# A New Methodology for Formulating Ill-Structured Problems

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# A New Methodology for Formulating Ill-structured Problems

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**A four phase model is presented in which problem generation and problem formulation precede problem solving and solution implementation. A relatively new heuristic for formulating ill-structured problems is described. The methodology is a systematic thinking process which combines analytical precision with structured imagination, and is called the 'why-what's stopping' analysis. Current techniques for defining problems are positioned as inadequate because they do not always fit the problems faced in day to day work and because they ignore human behavioral deficiencies. Deferral of judgment, active divergence and active convergence are identified as three behavioral skills which underly the successful application of the 'why-what's stopping' analysis. Several examples of the application of this process in real world situations are provided. Directions for future research are discussed.**

*Key words*—problem definition, ill-structured problems, problem solving, creativity, problem structuring

## INTRODUCTION

ALBERT EINSTEIN was once asked if he had one hour to save the world, how would he spend the hour? He is reputed to have said, "I would spend 55 minutes *defining* the problem and then only five minutes solving it." He believed that the best problem solvers were those who were able to formulate problems in new ways. John Dewey's famous quote is: "A problem well-stated is half solved" [13].

Problem-solving involves more than simply applying a methodology for identifying an optimal solution to an already well-defined problem. Normative processes suggest there are several phases. Activities preceding the problem solving phase have been identified variously as intelligence by Simon [36], problem-finding by Leavitt [25], definition by Evans [16], problem identification by Mintzberg *et al.* [29] and defining the problem by Dewey [13]. These early activities have been grouped by researchers into different components including problem recognition and diagnosis by Schwenk and Thomas [35]; decision recognition and diagnosis by Mintzberg [28]; and sensing and anticipating problems, fact-finding and problem definition by Basadur *et al.* [9].

Problem sensing and anticipating and fact finding are similar to Simon's opportunistic surveillance [36] and are grouped into an initial phase called problem generation by Basadur *et al.* [5], who also separate out a second phase which occurs after a problem has been generated.

This second phase is called problem formulation. Here the problem is defined, conceptualized and structured. Problem structuring has been defined by Pitz *et al.* [31] as the activity of identifying the relevant variables in a problem situation and the important relationships among those variables. Problem formulation is "the process of formulating the present set of conditions, symptoms, causes and triggering events into a problem or set of problems sufficiently well specified so that the risk of using analytic procedures to solve the wrong problem has been minimized" [35]. The third and fourth phases are called problem solving (developing solutions and implementation plans) and solution implementation (gaining acceptance for and implementing solutions and plans).

Problem formulation has been noted by many as difficult. Ackoff [2] suggests that researchers do not usually encounter well-defined problems, rather they encounter 'messes'. Watson [40] identified several categories of difficulties encountered: failure to recognize the existence of a problem; failure to define the correct problem (Type III error); failure to use all available information; and failure to recognize or question assumptions. Tversky and Kahneman [38] found that the 'framing' of the problem affected the decision maker's ability to make rational choices.

Some of these difficulties result directly from the type of problem to be solved. Basadur [8] described a continuum from easy to define to difficult to define. Simon [36] identified three types of problems: well structured, semi-structured, and ill-structured. Well structured problems come with complete information, are usually repetitive and routine, and can be solved with established solution techniques. Ill-structured problems are 'fuzzy'; i.e. there are no data, too few data or too many data available. Some of the data may also be difficult to perceive or quantify [4]. These problems tend to be complex, non-routine and difficult to define. Semi-structured problems include both well structured and ill-structured characteristics; portions of the problem appear to be well structured, while other aspects are quite messy and difficult to understand.

Ill-structured problems are the most difficult to define. In fact, there often is not a single correct definition, but some formulations are better in the sense that they provide an angle on the problem which, when defined in that way, can be solved effectively. The definition, therefore, rests on the point of view of the stakeholder(s). For this reason, aids to assist stakeholders in defining ill-structured problems are important. Over recent years, several methods have been developed with this in mind (see for example [33] which covers a number of such).

The purpose of this paper is to describe a new heuristic for formulating ill-structured (and semi-structured) problems. The methodology combines analytical precision with skills in structured imagination, which overcome attitudinal, perceptual and cognitive shortcomings in individual and group stakeholders. This methodology, called the 'why-what's stopping' analysis, has been applied since the mid 1970s to numerous business and technical problems in North America. This paper provides the theoretical grounding for the methodology, as well as a thorough explanation of how to execute the methodology. Future implications and research are discussed.

## PROBLEM DEFINITION FROM A MANAGERIAL PERSPECTIVE

Analysts and researchers in the field of management science have devoted relatively little effort to the study of problem definition. This can be observed through a perusal of the management science literature, where relatively few publications in the area of problem definition exist.

From the perspective of the OR/MS (operations research/management science) academic community (at least over the last 20 years), most problems have involved two types of issues:

(1) Formulation of a mathematical model from a well-defined problem situation, and
(2) Development/use of an algorithm for solving a mathematical model.

Practitioners, however, deal with a much broader class of problems. This includes dealing with ill-structured problem situations. Case studies have documented situations where a project involving management science failed, not because of lack of expertise or effort in the area of mathematical modelling, but because the problem was not *defined* correctly. A classic example is the one involving 'slow elevators', in which the more accurate problem definition was not that the riders were waiting too long for the elevators, but that they perceived themselves to be waiting too long [19]. Additional examples can be found in such journals as *Interfaces* and *Omega*.

Evans [16] notes that in OR/MS the word problem can be defined as a gap between the present and some desired state of affairs. Similar definitions have been proposed by others. A gap can carry a positive, negative or unknown connotation, providing three different views of the word problem. A positive gap exists when a fine opportunity is sensed for an innovative product or procedure which will move the state of affairs upward, higher than the present baseline even when the present baseline is satisfactory or the best seemingly possible. For example, Land [24] attributed his polaroid camera invention to his ability to discover and define a problem where seemingly no problem existed. A negative gap exists when there has been a drop in performance below a baseline that needs to be corrected. An unknown gap exists when our base state of affairs has been or soon will be wiped out by environmental changes beyond our control.

Within this definition based on different states of affairs there is the notion that some obtainable, identifiable set of values exists for these performance variables which is more desirable than the current set of values (i.e. current state). Hence, in order to define a problem fully, we must discover *a relevant set of performance measures*, as well as the important *stakeholder(s)* or *decision maker(s)* for a problem. The stakeholders of a problem must be intimately involved in determining the performance measures and establishing preference structures over the multiple performance measures.

Determining a relevant set of performance measures is more of an art than a science. MacCrimmon [26] suggests that the structuring of value systems can be accomplished in three ways: (1) an examination of the relevant literature, (2) analytical study (e.g. through the development of a model of the situation), and (3) causal empiricism (e.g. by talking to the problem's stakeholders).

Buede [12], Saaty [34], and Keeney and Raiffa [21] suggest that relevant problem criteria are best structured in a hierarchy. The criteria toward the top of the hierarchy are more general (e.g. optimize the well being of society) than those towards the bottom of the hierarchy (e.g. minimize $CO_2$ emissions).

