Management of Type III Error in Problem Identification

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Beneath the seemingly determinate and sophisticated tools of problem solving lies the often ignored type III error — solving the wrong problem. The sources of this error are diverse and often difficult to identify. The practicing manager should be aware of the major sources of type III errors and what strategies will minimize such errors.

The well-known type I and type II errors in statistical hypothesis testing have been the subject of much research and justifiably engage the attention of practicing managers. All too often, however, our concern with accepting or rejecting a hypothesis on false grounds blinds us to the possibility that we are testing the wrong hypothesis. For example, a statistical test of the hypothesis H_o: $D >= 40$ versus H_a: $D < 40$ for a sample of pipes is fine as long as the diameter, D, is indeed a parameter of critical interest; but if the successful performance of the pipes depends on their corrosion characteristics rather than the diameter, this test is obviously of no relevance to the problem being tackled.

The first and foremost question to be asked in any problem-solving context is whether we are solving the *right* problem. This is where type III error enters the picture (type III error is solving the wrong problem). The term, originally defined by Mitroff and Featheringham [1974], seems to be a misnomer considering its preeminence over type I and type II errors.

Type III error is not a construct that can be treated using elegant statistical techniques. It is an error that cannot be quantified because it emanates from the perceptions of people in interpreting real-

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ity. Sometimes vested interests deliberately introduce type III error or deliberately ignore its existence.

Type III errors are much more pervasive than type I and type II errors and are found in any general problem-solving context in organizations and are not confined to statistical hypothesis testing. This kind of error is best avoided by constant vigilance on the part of managers engaged in problem solving. However, the realities of organizational life often cause managers not only to ignore this error, but also to deny its very existence. As a result, organizations waste effort and funds on irrelevant problem-solving efforts.

Type III Error: A Real Life Example

Confusion between causes and symptoms is a major source of type III error. Inadequate analysis of symptoms at the design stage could sometimes lead to a wrong built-in solution. One of the authors of this paper was closely associated with the start-up and operation of one of the largest chemical plants in the world.

