfortunately, however, since relationships among organizational tasks and optimal methodologies are seldom established or explicitly known by decision-makers, unproductive or inappropriate methodologies are frequently selected.

This handbook is targeted at such problems. It is designed to acquaint (and reacquaint) decision-makers, managers, and analysts with a whole set of methods and

techniques which might be of invaluable analytical use to problem-solvers of all kinds. It is explicitly oriented to pragmatic applications; you will find very few purely theoretical discussions here.

The scope of the book is interdisciplinary. Instead of concentrating upon the analytical approaches and methods indigenous to one or two disciplines or fields of inquiry, I have selected for presentation those approaches and methods ripe for application—regardless of their origin. Accordingly, this book is oriented toward bridging the gap between those who develop and test analytical methodology and those who must solve real analytical problems.

The handbook itself is organized around the primary tasks which analysts and managers must perform when they deal with complicated problems. These tasks include:

- Organization
- Description
- Explanation
- Prediction and Forecasting
- Prescription (or Decision-Making)
- Evaluation
- Documentation
- "Defense" (Argumentation and Presentation)

Organizational tasks include those which must be performed in order to prepare for successful subsequent analysis. Not unlike the weekend golfer who avoids the practice tee all week, most analysts fail to bring to their analytical problems the set-up skills necessary for successful analysis. Some of these skills include requirements analysis, problem structuring, data identification, and talent, or expertise, assessment.

Requirements analysis and problem structuring involve answering a simple—but too often ignored—question: "What specific kind of analytical problem must I solve?" A good deal of research indicates that far too many of us fail to solve problems because we fail to define them accurately and, consequently, frequently select the wrong problem-solving method.

Problems must therefore be identified, defined, and structured according to their analytical category, substantive nature, urgency, and formality: "Is this a short-range forecasting problem?" "Is it an option selection problem?" "Am I only to describe the situation?" "Have I hours to solve the problem or weeks?" "Will my 'answer' become a report to my boss or will it be primarily for my benefit?" These questions are some of those connected with the organization and problem-structuring tasks.

Data and expertise requirements must also be established before an analysis is undertaken. "Will large amounts of data and an equally strong set of experts be required?" "Can I get the data I need?" "Can a one-man team handle the problem?" "Or will we need a team of experts to generate and process the data?"

Already we can see interrelationships developing: the nature and urgency of a particular problem will determine to a large extent data and expertise requirements. Yet how often are such organizational tasks performed as though they are distinct and unrelated?

Not only do the answers to some organizational questions determine the answers to others, but they all determine the optimal analytical method to be selected. Problem complexity, data requirements, available time, and the like all determine the method best suited to solving the problem at hand.

Descriptive tasks comprise one kind of analytical problem. They are perhaps the most numerous. They can also be the most frustrating and time consuming. But descriptive methods and techniques are also numerous, if not always widely known. They include statistical profiling, taxonomy building, and sampling, among others. On the substantive side, one can select a whole host of approaches to direct and inform such descriptive methods, including historical approaches, psychological approaches, communications approaches, and engineering approaches.

Explanation generally implies and often assumes causality. But causal methodology is not the only methodology by which explanations of events or conditions are generated. While historically skirts are known to rise and fall as the stock market rises and falls, few would suggest any causal relationship between skirt lengths and stock market activity. But many would argue that an *association* exists between the two phenomena. While certainly not as precise as causal explanations, explanations based upon observed associations can constitute useful (though sometimes dangerous) explanations of important phenomena.

Prediction and *forecasting* are often necessary analytical activities. However, few problem-solvers are aware of the many easy-to-use methods at their disposal, methods which range all the way from subjective Bayesian to the hardest quantitative-empirical. These and other methods, as well as the costs and benefits of each, are presented in special detail and context in the handbook.