Manheim and Hall [27] suggest two approaches for determining a hierarchy: specification and means-end. VanGundy [39] presents a discussion of the 5W's method for determining goals. Buede [12] suggests that the specification (or objective-driven) method is more appropriate for problems which are strategic in nature, and that the means-end (or alternative-driven) method is more appropriate for problems of a tactical nature.

Of the three connotations of 'problem', the tendency has been to consider mostly the second (negative) and only more recently, the third (unknown). The Kepner and Tregoe (K-T) Method [22] for problem defining explicitly recognizes the concept of a 'gap' as a *deviation* or drop from a formerly satisfactory level of performance. It provides a methodology for determining the root cause of this deviation and the person or persons associated with the root cause. One typical technique for determining root cause is to use a cause and effect diagram in which potential causes of a deviation are brainstormed within predetermined categories. Another approach is stairstepping which involves determining the cause of a situation and then the cause of the cause, and repeating until the lowest, most basic cause has been reached [20].

Brightman [10] extends these approaches by involving groups to explore different possible causes for a problem. Called the Alternative Worldview Method for problem diagnosis, each subgroup must gather data to support their problem causes. Following this the subgroups meet to develop a synthesized viewpoint. Of course, one of the advantages of the Alternative Worldview Method is that the subgroups can develop their causes in a relatively independent fashion. Also, as noted by Brightman [10], their method is successful "because it helps us do what we naturally do best—seek causes".

Each of the techniques described above are reasonable to use to define problems. Brightman *et al.* [11] noted that few of these are actually used by managers, however. One of the reasons is that these tools do not always fit the problems faced by people in day-to-day work. Only a small proportion of the problems require finding the root cause to enable returning to a well defined baseline performance level. Furthermore, people sometimes waste time determining the root cause of a problem that is entirely the wrong problem to be considered. Finding the root cause of slow elevators is a waste of time when the real objective is to find a way to help people enjoy their waiting time more. A larger proportion of everyday problems require setting higher goals above the baseline performance level or inventing new products with new base levels or, finding entirely new goals in new directions to take advantage of environmental change. These types are less structured and do not lend themselves to strictly sequential, logical reasoning from a predetermined base point.

A second reason for lack of use of these techniques is that there are human behavioral deficiencies that prevent people from following such systematic procedures even for problems that call for them. Managers' propensity to spend most of their time acting in haste to correct situations rather than taking the time to think them through is well-documented by Mintzberg [28]. The following section describes problem definition from a behavioral perspective taking into account these human deficiencies. These behavioral deficiencies can be perceptual, attitudinal or cognitive in nature.

## PROBLEM DEFINITION FROM A BEHAVIORAL PERSPECTIVE

Elbing [15] identifies the following perceptual biases that interfere with problem analysis and that often cause managers and other organizational members to act hastily and to handle problems ineffectively. They tend to: evaluate before investigating, thus precluding inquiry and a fuller understanding of the situation; equate new and old experiences, searching for the familiar rather than the unique in a new problem; approach problems at face value, rather than ask questions to unearth reasons underlying the problem's more obvious aspects; direct decisions toward a single goal, not recognizing that most problems really involve multiple goals that need simultaneous handling; confuse symptoms and problems; overlook 'unsolvable' problems and concentrate instead on simpler concerns; and respond automatically or act before thinking (sometimes called the 'knee jerk' effect).

Basadur [3] identifies the following attitudinal, perceptual and cognitive shortcomings. People wait for others to find problems for them to solve rather than take the initiative to seek them out. Important problems that cross organizational, functional and departmental lines are often avoided: "That's not our problem." People often make the premature assumption that "it can't be done". Too much knowledge of the particular field causes them to experience 'tunnel vision' and to lose childlike inquiry and challenging of custom. Unsubstantiated assumptions are accepted as facts. People are unwilling to take the time to discover the real facts, which might lead them to refreshing new ways to define the problem. They emphasize problem solutions rather than problem definitions, believing that "I already know what the problem is." Failure to observe and consider trivia and to investigate the obvious prevents individuals from finding a balance between narrowing the problem too much (missing the 'big picture') and broadening the problem too much (not breaking it down into small enough subproblems). This shortcoming can be further fuelled by people's inability to sufficiently use imagination to connect seemingly unrelated matters.

## HARNESSING THE IMAGINATION

The methodology for problem formulation provided in this paper encourages the use of a systematic thinking process that overcomes such perceptual, attitudinal and cognitive inadequacies. This process incorporates logic, sequencing and imagination.

One of the keys to imagination is often expressed as divergent thinking [18]. Another key is deferral of judgment. Divergent thinking is the nonevaluative generation of information from a given source with an emphasis on variety [32]. The imagination is used to generate multiple alternatives while deferring judgment (i.e. evaluative thinking) until this generative thinking is completed. In the earlier elevator example, the imaginative problem definition statement "How might we make the people enjoy their waiting time more?" served as an alternative to "How might we make the elevators go faster?" A third key, convergent thinking, is important in choosing and focusing in on important and leverageable issues, facts and problem formulations. Basadur and Finkbeiner [7] identify deferral of judgment, active divergence and active convergence as three separate behavioral skills required to harness the imagination in organizations.

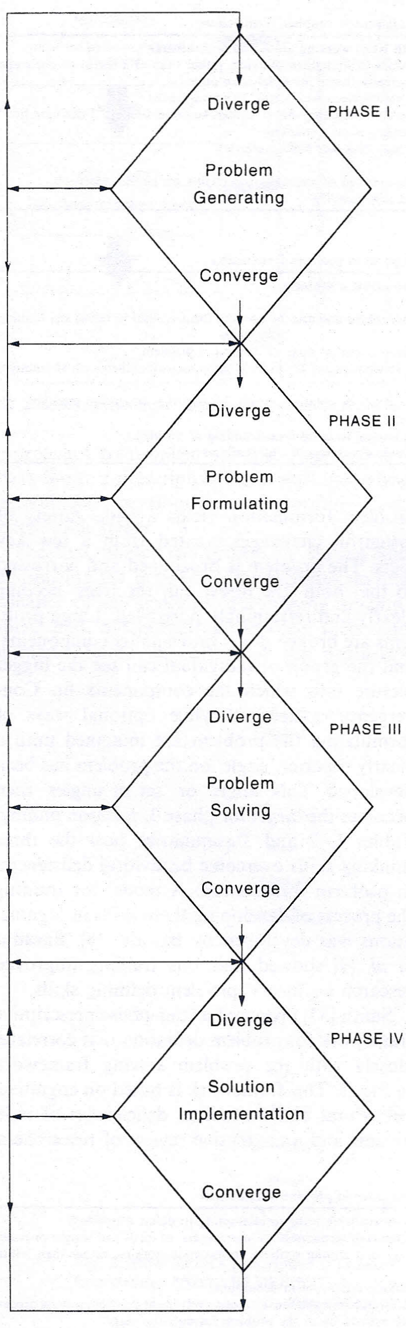


Fig. 1. Problem solving as a 4-stage process emphasizing deferral of judgment, divergent thinking and convergent thinking in each stage.