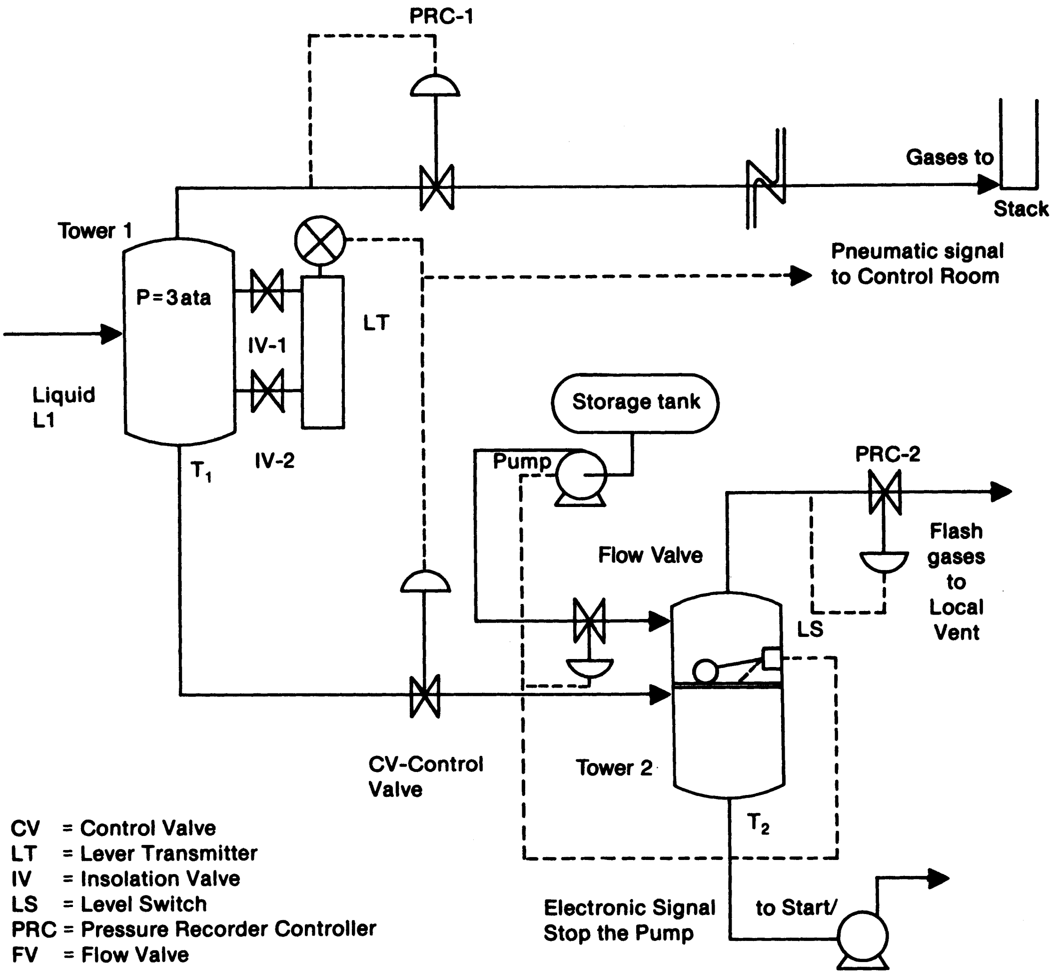

Figure 1: A section of the plant.

In spite of the high degree of automation and the advanced technology, construction of the plant was to a considerable degree a process of trial and error with numerous on-site adjustments to the instruments and operating procedures. The incidence of type III errors was extremely high. We illustrate a type III error here with one relatively simple example.

Figure 1 represents a simplified version of a section of the plant. A major operating mistake occurred primarily through a type III error in design, and it turned out to be quite expensive for the organization.

As shown in Figure 1, a liquid is flashed in two stages in two towers (T1 and T2). The flash gases from the first tower (T1) are vented into the atmosphere through a stack located far away from the plant; those from the second tower (T2) are vented locally (because they are less dangerous). The liquid levels in the two towers are critical parameters and are maintained by means of a control valve (CV) and a level switch (LS). When the level in the first tower falls below a preset limit of 15 percent, the control valve closes, and when it rises beyond the preset limit of 90 percent, it opens. Between these two extremes the regulation of flow is gradual. Any control system of this nature in a large plant of sequential interdependencies must necessarily have provisions somewhere to avoid the ripple effect and a consequent shutdown of the plant. To this end, the second tower is provided with an independent source of supply of liquid from a storage tank equipped with a pump. When the liquid level in the second tower falls below the preset limit of 15 percent and it cannot be made up from the supply coming through the control valve from the first tower, the low-level switch (LS) is actuated, a pump (P) is started, and valve (FV) opens up automatically. When the level is restored to normal, the level switch returns to its normal position, the pump stops, and the flow valve closes.

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The sequence of events leading to the discovery of a type III error was as follows. One night the plant had been started and was in the process of stabilization. Suddenly the level in the second tower dropped to an alarmingly low level. The alarm sounded in the control room and at the same time the pump started pumping liquid into the tower; the level was soon restored to normal. The plant stabilized and appeared to be running smoothly. However, toward the end of the shift, an operator in a different section reported that liquid was gushing out of the stack, and a large pool of this highly toxic and explosive liquid had accumulated around it.

The indicators in the control room, however, showed that the plant was operating normally. The plant had to be shut down immediately and a step-by-step investigation undertaken.

It turned out that the isolation valves

(IV-1 and IV-2) were completely closed. The instrument technician had done a maintenance job on the level transmitter (LT) during the previous shutdown and had closed these valves and drained the level gauge in order to isolate the instrument and facilitate calibration. After the instrument was handed over, the production personnel, in turn, failed to open the isolation valves, and the result was that

> ... a person is confronted with a problem when he wants something and does not know immediately what action he can take to get it.

the level of the first tower shown in the control room was totally false. It was the level in the level gauge rather than that in the tower. As can be expected, the control valve was fully closed the whole time since the plant was started up. The liquid entering the first tower at high pressure had no outlet except through the stack. The loss of liquid through the stack was, of course, constantly being made up through the pump (P1). After this diagnosis, several measures were taken to avoid the recurrence of such incidents, the most important of them being

(1) The control valve was converted to sound an alarm in the control room if the first tower has too high or too low a level of liquid,
(2) An alarm will sound in the control room if the pump runs for more than 15 minutes, and
(3) Operating and maintenance procedures were modified so that after any instrument is handed back by the maintenance department, it is the joint responsibility of the production and maintenance departments to take the instrument back "in line."

After these measures were instituted, no similar situation ever occurred. In retrospect, a type III error was made in this instance by solving a wrong problem — how to maintain flow into the second tower to prevent shutdown of the plant. The real problem was to insure that the level transmitter was "in line."

