Chapter 2
Problems and Messes

Abstract As problems have grown more complex, the methods we use to address them must evolve as well. Machine age problems, consisting of simple systems, have traditionally been addressed using a primarily technical perspective. Despite their increased complexity, in systems age problems, a predominantly technical perspective continues to be used at the expense of other complementary perspectives. This myopic approach has often been unsuccessful in solving these problems. The development of multiple perspectives requires those faced with addressing complex problems to include additional perspectives in order to achieve increased understanding. This includes the integration of hard and soft perspectives to ensure that, in addition to a technical perspective, the equally important organizational, political, and human perspectives have been included. The application of multiple perspectives offers a more inclusive framework through which complex problems may be addressed. The integration of technical, organizational, political, and human perspectives widens the aperture through which a problem is viewed, which then increases the likelihood of correctly addressing these complex problems. Embracing these complementary perspectives, guidance is given on how to begin to structure our mess into a number of discrete problems for analysis.

2.1 A Brief Introduction to Complexity

This section will provide a brief discussion on understanding complexity and on the emergence of the systems age and how problems in the systems age are unique from those in the machine age.

2.1.1 Understanding Complexity

Returning to the preface, it is clear that there are many definitions of complexity. While it may seem like an exercise in semantics to differentiate between, for

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example, *complex* and *simple* systems, it is anything but. From a scientific perspective, we wish to understand complexity in a manner that allows us to appropriately deal with it (if indeed there is an it to deal with). We can first begin by looking at the word *complex* itself. The word has origins as a form of the Latin *complector*, meaning *woven together*. From a linguistic perspective, the opposite of the word complex is *simple*, but the linkage between simple and complex is not so straightforward. "A complex system cannot be reduced to a simple one if it was not simple (or perhaps merely complicated) to start off with" (Cilliers, 1998, p. 9). This evokes parallels to the idea of a system as a whole greater than the sum of its parts. Further, "Complex systems are said to be poised at such a position, between order and chaos" (Rickles, Hawe, & Shiell, 2007, p. 935).

> Because complexity results from the interaction between the components of a system, complexity is manifested at the level of the system itself. There is neither something at a level below (a source), nor at a level above (a meta-description), capable of capturing the essence of complexity. (Cilliers, 1998, pp. 2–3)

"A complex system is a system formed out of many components whose behavior is emergent, that is, the behavior of the system cannot be simply inferred from the behavior of its components" (Bar-yam, 1997, p. 10). A complex system

> "must be able to store information concerning the environment for future use; and it must be able to adapt its structure when necessary….Any model of a truly complex system will have to possess these capabilities. In other words, the processes of representation and self-organisation must be simulated by the model." (Cilliers, 1998, p. 10)

Regarding representation, "the structure of the system cannot consist of a random collection of elements; they must have some *meaning*" (Cilliers, 1998, p. 11). Self-organization can be described as "a process whereby a system can develop a complex structure from fairly unstructured beginnings" (Cilliers, 1998, p. 12).

What does analysis of all of these definitions lead us to conclude? Are we any closer to our elusive goal of precisely defining complexity? Seemingly the answer is no. Gershenson (2007) sheds light on the difficult in doing so: "The problem of a strict definition of complexity lies in the fact that there is no way of drawing a line between simple and complex systems independently of a context" (p. 13).

Hester (2016) summarizes the discussion by defining a complex (vice a simple) system as "a purposeful collection of elements whose initial conditions give rise to emergent behavior not present at other levels of system abstraction." The precise distinction drawn is that of the presence of emergence not found in simple systems (but present in complex systems). We utilize this definition for the remainder of this text. So, the next question is, is the rise in problem complexity the result of a natural evolution of problem structure or a fundamental shift in the way in which we have approached problems? That is, are problems actually getting more complex or are we simply tackling more complex problems (given, for example, our advances in computing capabilities as compared to previous generations)? For an answer to these questions, we turn to the notion of the machine and systems ages.