Divergent thinking consists of two parts, deferral of judgment and active divergence. Deferral of judgment is the skill of separating divergent thinking from convergent thinking. By resisting the tendency to prematurely evaluate options, deferral of judgment sets the stage for active divergence. Active divergence is the skill of aggressively thinking of a wide range of options no matter how 'wacky'; appreciating new, different points of view and thoughts not only as possible endpoints but as building blocks to create more new thoughts; and believing that generating novel options is not a mysterious process confined to a few unusual, 'offbeat' people but a normal process that should involve everyone in the organization.

While deferral of judgment and active divergence are necessary, they are less than sufficient for harnessing the imagination. Active convergence is a skill that resists the tendency to loiter in divergent thinking. Active convergence decisively selects and acts upon good options and leads to the ultimate implementation of change.

The four-stage problem solving framework proposed in Fig. 1 is a systematic thinking process for problem definition and problem solving. Its stages of problem generation, problem formulation, problem solving, and implementation constitute a complete process. (What is meant by a complete process is that (i) there are multiple stages; (ii) within each stage judgment is deferred and divergent and convergent thinking are oscillated to generate multiple ideas and assess their relevancy; (iii) there are feedback loops among all stages to permit a return to earlier stages and leapfrogging to later stages as environmental changes occur and new insights are revealed as the process and events unfold.)

Problem generation consists of sensing and anticipating problems, and fact finding. Skills in problem sensing and anticipating include deferring judgment while actively diverging to collect many problems, changes and opportunities that might be relevant to the organization, then screening them (converging) to select a smaller number for further exploration. The skills include tolerating these problems, changes and opportunities as ambiguous fuzzy situations

Table 1. Behavioral skill in deferral of judgment in problem formulation

- Avoid making premature negative judgments of fledgling thoughts (both when working alone and with others)
- Visibly value, appreciate and welcome other points of view as opportunities to strengthen thinking, rather than as a threat to one's ego
- Patiently maintain an awareness that some facts are more difficult to perceive (more invisible) than others
- Question assumptions for validity and search out hidden, unconscious assumptions which may be unwarranted
- Tackle problems with an optimistic 'can-do' attitude rather than prematurely concluding that it 'cannot be done' because 'I can't see how'
- Tend not to jump prematurely to a conclusion as to what the 'real problem is' in a situation
- Avoid attaching negative connotations to problems; such prejudgment may bias fact finding efforts
- Visibly stay open-minded to others' versions of the facts
- Often pause deliberately to try an unusual approach to define a problem instead of automatically relying on an old approach
- React positively to new radical thoughts as opportunities to build fresh new thinking

Table 2. Behavioral skill in active divergence in problem formulation

- Search out many different facts and points of view before attempting to define a problem
- Define problems in multiple and novel ways to get a variety of insights
- Clarify problems by breaking them down into smaller, more specific subproblems and also by opening them up into broader, less limiting challenges
- Deliberately extend effort to create additional unusual, thought provoking potential ways of defining a problem
- Give credit for divergent thinking by others; praise others for alternative viewpoints and try to build upon and strengthen such alternatives to increase variety of choice
- Turn premature, negative evaluations of ideas into positive challenges to keep the creative process flowing; that is, change negative "We can't because . . ." thoughts into positive "How might we? . . ." thoughts
- Share information and ideas freely with other people and departments hoping to build understanding of problems
- Get teams to formulate problems in ways which transcend individual and departmental considerations

that are ill-defined but that represent 'tips of the iceberg'. Research by Getzels [17] showed that tolerating such fuzzy situations leads to effective and often inventive solutions. Fact finding skill consists of actively gathering information that might relate to a fuzzy situation while deferring judgment. Evaluation and analysis are suspended and all points of view and versions of the facts accepted. Establishing what is *not* known is as important as what *is* known or is *thought* to be known. Only during convergence are the most relevant and worthwhile facts identified. A skilled fact finder avoids unwarranted assumptions and examines a given situation from a wide variety of viewpoints; listens well to other versions of the facts and accepts them; extends effort to 'dig out' further information even when it seems that all facts have already been unearthed; and asks fact finding questions in the simplest, most childlike way, never being too embarrassed to ask questions to increase understanding. After gathering such information, this person can converge upon a small number of facts believed to be especially relevant.

Problem formulation consists of problem defining, conceptualizing and structuring. Skilful problem formulation yields a wide variety of insightful challenges created from a few key facts. The problem is broadened and narrowed so that both 'the forest and the trees' become clearly and refreshingly portrayed. Large problems are broken down into smaller components, and the group or individual can see the bigger picture into which the components fit. Convergence is deferred while optional ways of formulating the problem are imagined until a clearly superior 'angle' on the problem has been developed. This 'angle' or 'set of angles' then becomes the target for phase 3, solution finding. Tables 1, 2 and 3 summarize how the three thinking skills overcome behavioral deficiencies in problem formulation. A model for training the process of developing these skills in organizations was developed by Basadur [6]. Basadur *et al.* [9] showed that this training improved research engineers' problem defining skills.

Smith [37] proposed a four-phase prescriptive framework for problem definition that correlates closely with the problem solving framework in Fig. 1. This framework is based on cognitive, behavioral and attitudinal deficiencies of individuals and an extensive review of researchers'

Table 3. Behavioral skill in active convergence in problem formulation

- Take the time to select, clarify and focus upon the most significant facts available prior to attempting to define a problem
- Recognize and accept the critical few best problem definition options in terms of 'broadness' vs 'narrowness' of focus and insight provided
- Open-mindedly develop and use multiple, unbiased criteria for selecting from among problem formulation options, rather than letting preconceptions or hidden motives sway decisions
- Take the risk of failing or being criticized for being different for selecting novel problem definitions
- Be willing to accept and participate in consensus decisions about problem formulation and move on decisively in the problem solving process
- Do not wait for the 'perfect' option to emerge; instead take reasonable risks to finish the problem formulation stage

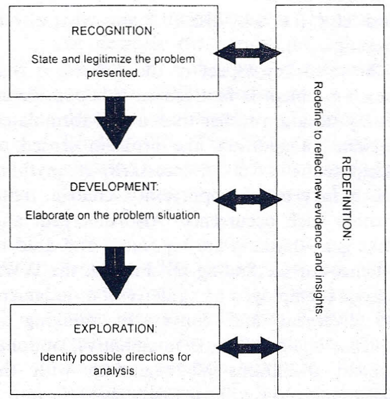


Fig. 2. Smith's prescriptive framework for problem definition.

approaches to problem solving. Figure 2 displays Smith's prescriptive framework including recognition, development, exploration and redefinition stages.

The first phase, recognition, is stating and legitimizing the problem. This includes sharing evidence of the problem, questioning assumptions, and differentiating between facts and opinions. Smith suggests that the problem's existence be vigorously challenged. The second phase, development, includes identifying stakeholders, generating alternative perspectives, learning about the problem, and creating a working definition of the problem. This involves the development of a broader perspective of the problem situation. In exploration, the individual or group considers the problem from various levels of breadth and various angles, decomposes the problem into subproblems, identifies difficulties in solving the problem, and explores possible causes of the problem. The redefinition phase occurs concurrently with the first three as depicted in Fig. 2. As new information is uncovered, definitional mistakes are discovered and the inadequacy of the current definition noted. Smith [37] recommends reframing, strategy switching, generalizing, and making problems more specific to aid in redefinition.