Problem Definition: The First Step

To define the exact nature of the problem is the first step in problem solving. From Newell and Simon's [1972] perspective, a person is confronted with a problem when he wants something and does not know immediately what action he can take to get it. According to Raaheim [1974] and Green [1973], the essential core of problem solving is the process of reducing the unknown to the known, that is, to state the problem in terms that are known as opposed to terms that are unknown. However, defining the problem in terms of familiar solutions or methodologies may put the whole process of problem solving on the wrong track and contribute to type III error. Consider the joke about the doctor who, unable to diagnose the patient's illness or prescribe a treatment, advises him to take a long dip in the chilly waters of a lake during an early winter morning. When the patient asks why, the doctor replies, "I don't know how to cure your present ailment, but if you follow my advice, you stand a very good chance of catching pneumonia. And I know how to cure that."

In their attempts to reduce the unknown to the known, managers of organizations sometimes act like that doctor. The end result is that problems are defined in terms of known solutions. Viewed against this background, Gordon's [1961] "antithesis" — that a major aspect of problem solving (and hence problem definition) consists, not in transforming the unknown to the known, but rather in the exact opposite, that is in transforming a known situation into a strange one — appears to offer a promising perspective on problem definition. In other words, it might be appropriate to approach problems with an open mind rather than with a repertoire of known solutions and techniques.

The causes of the type III errors examined so far are fairly obvious. However, more subtle and imperceptible sources are often difficult to trace. One such source is "type III problem."

Type III Problems and the Irony of Change

Giblin's [1981] paradigm for differentiating organizational problems offers a useful perspective for understanding one of the major sources of type III error in organizational problem solving. Giblin identifies three fundamental types of organizational problems: (1) type I problems, which are externally generated; (2) type II problems, which are internally generated, and; (3) type III problems, which are caused by "the tendency of organizational members to use the organizations as vehicles for self-gratification."

Managements often deny the existence of type III problems or attempt to pass off their secondary effects as the problem. What ensues are solutions to the wrong problems. At the other extreme, we find the "irony of change" operating at the various problem-solving levels of organizational hierarchy. Groups of organizational members responsible for problem solving attempt to solidify their power by "inventing" problems where none exist.

"I don't know how to cure your present ailment, but if you follow my advice, you stand a very good chance of catching pneumonia. And I know how to cure that."

This suggests a broader definition of type III error as solving not only the wrong problem but the nonexistent problem.

Major Sources of Type III Error and Their Management

Some of the strategies available to managers for minimizing the occurrence of type III errors are implicit in our earlier discussion and others follow.

Suppose that you have, for some days, felt a burning sensation in your chest and that you have begun to wonder whether this could be a symptom of a potentially dangerous heart condition. So you go to your physician who gives you a thorough check-up, runs a series of tests, and declares that your condition is nothing but heartburn. You heave a sigh of relief.

Let us now examine the events in the above scenario. It all began with your perception of a problem. This is perhaps the beginning of all organizational problems as well. Problems do not exist in objective reality but are simply conceptual constructs. As a result they tend to vary with individual managers and the way they conceptualize the situation. Thus, as suggested by Graham and Jahani [1977], problem identification is a process of designing problems as opposed to discovering them. The central question in problem identification, then, is not whether a subjective bias is present or not, but whether such biases can be made explicit, and whether we can determine how they influence the process.

Getting back to our example, your physician has tried to diagnose your problem using not only your symptoms, the information supplied by you, and the results of the tests, but also his own professional skills, judgment, and perspective. Perspective strongly influences problem identification. One way to avoid investigator bias is to use a dialectic approach to problem identification. The dialectic process (schematically presented in Figure 2) presumes that it is possible to achieve a higher level of understanding (a synthesis) by deliberately creating two diametrically opposed views to explain a situation (a thesis and an antithesis) [Sussman and Heiden 1982].