Often following a descriptive, explanatory, or predictive analysis, decisions must be made regarding which option to implement. This task is *prescription*, and, as with all of the other tasks, there are many available methods ranging from operations research to decision analytic methods and techniques based upon classic (and not so classic) decision tree structuring. A variety of strategies are presented here.

Evaluation problems come in all shapes and sizes. Often problem-solvers are required to evaluate the performance of some piece of equipment, software, reports, people, and options in terms of how they all contribute to a goal or compare against members of the group under evaluation. Most popular evaluation techniques, however, fail to recognize evaluative criteria, criteria weights, and procedures for calculating "worth" logically. Building upon utility theory, the handbook presents several techniques which permit manual or computer-based evaluations.

A special kind of evaluation is *resource allocation* with its associated cost/benefit analytical requirements. The handbook explains those methods based upon subjective criteria and data as well as those which are quantitative-empirical.

All of these techniques require the problem-solver to engage in some form of *modeling* prior to analysis. The handbook looks at models from a functional point of view and discusses the applied essence and proper use of several kinds of models and modeling.

Unless solutions are *documented* properly, they are invariably misunderstood, misapplied, or forgotten. The handbook presents strategies for "packaging" solutions of all natures so that they can be assimilated readily into the administrative and analytical processes of the surrounding environment. These strategies begin with the fundamentals of report preparation and proceed all the way to effective distribution.

Finally, unless a problem-solver can successfully *defend* his or her conclusions, the fruits of labor are generally lost. But how many problem-solvers appreciate or understand the mechanics of solid presentation and argumentation? The handbook examines and illustrates the costs of poor argumentation and presentation and outlines techniques for effective defense.

In addition to all of the above, special attention is given to the *role of the macro-, mini-, and microcomputer in the problem-solving process.* Perhaps surprisingly, in spite of the revolution in analytical and scientific computing, very few problem-solvers are aware of the opportunities and capabilities resident in today's computer—many of which are desktop, inexpensive, and preprogrammed. Computer-based systems for virtually every analytical problem now exist in one form or another and are discussed in detail in problem-solving contexts throughout the handbook. Attention is also given to how a computer-based solution to a recurring or particularly recalcitrant problem or set of problems can be developed cheaply and quickly. Finally, the inappropriateness of some computer-based problem-solving is discussed.

It is hoped that the twelve chapters in this handbook combine to:

- Characterize problem-solving as a process comprised of interrelated and interdependent sub-processes.
- Increase awareness of antecedent problem-solving requirements and constraints.
- Introduce problem-solvers to the array of approaches and methods available for organizational, descriptive, explanatory, predictive, prescriptive, and evaluative problem-solving.
- Present techniques for the successful documentation of solutions.
- Present techniques for effective solution defense.
- Define the optimal role of the computer in the problem-solving process.

Every attempt is made to present the material in a manner consistent with productive use. However, since each chapter might well fill an entire volume, this handbook

should not be viewed as a comprehensive text in applied analytical methodology. Bibliographic essays thus appear after every chapter for the reader who wants additional information. Illustrative examples of analytical methodology at work also appear throughout this handbook, and a glossary is presented at the end of the book for quick reference purposes.

Acknowledgments

TEN YEARS ago I began to approach problem-solving systematically. Since then I have studied, misunderstood, applied, and forgotten a lot of analytical methodology. I have also incurred a large intellectual debt along the way to a great many individuals, including—but certainly not limited to—Drs. Jonathan Wilkenfeld, Clinton W. Kelly, III, Don C. Piper, Robert A. Young, and Gerald W. Hopple. Wilkenfeld showed me how to quantify everything. Kelly introduced me to the joys of expert-generated data and the Reverend Thomas Bayes. Piper helped me keep it all in perspective, while Young instructed me convincingly that it is better to solve a problem partially or even temporarily than to debate endlessly about how to proceed. Hopple has witnessed it all and is still improving my work.