These stages are ordered to reduce the risk of error by promoting the generation of data that helps to redefine the problem in its situational context early in the process. The stages of decomposing and exploring causes of the problem are not completed until the last phase, exploration. In addition, problem redefinition is

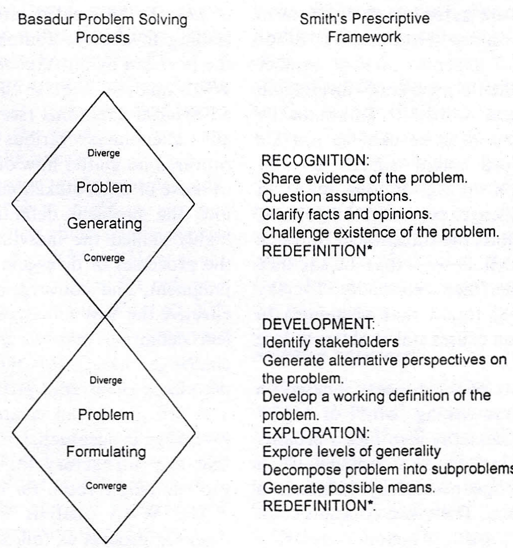


Fig. 3. How Smith's prescriptive framework is embedded in problem generating and problem formulating. *Note: REDEFINITION occurs throughout problem generating and problem formulating, as prescribed by Smith.

viewed as an ongoing process that occurs during all phases, not at a single decision point. Smith promotes the use of both analytical and creative methods for defining problems.

Figure 3 synthesizes Smith's framework with the model of Fig. 1. It depicts the key elements of Smith's framework, which are embedded in the problem definition stages of the framework of Fig. 1. Smith's recognition phase is almost analogous with the problem generating stage. Development and exploration are aligned with the problem formulating stage. Redefinition occurs throughout both stages as new information and insights are gained into the problem. Redefinition appears to be strongly related to active convergence.

The focal point of this paper is a systematic process for the development, exploration and redefinition phases of Smith's model and the second stage of the model in Fig. 1, problem formulating.

## THE 'WHY-WHAT'S STOPPING' ANALYSIS

The systematic process for problem formulation discussed above is called the 'why-what's stopping' (WWS) analysis. There are three important aspects to this process. First, all problem definitions are stated in a challenge form beginning with the phrase "How might I . . ." or "How might we . . ." depending on the number of stakeholders. When a problem is formulated beginning with these words, it automatically invites the imagination to be used to provide solutions. The word might signals a non-evaluative reception to all options made in response to the challenge. Secondly, the positive, optimistic tone permits the stakeholder to frame the problem in such a way that he/she/they does not lose his/her/their rationality. Tversky and Kahneman [38] found that pessimism in problem formulation causes stakeholders to lose rationality.

The second aspect of this process is based on two basic principles: Asking 'why?' of a particular challenge necessarily identifies a broader challenge while asking 'what's stopping you?' of a particular challenge necessarily identifies a narrower subproblem. These two concepts combined provide the tools to develop a hierarchy of the problem. As discussed further below, the hierarchy becomes a two-dimensional 'map' when the two questions are augmented with the word 'else' (i.e. why else . . .? and what else is stopping . . .?).

The third key aspect of this process is that when a problem is first sensed it is considered a fuzzy situation rather than a well-formulated problem. In addition, the problem sensed or anticipated is not taken necessarily as anything bad. It may be an opportunity, change, trend or other such occurrence. Also divergent and convergent thinking are separated and used in sequence for factfinding [3]. Finally, the WWS analysis is employed using deferral of judgment and divergent and convergent thinking in sequence again to create imaginative, optional problem definitions all beginning with the challenging phrase, 'how might we?' . . . into a WWS 'map' or hierarchy. The goal of the WWS analysis is not to give the problem definition to the stakeholder(s). Rather, it provides a meaningful aid to assist the stakeholder(s) in developing the most meaningful, leveragable problem statements for them, as well as providing them with a visual representation of the 'big picture'. The WWS analysis 'layers' problems and subproblems from broad to narrow, as well as provides a mechanism for relating the problems and subproblems. In a group this interactive methodology encourages different points of view to be melded into succinct challenges leading to a more complete understanding of the problem by all stakeholders. Therefore, the WWS analysis is quite effective even in highly adversarial situations (see Example 3) because all stakeholders' various points of view are captured no matter how different or contrasting to those of other stakeholders and incorporated into the problem definition map. The more highly skilled the individuals in the group in the processes of divergent thinking, deferral of judgment, and convergent thinking, the more effective the WWS analysis. The resulting problem definition map reconciles all the diverse challenges, recognizing the value of each one in describing the overall picture. Virtually always, a skilled group can create and converge upon carefully conceptualized problem definitions that are satisfactory for all stakeholders and provide ample room for creative solutions.

The WWS analysis employs a three-step thinking process as follows:

(1) Ask 'Why' or What's Stopping us . . .' from the problem formulation. For

example, if the challenge is "How might we decrease the number of defects in Product X?", the 'why' question then becomes "Why would we want to decrease the number of defects in Product X?" The 'What's stopping' question becomes "What is stopping us from decreasing the number of defects in Product X?"

(2) Answer the question in a complete sentence. The answer to the 'why' question might be that "We have too many returns of Product X from our customers." An answer to the 'what's stopping' question might be "We reward employees only for high quantity of output, not high quality". Optional answers are produced in one of two ways, either by simple extended effort or by deliberate use of the word 'else' as in "Why else would we want to decrease the number of defects in Product X?" and "What else is stopping us from reducing the number of defects in Product X?"

(3) The answer to the question is then transformed imaginatively into another problem formulation. For example, the answer to the 'why' question above might become transformed into "How might we reduce the number of Product X returns from customers?" or "How might we make our customers more satisfied with the Product X they are receiving?" The answer to the 'what's stopping' question might become transformed into "How might we get our employees excited about improving the quality of Product X?" or "How might we reward our employees for reducing the number of defects in Product X?" or "How might we get our employees to give high attention to both quantity and quality when making Product X?"

Each new challenge is placed according to the question it answers. Figure 4 shows the theoretical placement of the problem statements. The placement can be checked by reversing the question to the newly formulated challenge. For instance, in the example above, the answer to "What is stopping us from decreasing the number of defects in Product X?" is that "We reward employees only for high quantity of output, not high quality" resulting in a new problem statement of "How might we reward our employees for reducing the number of defects in Product X?" To check if this problem statement meets the 'why-what's stopping' logic, we can reverse it by asking, "Why would we want to reward our employees for reducing the number of defects in Product X?" If one answer is "We want to decrease the number of defects in Product X" we can see that we can easily transform this fact into the original problem statement "How might we decrease the number of defects in Product X?"

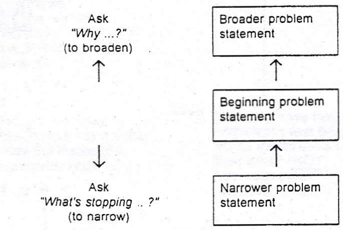

Fig. 4. Placing of problem statements.

Once the new statement is checked via the reversal question, an arrow is drawn from the lower challenge to the higher challenge. Optional problem definitions are placed side-by-side and checked in the same way with arrows always connecting the lower challenge, a subproblem, to the higher challenge, a broader problem. Figure 5 shows a step-by-step visual example.