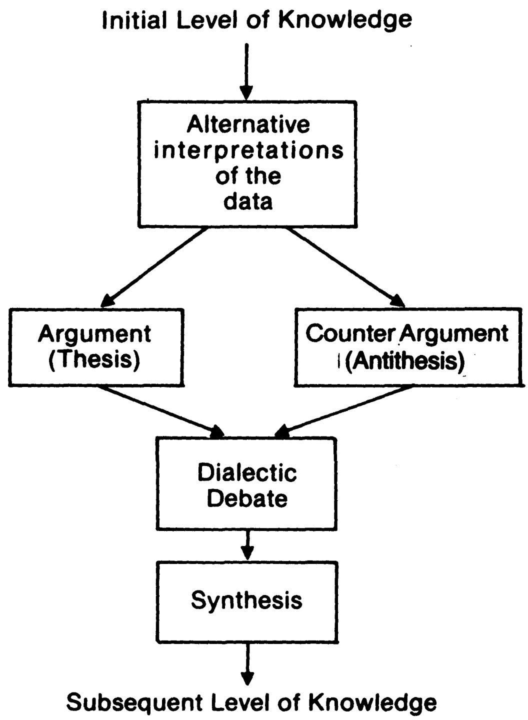

Figure 2: The dialectic process.

Anderson and Janson [1979] suggest that formalized (as opposed to intuitive) approaches be used to structure cause-effect relationship in the process of problem identification. The use of a structured approach will help provide new insights besides ensuring that all relevant variables are included in the analysis.

A person's relationship to the problem can strongly influence what is identified as a problem. Some senior executives tend to be on the defensive and may even deny the existence of problems because they see the organization as their own creation (at least in part). A solutions perspective [Graham 1976] can sometimes be used to get around this. Instead of asking the executives what they think the problem is, one could ask them to specify solutions, that is what they would change if they had the power and freedom to do so. Such an approach often elicits free and frank response which can be used to work backwards and generate a matrix of problems from the suggested solutions. We can thus see that a solutions approach — despite its shortcomings — is not totally without application.

Kilman and Mitroff [1977] conceptualize the problem-solving process as consisting of five steps:

(1) Sensing problems,

(2) Defining problems,
(3) Deriving solutions,
(4) Implementing solutions, and
(5) Evaluating outcomes.

They argue that most consultants enter the process at step 3, and that this results in significant type III errors. A good strategy for reducing type III errors would be to bring the consultant in right in step 1.

The sources of type III error are so diverse that there is no cut-and-dried formula for dealing with them systematically. It seems that it is the manager's awareness and sense of proportion alone that can successfully prevent type III errors.

Conclusion

As organizations and their environments become more complex, problem definition has become a formidable problem. Organizations cannot afford to experiment or use trial and error methods. Human solutions to technical problems or technical solutions to human problems are as bad as creative solutions to what could be nonproblems. Awareness of the existence and costs of type III errors on the part of practicing managers should help ensure that problem-solving efforts are not wasted on badly defined problems — or what is worse, bring in their wake additional problems.

References

Anderson, J. C. and Janson, M. A. 1979, "Methods for managerial problem cause analysis," *Interfaces*, Vol. 9, No. 5 (November), pp. 121–128.

Giblin, Edward J. 1981, "Differentiating organizational problems," *Business Horizons*, Vol. 24, No. 3 (May-June), pp. 60–64.

Gordon, W. J. J. 1961, *Synectics: The Development of Creative Capacity*, Harper and Row, New York.

Graham, R. J. 1976, "Use of solutions for problem identification," *Interfaces*, Vol. 7, No. 1, part I (November), pp. 63–65.

Graham, R. J. and Jahani, Mohammed 1977, "People, problems and planning: A systems approach to problem identification," *Interfaces*, Vol. 8, No. 1 (November), pp. 50–55.

Green, Thad B. 1973, "Problem definition — Key to effective problem solving," *Management Advisor*, Vol. 10 (November-December), pp. 42–45.

Kilman, Ralph H. and Mitroff, Ian I. 1977, "A new perspective on the consulting/intervention process: Problem defining vs. problem solving," *Proceedings of the 37th Annual meeting of the Academy of Management*, Orlando, Florida, pp. 148–152.

Mitroff, Ian I. and Featheringham 1974, "On systematic problem solving and the error of the third kind," *Behavioral Science*, Vol. 19, No. 6, pp. 383–393.

Newell, A. and Simon, H. A. 1972, *Human Problem Solving*, Prentice Hall, Englewood Cliffs, New Jersey.

Pounds, William F. 1969, "The process of problem finding," *Industrial Management Review*, Vol. 11, No. 1 (Fall), pp. 1–19.

Raaheim, K. 1974, *The Paradoxes of Productive Thinking*, Reports from the Institute of Psychology, University of Bergen, Bergen, Norway.

Sussman, Lyle and Herden, Richard 1982, "Dialectical problem solving," *Business Horizons*, Vol. 25, No. 1 (January-February) pp. 67–71.