Table 2.1 Ackoff's machine age and systems age characteristics

	Machine age	Systems age
Description	Simple system	Complex system
Boundary	Closed	Open
Elements	Passive parts	Purposeful parts
Observable	Fully	Partially
Method of understanding	Analysis and reductionism	Synthesis and holism

2.1.2 The Machine Age and the Systems Age

Systems and management pioneer Russell Ackoff [1919–2004] (1974b) used the terms *machine age* and *systems age* to refer to eras that he contended were concerned with two fundamentally different types of problems. The machine age was concerned with simple systems (and problems), and the systems age is concerned with complex systems (and problems). Table 2.1 contrasts the most basic characteristics of the machine and systems ages.

Ackoff (1979a) recognized that the technical perspective of the machine age was inadequate for coping with what he termed the *messy* situations present in the systems age, where human activity systems were predominant. He coined the concept of a *mess* and *messes* in 1974 and continued to use the term in 1979 when he solidified the idea in two papers where he was arguing that traditional operations (or in UK terms, operational) research was passé and that a more holistic treatment of systems problems was required (Ackoff, 1974a, 1979a, b). He foresaw that a wide variety of disciplines would be necessary to solve systems problems. Ackoff's (1979a) definition of a mess and messes is worthy of review:

> Because messes are systems of problems, the sum of the optimal solutions to each component problem taken separately is not an optimal solution to the mess. The behavior of the mess depends more on how the solutions to its parts interact than on how they interact independently of each other. But the unit in [operations research] OR is a problem, not a mess. Managers do not solve problems, they manage messes. (p. 100)

The bottom line is that complex problems in the real world must include a definition of human activity in the development of the contextual framework for the problem. For Ackoff (1979a), context was the essential element that modern systems age problem solvers would need to include in each problem formulation if these problems were to be understood and later addressed. He argued that the utility of traditional operations research had been diminished because these techniques, rooted in a machine age paradigm, were unable to account for the complexity caused by humans that were present in almost all systems age problems. Burrell and Morgan (1979) support Ackoff's contention, stating:

> Mechanical models of social systems, therefore, tend to be characterized by a number of theoretical considerations and are thus of very limited value as methods of analysis in situations where the environment of the subject is of any real significance. (p. 61)

In short, the methods and techniques of traditional operations research are "…mathematically sophisticated but contextually naïve and value free" (Hughes & Hughes, 2000, p. 10). Ackoff's work established the need for a clear understanding of specific or relevant context as fundamental to understanding and analyzing systems age problems.

Additional support for Ackoff's notions was provided by Nobel laureate Herb Simon [1916–2001] who addressed what he labeled an *ill-structured problem*. Simon (1973) states that "an ill-structured problem is usually defined as a problem whose structure lacks definition in some respect" (p. 181). A systems age problem is ill-structured when circumstances and conditions surrounding the problem are potentially in dispute, not readily accessible, or lack sufficient consensus for initial problem formulation and bounding. There may be multiple and possibly divergent perspectives or worldviews, rapidly shifting and emergent conditions that render stable solution methods innocuous, and difficulty in framing the problem domain such that the path forward can be engaged with sufficient alignment of perspectives to remain viable. Rittel and Webber (1973) termed this type of problem a *wicked problem*, where:

> The information needed to understand the problem depends upon one's idea for solving it. That is to say: in order to describe a wicked-problem in sufficient detail, one has to develop an exhaustive inventory of all conceivable solutions ahead of time. The reason is that every question asking for additional information depends upon the understanding of the problem—and its resolution—at that time. Problem understanding and problem resolution are concomitant to each other. Therefore, in order to anticipate all questions (in order to anticipate all information required for resolution ahead of time), knowledge of all conceivable solutions is required. (p. 161)

A wicked problem may be contrasted with a *tame* problem, described as "one which can be specified, in a form agreed by the relevant parties, ahead of the analysis, and which does not change during the analysis" (Rosenhead & Mingers, 2001, p. 5). The immediate result of a wicked problem is the questionable ability of traditional approaches based upon a single technical perspective to be successful. Still another articulation of this class of problems comes from Schon, who coined the term *swamp* to describe this class of problems:

> …there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing "messes" incapable of technical solution. The difficulty is that the problems of the high ground, however great their technical interest, are often relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern. Shall the practitioner stay on the high, hard ground where he can practice rigorously, as he understands rigor, but where he is constrained to deal with problems of relatively little social importance? Or shall he descend to the swamp where he can engage the most important and challenging problems if he is willing to forsake technical rigor? (Schon, 1983, p. 42)

Ravetz (1971) introduced the idea of the practical problem to contrast with a technical problem. Technical problems have a clearly defined function from the inception of the analysis, which can be solved by experts, whereas *practical* *problems* have a vague statement of the purpose to be achieved and their output is consensus regarding problem definition, leading to a recommendation for appropriate solution means.

Finally, Ozbekhan (1970) discusses the notion of a *problematique* as a "meta-problem (or meta-system of problems)" (p. 13), in contrast to a standard, well-bounded problem. This new class of problems such as poverty, urban blight, and criminal activity cannot be viewed as problems that exist in isolation. Thus, the problematique arises as a series of interconnected problems for all but the most trivial of problems. Once again, consideration of context is paramount.

The fact that a new class of problems has emerged is clear. The question of how to deal with these messes (beyond simply not applying traditional operations research techniques) is not so clear.

2.2 Dealing with Systems Age Messes

All of the differing articulations of complex problems presented in the previous section describe situations where there are divergent stakeholders, emergent conditions, and nonoptimal solutions to ill-defined problems. Given these difficult conditions, the question becomes, how do we deal with these situations? From our point of view, it seems reasonable to assume that the manner in which a systems age mess is perceived by its stakeholders is a major determinant of the degree of these factors that each of the stakeholders is able to clearly identify as part of the problem analysis.

2.2.1 Scientific Approaches to Complex Problems

Thomas Kuhn defines *paradigm* to be "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (Kuhn, 2012, p. xlii). Each scientific community has its own paradigm, including its own ontology, epistemology, axiology, rhetoric, and methodology, that it uses to address a problem (Adams & Hester, 2016). The combination of these factors results in a unique scientific approach, as shown in Fig. 2.1.

Further, relativistic perceptions of complexity add to the difficulty in understanding complex problems. Just like beauty, complexity is in the eye of the beholder. What may be complex to one individual may be simple to another. Take education, for example. A lifelong school administrator may find setting the budget for a given middle school a trivial task, whereas a teacher at the very same school may struggle to keep students out of trouble given a scarcity of after school activities, a direct result of the budget process. A more difficult question is certainly balancing the budget of said school with all others in the district, or perhaps the state or nation. Such a broadening of scope would certainly entail game theory, sociology, economics, and a host of other considerations certainly presenting

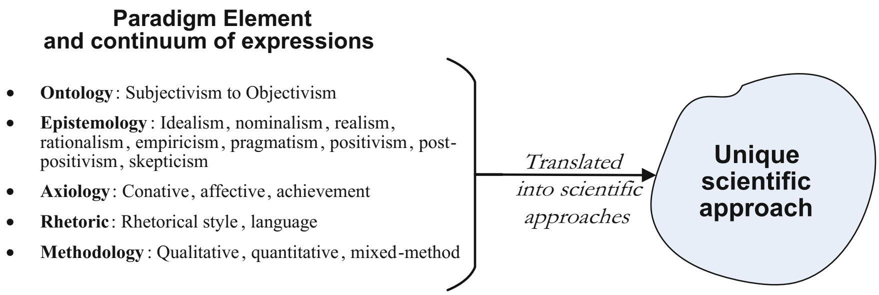

Fig. 2.1 The relationship between paradigm element and scientific approach (Adams & Hester, 2016)

complexities to most, if not all, individuals. So, while the administrator sees a simple budgeting exercise, the educator may see a much more complex problem rife with socioeconomic factors. How can this duality exist? Mitchell (2009) summarizes this phenomenon as "…there is not yet a single science of complexity but rather several different sciences of complexity with different notions of what complexity means" (p. 95).