If the new problem statement does not 'fit' when the reversal question is asked, it is recommended that the card be placed to the side temporarily and go back to step 1 in the 3-step process. It is likely that the fact or problem formulation was not well-stated as discussed in the next section.

### *Avoiding vagueness*

It is vital to provide answers to the 'why' and 'what's stopping' questions which are simple, clear and specific. Suppose the original starting point challenge was "How might we decrease the number of defects in Product X?" (as in Fig. 5) and the question "why else (would we want to reduce the number of Product X defects)?" were asked. If one knew another accurate answer to be "our employees feel badly about so many rejects being made" but

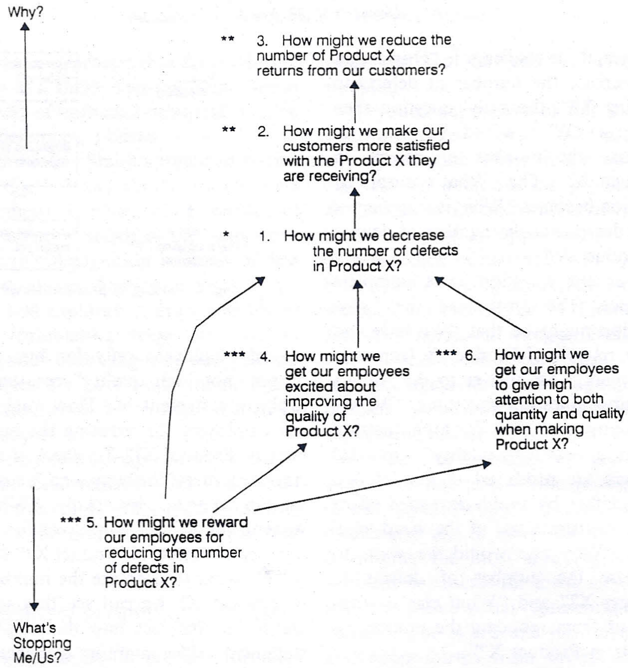


Fig. 5. Visual example of how the three-step thinking process works. *Starting point challenge. **Optional challenges created by asking 'why?' of starting point challenge. ***Optional challenges created by asking 'what's stopping us?' of starting point challenge.

one chose to answer more vaguely instead that "morale is low", this could result in the new challenge "How might we improve morale?"

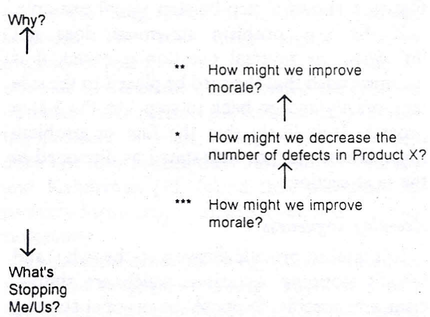


Fig. 6. What happens when answers to why? and what's stopping? are stated too vaguely. *Starting point challenge. **Optional challenge created by asking 'why?' of the starting point challenge but answering vaguely ('morale is low'). ***Optional challenge created by 'what's stopping us?' of the starting point challenge but answering vaguely ('morale is low').

being placed *above* the original challenge. Now suppose the question "what else is stopping us?" were offered to the same original challenge. If one knew another accurate answer to be "people are not paying much attention to quality" but chose instead to answer more vaguely, "morale is low", this would result in the new challenge "How might we improve morale?" *below* the original challenge. Then the same challenge would appear both above and below the original as shown in Fig. 6. Such circularity violates the rule that 'why?' broadens the problem and 'what's stopping?' narrows it.

If the more specific, clear and simple answer had been provided instead, the three challenges could be ordered hierarchically without ambiguity with the broadest at the top and the narrowest at the bottom as in Fig. 7. Such vagueness is often introduced unconsciously by stakeholders either because they would prefer to ignore the real underlying issues [14, 23] or because they do not try hard enough or lack the

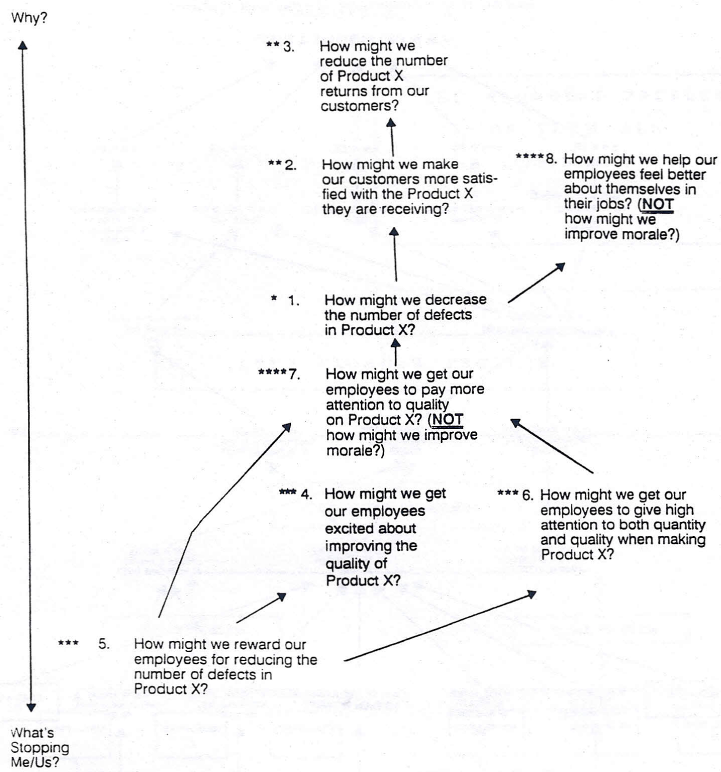


Fig. 7. Expansion of the visual example of how the three-step thinking process works. *, **, ***, See Fig. 3. ****Additional optional challenges created by asking 'why?' and 'what's stopping?' of starting point challenge and avoiding vagueness.

skill to articulate the answers clearly, simply and specifically. Further examples of how problem definition maps are built using the 'why-what's stopping' analysis follow below.

### *Completing the map*

The extent of a problem definition map is limited by two considerations: 'Happiness and Bliss' and 'Do it'. 'Happiness and Bliss' is the theoretically broadest challenge. In a business this might equate to "How might we increase the profitability of our Company?" 'Do it' occurs when, by asking 'what's stopping' takes us so low on the hierarchy that the problem statement is so well defined it is an idea which can be easily executed, thus, 'do it'.

It is not necessary to reach these limits on maps developed. The intent of the map is to develop a better problem formulation, that is, understand how different problems and subproblems relate to one another and to help the stakeholder(s) choose the best problem definition or angle on the problem. The following heuristic is recommended in the development of the map:

(1) Ask 'why' and 'why else' of the original problem statement until all slightly broader problem statements are uncovered. This will usually result in 2–5 broader problem statements.
(2) Ask 'what's stopping' and 'what else is stopping' of the original problem statement until all subproblems are uncovered. This will usually result in 1–10 subproblems.