I would also like to acknowledge the advice and suggestions of the Central Intelligence Agency's Information Science Center's Office of Training and Education which critiqued an earlier version of this handbook, and Mr. Wayne Norby, of the above office, for the opportunity to present the material to a group of intelligent and forthright professionals.

In spite of this collective debt, I alone am responsible for any errors in the handbook. It is hoped they are few in number and of little real importance.

S.J.A.
Marshall, Virginia

Contents

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The Process of Problem-Solving

IN SPITE of philosophical arguments to the contrary, all problems are categorizable and solvable. This of course is not to argue that all solutions are durable or that anyone can solve complicated problems. Rather, it is to suggest that problems can be categorized and "solved" *if* one has an appreciation for the general and specific processes of problem-solving *and* an understanding of precisely how the many available analytical methodologies can be most profitably applied.

But what kinds of problems do we most frequently face? Clearly they who generate problems seldom characterize them as belonging to a particular class; nor do they as a matter of course suggest useful analytical methodologies. Instead, problem-generators simply communicate their desire to determine a range of alternative marketing strategies, assess the likelihood of a product price increase, evaluate personnel, and describe in perfect detail "where the money went"; and then they tell you when they need the answer. So long as the answer is clear and relevant to the original problem, the consumer usually cares little about exactly how it was produced. Problem-solvers are thus frequently in a position to select analytical methodologies and thereby exert a powerful influence upon the problem-solving process. Indeed, as we will see elsewhere in this handbook, the selection of a particular methodology can dramatically affect the timeliness, content, and use of analytical solutions; those who select and implement methodologies can therefore dramatically affect the processes of organizational problem-solving in ways which are at times incalculable.

General Problem-Solving Processes

The American College Dictionary defines a *process* as "a systematic series of actions directed to some end." Presumably the series of actions has a beginning, a middle, and an end, and that the actions therein are somehow interrelated.

The notion of process is by no means new. We are all familiar with the processes of government, policy processes, and the processes of internal combustion engines. Yet when we think about analytical problem-solving we tend to see it as comprised

of a set of unrelated tasks. Obviously, problems have origins, give rise to analytical strategies, are studied, and sometimes solved. But each of these components is generally treated as relatively independent.

The problem with such perceptions is that they frequently exclude key components of the problem-solving process and, just as dangerously, fail to recognize the dependencies which exist within and throughout the process.

In virtually every professional environment today, problems and the process of problem-solving are characterized by as many "social," administrative, bureaucratic, and organizational variables as they are by substantive analytical ones. No longer is a problem just a problem. Problem-solvers must assess all of their capabilities, organize, analyze, present, and defend their work in a multifaceted environment which may actually inadvertently inhibit the process of problem-solving and the absorption of "findings." For example, as criminal attorneys have known all too well for some time now, the success or failure of one's arguments may depend as much upon the way they are presented as upon how well constructed (that is, how internally consistent) they may be. Similarly, regardless of how competent a problem-solver may be, his or her success or failure may well depend upon the depth and attitudes of available support personnel. Finally, unless the real problem is defined and matched perfectly with the "right" methods and approaches, all is lost.

Graphically, the general problem-solving process can be visualized as suggested in Figure 1.1. Note that regardless of the purposeful nature of the problem-solving