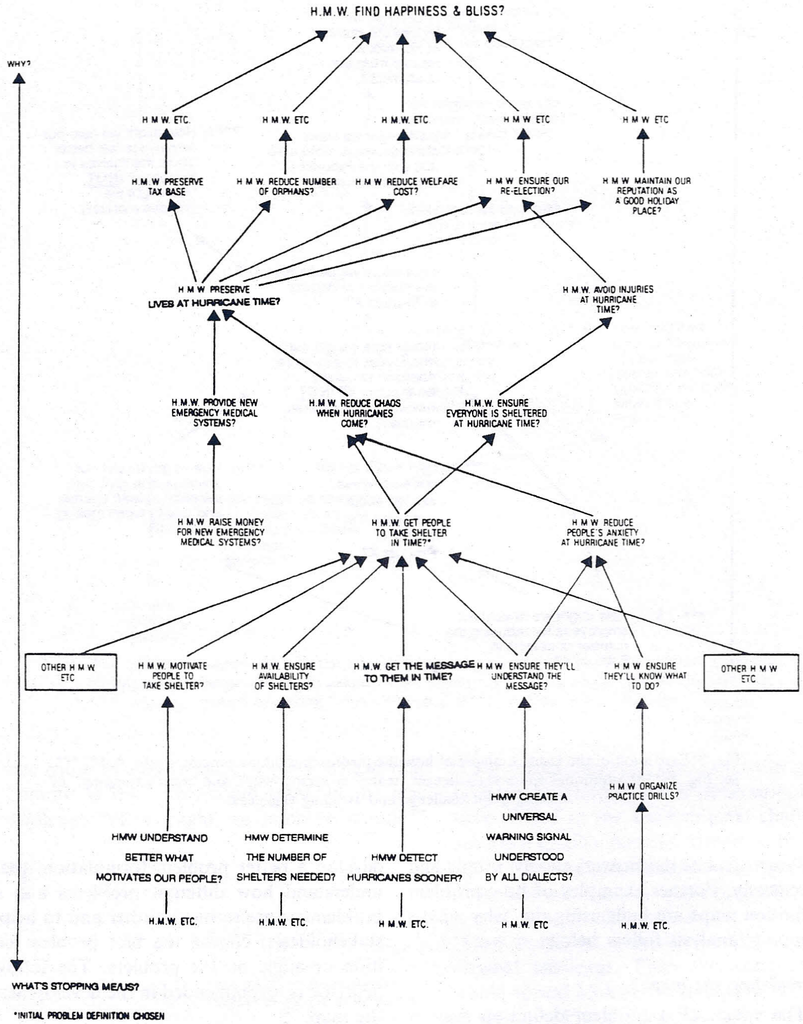


Fig. 8. More fully expanded why-what's stopping problem definition map. 'The Hurricane Problem'.

(3) Review the map for challenges the stakeholder(s) wish to explore further: to break subproblems down even further or to explore broader 'purposes'. Do not forget to check for "what else is stopping . . ." or "why else . . .".
(4) Have stakeholder(s) review the map for 'points of maximum leverage', i.e. the problem statement(s) they believe best define their problem. If this convergence cannot be achieved, return to step 3 to explore the map further on those challenges the stakeholder(s) believes have most merit.

Figure 8 shows a completed 'why-what's stopping' map for a hypothetical example of a government of a tropical country mapping out

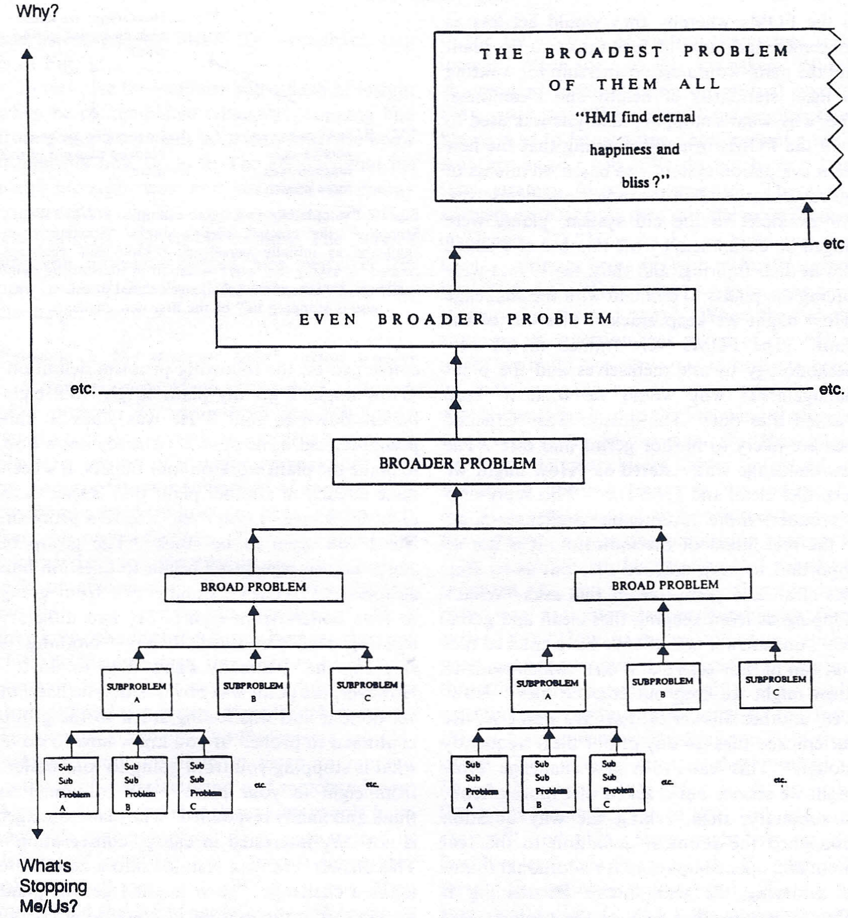


Fig. 9. Complex problem definition—big picture.

its challenges related to people getting injured and killed in hurricane season. The challenges range from "How might we determine the number of shelters needed?" and "How might we detect hurricanes sooner?" to "How might we preserve lives at hurricane time?", "How might we reduce chaos when hurricanes come?", and "How might we ensure our re-election?" Figure 9 portrays a generalization of a completed map. The examples below show insights experienced when applying this methodology to real business and technical situations.

***Example 1. The cracked tiles: a micro-example of 'why'***

This example concerns a group of field operations managers (FOMs) acting as consultants to manufacturing plants in a food and beverage company. One of the duties of the FOMs was to perform a plant evaluation yearly on each plant. The plant evaluation was based on a 'policeman approach' whereby specific criteria were checked off as to whether or not they were met. A new plant evaluation system was introduced to the FOMs whereby they would act less as policemen and more as facilitators to the plant and the plant would take ownership for wanting to meet standards of health and cleanliness. The 'why-what's stopping' analysis was used to train the FOMs in understanding that the new plant evaluation system was based on intents of indicators rather than the indicators themselves. For example, in the old system, plants were judged on cleanliness by the number of cracked tiles in their flooring, and thus, the FOMs were forcing the plants to contend with the challenge "How might we keep cracked tiles out of the plant?" The FOMs were trained in the new methodology to ask themselves and the plant management "why would we want to keep cracked tiles out?" The answer was "Cracked tiles are likely to harbor germs and dirt". The new challenge was restated as "How might we keep tiles clean and germ-free?" This represents a broader, more leveragable challenge closer to the real intent of the indicator. It is not so important to keep cracked tiles out as to keep tiles clean and germ-free. If one asks "What's stopping us from keeping tiles clean and germ-free", one answer is that "We have cracked tiles that can harbor germs and dirt" which leads to 'How might we keep out cracked tiles?" However, another answer is that 'We don't service our cracked tiles (or any of our tiles) frequently enough". This leads to a new challenge 'How might we service our cracked tiles more often?" In summary, then, asking the why question broadened the problem definition to the real intent and opened up room for additional routes to achieving the true intent. Broadening it offered an expanded view of the problem and more flexibility in solving it. It also offered the FOMs an expansion of their consulting skills by helping them lead the plant to focus on the intent of the requirement and thereby take ownership of meeting the intent in the plant's own preferred way. By getting a freer hand in how they would change, the plant was much more willing to make a change. Figure 10 is the completed map.

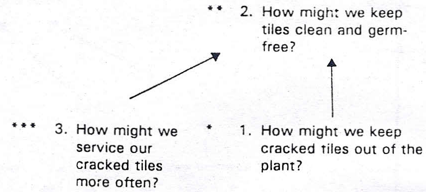


Fig. 10. Example No. 1. A micro example of 'Why?/What's Stopping?' the cracked tiles example. *Starting point challenge as initially perceived. **First new challenge created by asking the 'why?' question of the starting point challenge. ***Second new challenge created by asking 'what else is stopping us?' of the first new challenge.

### *Example 2. Four boilers from eight: an example of 'what's stopping'*

The 'why-what's stopping' analysis was also used to help a manufacturing engineer to narrow his focus. He had worked his way through factfinding and had preliminarily converged on the following problem definition: "How might I get my plant to go from eight boilers down to four?" He was stuck at this point because, as he put it, "I already know how to make the plant work on four boilers. It's been done already in another plant that is similar to ours. So, I guess I don't really have a problem. But I still seem to be stuck". The group of which he was a member began to question him as follows; "What's stopping you from going to four boilers from eight?" He had difficulty replying and continued to say "Nothing is stopping me, I already know how to do it." However, the point was obvious that he had not yet done it and was feeling stuck so the group continued to probe: "If you know how to do it, what is stopping you from going to four boilers from eight in your plant?" He continued to think and finally responded "The plant manager is not very interested in energy conservation". This answer was then restated into a new, more focused challenge, "How might I get the plant manager more interested in conserving energy

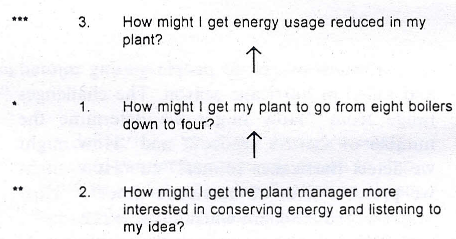


Fig. 11. Example No. 2. 'Four Boilers from Eight'. *Starting point challenge as originally perceived. **New challenge providing new insight created by asking 'what's stopping you?' repeatedly of the stakeholder with respect to the original challenge. ***Additional challenge created by asking 'why?' of original challenge.

and listening to my idea?" The completed map is in Fig. 11.

In this case the engineer had a flash of insight when he contemplated what was stopping him from going from eight boilers to four. He knew technically how to do it. The key fact that his plant manager was not interested in energy conservation was the big eye-opener. This fact was formerly not visible to him. The 'what's stopping' question helped him perceive this new fact and therefore, the new, more fruitful challenge.

***Example 3. The strategic collaboration process***

A third example which shows the structuring of a problem by using both the 'why' and 'what's stopping' questions concerns a strategic planning session of a major corporation. This major corporation is comprised of approx. 50% company-owned facilities and 50% independent franchise-owned facilities. There is considerable mistrust between the groups and considerable lack of efficiency in operations due to this mistrust. The independent franchisees believe they know the business better because they are closer to the customer; they tend to believe the company has sinister motives to ultimately buy them out and not respect their franchise rights. The company believes the franchisees are old-fashioned and unwilling to listen to modern methods of manufacturing and merchandising. A group of twelve, six high ranking people from each side, was assembled. They were trained in deferral of judgment and divergent-convergent thinking skills and in the WWS analysis. They confronted the fuzzy situation as "How might we work better together?", generated a large number of facts and picked the most important. From these they generated 45 challenges and selected the most important few. These few were then subjected to the 'why-what's stopping' questions and arranged into a hierarchy. As the hierarchy was developed, new challenges emerged. The first challenge selected to begin the map was somewhat arbitrarily chosen as (1) "how might we agree on mutual goals?" and was placed in the center of a large $4' \times 4'$ paper. When the question 'why' was asked leading to the following three broader challenges: (2) "How might we be more effective with our customers?", (3) "How might we impove operating profitability?" and (4) "How might we help our franchisees to focus more on winning in the future than protecting themselves from losing?" When the question was asked "What's stopping us from agreeing on mutual goals?" the answer was "We do not have enough trust between us to let us agree upon mutual goals". Another answer was "We do not have a long term strategy for the company". These two answers were transformed into the more focused challenges, (5) "How might we build two-way trust in order to come up with mutually agreed goals?" and (6) "How might we get a long term strategy for the company?" When the 'what's stopping us' question was asked of the "How might we build two-way trust in order to come up with mutually agreed upon goals?", four separate answers lead to the following challenges one level lower in the hierarchy: (7) "How might we keep the franchisees better informed of the macro business trends in the industry?", (8) "How might we get all franchisees believing the President's franchise acquisition message?" (The franchisees at this meeting had heard the president say, and believed him, that the company was not interested in purchasing franchises.) (9) "How might we maintain reliable processes for communicating and coordinating throughout the system?" and (10) "How might we minimize funding procedures to the franchisees from corporate headquarters as a trust issue?" Two other challenges that resulted to fill out the map are (11) "How might we make the system more flexible to deal with industry change?" and (12) "How might we put the franchise legal rights fears to bed?" (i.e. eliminate them). The entire map is shown in Fig. 12. As indicated in Fig. 12, the team converged and prioritized the three most important challenges to solve.