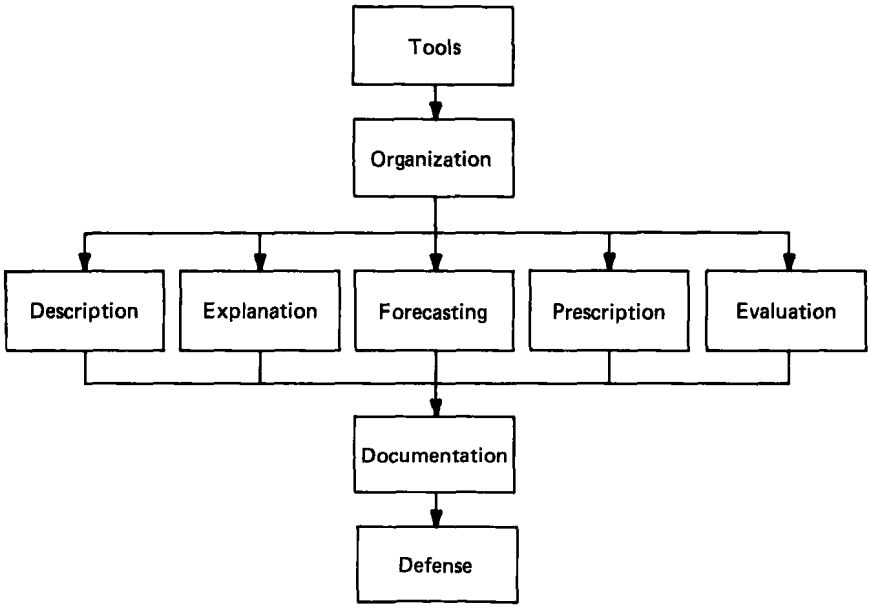

FIGURE 1.1
THE PROBLEM-SOLVING PROCESS

process there are four constants: the assessment of problem-solving tools, organizational tasks, and solution documentation and defense.

SPECIFIC PROBLEM-SOLVING PROCESSES

Figure 1.1 suggests the general sequential steps one should take in order to solve complicated problems but sheds little light upon how one should proceed to solve specific problems. The following chapters survey this terrain. Following discussions regarding the tools of problem-solving and organization, this handbook turns to the specific steps necessary to implement a whole host of computer-based and noncomputer-based analytical methodologies, how to document analytical results, and how to defend the results under conditions of relative organizational harmony and skepticism. Figure 1.1 may thus be treated as the blueprint for this handbook.

SUMMARY

Above all, it is essential that problem-solvers regard problem-solving as a process comprised of a set of interrelated analytical steps which always involve an assessment of tools, the performance of organizational tasks, problem categorization, and solution documentation and defense. Any deviation from this perception will undermine problem-solving efforts.

BIBLIOGRAPHIC ESSAY

Problem-solving is as much a matter of perspective as anything else. For example, one's orientation to change can determine whether or not a problem is resolved. Russell L. Ackoff, in his *The Art of Problem Solving* (New York: John Wiley, 1978) discusses problem-solving flexibility particularly as it applies to problem definition. He also looks at the role which creativity should play in the problem-solving process. The book is also filled with a number of case studies and ends nicely with a chapter devoted to how to keep problems solved. L. Thomas King's *Problem Solving in a Project Environment* (New York: John Wiley, 1981) is also a very useful problem-solving introduction and overview, as are Joseph E. Robertshaw, Stephen J. Mecca, and Mark N. Rerick's *Problem Solving: A Systems Approach* (Princeton, N.J.: Petrocelli Books, 1978), and Charles Magerison's *Managerial Problem Solving* (New York: McGraw-Hill, 1974). In his "Don't Jump to Conclusions," Warren Eberspacher (*Inc.*, August 1980, pp. 67–70) presents a general method for approaching managerial and organizational problems which is grounded in assumptions about the value of brainstorming and group problem-solving. The short article is useful because it presumes that problem-solving is generally too complicated to be attempted by individuals and is most productive when approached by a well coordinated team. Alex Osborn's *Your Creative Power* (New York: Charles Scribner's Sons, 1949) also presents some techniques for group problem-solving and idea generation. Kenneth J. Albert's *Handbook of Business Problem Solving* (New York: McGraw-Hill, 1980) is an excellent compendium of articles on virtually every aspect of managerial and administrative prob-

lem-solving with specific sections devoted to management strategy, planning, and control, management organization, staffing, and development, marketing, new product problems, human resources problems, information systems and data processing problems, cost control and cost reduction, production, and physical distribution and materials management problems. While some of the contributions to this enormous volume are targeted at specific substantive problems, many others are generic and therefore of particular relevance to the general process of problem-solving. Similarly, James Adams' *Conceptual Blockbusting* (San Francisco: San Francisco Book Co., 1976), presents some very useful general ideas regarding how to reduce the barriers to accurate problem perception and the flexible conceptualization of solutions.