***Example 4. Plant purpose and corporate oneness***

The senior management group of a medium-sized industrial firm was meeting to establish future direction. A major issue, the two plant managers believed, was that they needed to better define the unique purposes of the Canadian and US plants, i.e. which products each would make. However, when the group tried to move on into solving this problem, it was obvious that there was not true consensus and other issues were surfacing. By asking "Why would we want to define the purpose of the Canadian and US plants?" two higher level objectives emerged. First, there was significant competitiveness

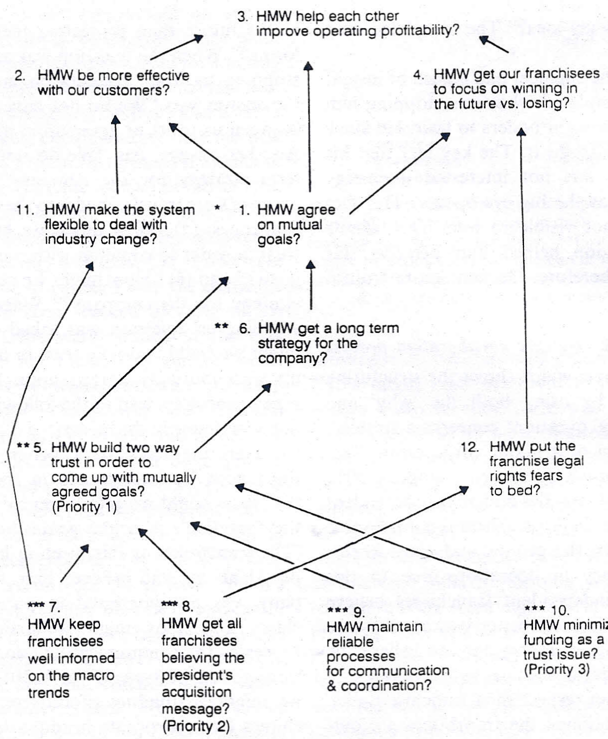


Fig. 12. Example No. 3. The strategic collaboration process. *Starting point challenge. **More focused challenges created by asking the 'what's stopping us?' question of the starting point challenge. ***Even more focused challenges created by asking the 'what's stopping us?' question of challenge No. 5.

between the plants for products. A second fact was that barriers had developed between the two plants. These facts generated two new challenges: "How might we minimize competitiveness between the plants for products?" and "How might we individually contribute to breaking down barriers?"

Asking "Why would we want to minimize competitiveness between plants for products?" led to the fact that this would allow the Canadian plant to feel a part of the US organization, as opposed to being a separate company. This fact led to a major 'aha' to the group that their broader problem to solve was "How might we improve oneness with the Canadian plant?"

The team next looked at what was stopping them from improving oneness with the Canadian plant. As can be viewed in Fig. 13, four additional subproblems were uncovered. These subproblems were broken down further using the 'What's stopping us..." question and resulted in an extensive map of relationships of problems and subproblems. This map became their strategic planning tool from which three subproblems were chosen to work further in corporate teams. Secondly, the WWS map served as a method of sharing with other managers the relationship of the problems they were experiencing and allowed them to understand how, by solving some of the tactical problems (narrower), they were helping the company address some broader (more strategic) issues.

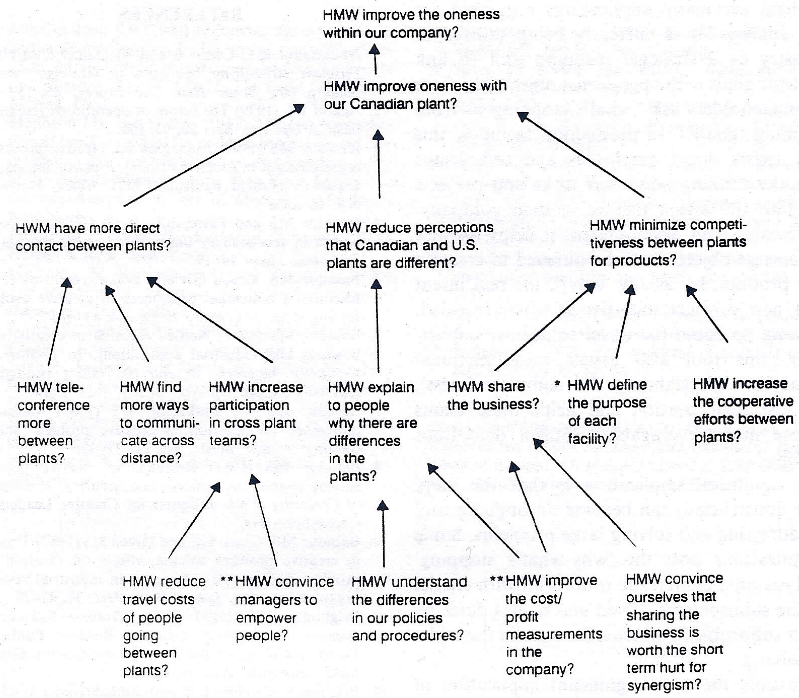


Fig. 13. Example No. 4. Plant purpose and corporate oneness. *Starting challenge on the map. **Ending challenges chosen after considering the problem definition map as a whole. Note: This map continued to be utilized over several months at several strategic planning meetings as other challenges were addressed from it.

## DISCUSSION

The construction of the 'why-what's stopping' analysis is a combined creative and analytical exercise. Divergent thinking is required to generate both the multiple 'why else' and 'what else is stopping' problem statements. In addition, divergent thinking is required to transform the answers into meaningful new challenges. Analytically, the methodology requires a disciplined approach using 'why' to broaden and 'what's stopping' to narrow so that problem statements 'fit' into a logical hierarchy.

The process of mapping often leads the stakeholder(s) to an 'aha' experience. If, for instance, the stakeholder originally defined as a symptom as the problem, upon asking 'what's stopping?' the 'real problem' will emerge. In addition, some stakeholders narrow the problem too much in the beginning (they cannot see the forest for the trees), so that by broadening the problem, they gain a perspective and a better, more leverageable problem definition. Or, the stakeholder's try to 'eat the elephant' instead of breaking the problem down into 'bite size chunks'.

Problem definition is particularly difficult on ill-structured problems. Stakeholders do not know when they initially try to define the problem whether they have a 'good' problem statement or not. The 'why-what's stopping' analysis *does not* choose the correct problem statement for the stakeholder(s). It does create a meaningful visual representation of the problem so that the stakeholder(s) can consider how to strategically approach the ill-structured 'mess'. The stakeholders must then consider which problem definition(s) they believe will best lead to an improvement of the 'mess'.

There are many implications suggested for this analysis. It is currently being utilized in industry as a strategic planning tool to link strategic goals with operational objectives where the stakeholders ask "what's stopping us from attaining (goal)?" In production facilities, this tool assists direct employees and technicians in understanding how their tasks and projects 'fit' into the bigger picture in their company. In research and development, it helps identify the correct objectives to be pursued to create a new product. By asking 'why?', the real intent of a new product initiative is often revealed, opening up room for novel solutions. Importantly, this tool also assists multifunctional teams in understanding the complete 'mess', not just their portion and helps these teams choose more leveragable problem definitions to solve.

A significant implication is that the map, once constructed, can become an ongoing tool in addressing and solving large problems. Some organizations post the 'why-what's stopping' analysis on a conference room wall with checks by the subproblems solved and names/dates by other subproblems which others are in the midst of solving.

Possibly the most significant implication of the 'why-what's stopping' analysis is its impact on building problem defining skills. Evans [16], Watson [40], and others suggest that individuals are poor at problem defining. Abualsamh *et al.* [1] recognized that individuals rarely use decision aids in problem defining and, thus, studied the results of two basic problem structuring heuristics. They found lower satisfaction with the process and a lower confidence with the results when forced to use a heuristic. An alternative explanation for this finding is that the subjects, along with being placed under time constraints, were not trained in using the heuristics and were not using the 'expansion' and 'reduction' heuristic at the same time. Research is underway to consider the problem defining performance, confidence, and skills built using the 'why-what's stopping' analysis. These findings will help validate and refine the theoretical models explored earlier, identify situations where the 'why-what's stopping' analysis is most effective and develop training for improving problem defining performance on ill-structured problems in the workplace and homeplace.

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