On a more technical level is Donald F. Mulvihill's edited *Guide to the Quantitative Age* (New York: Holt, Rinehart and Winston, 1966), which attempts successfully to introduce a number of quantitative problem-solving concepts. Herbert A. Simon's *The New Science of Management Decision* (New York: Harper and Row, 1960) is still excellent. His first chapter, "The Executive as Decision Maker," is especially relevant. The first chapter of Hubert M. Blalock, Jr.'s *An Introduction to Social Research* (Englewood Cliffs, N.J.: Prentice-Hall, 1970) is also very relevant because it addresses the complexity of quantitative problem-solving. Two philosophical classics include Israel Scheffler's *The Anatomy of Inquiry* (Indianapolis: Bobbs-Merrill, 1963), and Abraham Kaplan's *The Conduct of Inquiry* (Scranton, PA: Chandler Publishing, 1964). Both are excellent but complicated. It can also be useful to examine the processes of unconventional problem-solving and creative thinking. Osborn's *Your Creative Power* is again relevant. Arthur Koestler's *The Art of Creation* (New York: Dell, 1973); Edward deBono's *Lateral Thinking* (New York: Harper and Row, 1973) and *New Think* (New York: Basic Books, 1967); Sidney J. Parnes and Harold F. Harding's edited *A Source Book for Creative Thinking* (New York: Charles Scribner's Sons, 1962); and Irving A. Taylor's edited *Perspectives in Creativity* (Chicago: Aldine, 1975) also present interesting and useful looks at the processes by which we creatively think, solve problems, make decisions, and manage information, organizations, and people. Eugene Raudsepp's "Nurturing Managerial Creativity" (*Administrative Management,* October 1980, pp. 32–3, 55–6, 75) is targeted directly at individuals within organizations and organizations comprised of inflexible individuals. Several suggestions for "nurturing" creative problem-solving are presented as are some insights regarding the sources of managerial creativity. Finally, John Dewey's *How We Think* (New York: D.C. Heath, 1910) is still one of the best presentations available regarding how we cognitively process information and solve problems.

2

The Tools of Problem-Solving

INTERESTINGLY, WHEN we have to repair a faucet, tighten a screw, work with wood, or tune-up a car, we carefully select (or purchase) the necessary tools, pick a convenient time, and then go to work. Rationally, if we do not have the necessary tools (and the cost of purchasing new or used ones is prohibitively high), experience, or time to complete the task successfully, we call an "expert" in to help. If we cannot find a competent expert, or cannot afford one, then the work goes undone.

This behavior is interesting because it is logical and routine. Yet when we look at our behavior connected with the execution of analytical tasks which arise in our professional environments, all too often we routinely find ourselves acting illogically by frequently failing to assess our most basic problem-solving capabilities. Instead, we make a series of (often unwarranted) positive assumptions about the tools available to us.

Part of the problem can be traced to the assumptions prevalent in most professional environments, assumptions which often define the very "scope and method" of organizational behavior. For example, while the U.S. federal government's Office of Personnel Management requires the revision of job descriptions almost as frequently as jobs are vacated, job descriptions seldom contain information about what the job-holder is actually supposed to do. Consequently, federal bureaucrats are simultaneously presumed omnipotent and incompetent; omnipotent because job descriptions are (intentionally) vague and sweeping, and incompetent because it is generally impossible to deduce from the job description the precise duties of the job-holder. This vagueness contributes to rising expectations about the position and, secondarily, the position-holder. In practice, one seldom hears federal workers openly admitting that they simply cannot perform a given task. Indeed, if they are experienced they will find a way to deflect or ignore the task; if they are naive, they will attack the impossible task and fail.