2.2.2 Perspectives in Complex Problems

Thus, in order to improve our understanding about a complex problem, we must consider numerous perspectives. If we view a problem as simple, it may indeed be simple, or we may not be considering it holistically enough. Because there is not a single true reality or correct perspective of any systems age mess, the systems *principle of complementarity* (Bohr, 1928) must be applied. The principle simply states:

> Two different perspectives or models about a system will reveal truths regarding the system that are neither entirely independent nor entirely compatible.

If we think of a perspective as the state of one's ideas or the known facts, then we can represent the worldview of the observer as a function of the number (i) of perspectives (P_i) utilized to represent the problem under study. Equation 2.1 (Adams & Meyers, 2011) is a mathematical representation of contextual understanding for a limited number of perspectives (n). It is worth noting that this equation is intended to be illustrative, rather than prescriptive. Recalling the earlier discussion of a mess and its properties, our understanding is certainly not a linear summation of constituent perspectives, but rather a complicated relationship that indicates, at least in the abstract, that more perspectives lead to an improved understanding of a complex problem.

$$\text{Contextual Understanding} = \sum_{i=1}^{n} P_i \tag{2.1}$$

Perfect understanding requires complete knowledge of the infinite number of perspectives, a fact that problem solvers struggle to control when bounding messy, ill-structured, or wicked problems. Equation 2.2 (Adams & Meyers, 2011) is a mathematical representation of perfect understanding.

$$\text{Perfect Understanding} = \sum_{i=1}^{\infty} P_i \tag{2.2}$$

A depiction of these concepts is shown in Fig. 2.2. This figure shows that as both time (t) and the number of perspectives increases, our understanding increases dramatically. Perfect understanding is depicted as a plane that we attempt to attain but cannot reach no matter how much time passes or how many perspectives we consider.

Because, by definition, our scope of perspectives is limited, we can never have perfect understanding of a complex problem, and thus, we must strive to increase the value of our contextual understanding. The question naturally arises, then, as to how many perspectives are sufficient. There are two answers: (1) the academic perspective and (2) the practical perspective. The academic answer, as quantified by Eq. 2.2, is that there are never enough perspectives for a problem. While this is true, we must strive for perspective saturation (Glaser & Strauss, 1967). That is, we should continue to gather perspectives until we no longer obtain new or insightful information. The practical answer, however, says the act of gathering perspectives is typically undertaken until we run out of resources (e.g., time and money), which is often well in advance of having collected a sufficient number of perspectives. Practical constraints limit the number of perspectives that we are able to consider and many of us erroneously only consider a singular perspective, our own, when

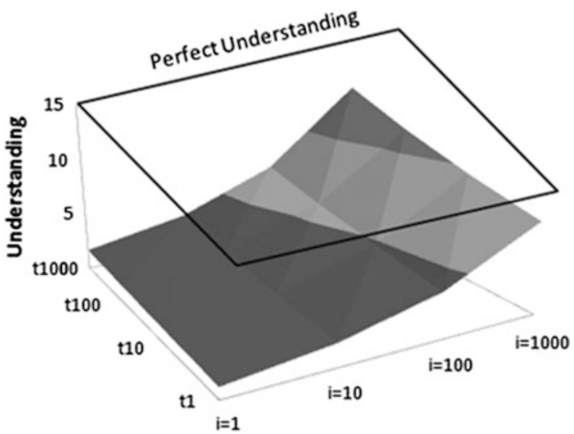

Fig. 2.2 Depiction of increased understanding as a function of time (t) and perspectives (i)

addressing a problem; however, it is clear that it is useful to obtain numerous perspectives as appropriate and available.

It is exceedingly important, then, that we choose the perspectives that we incorporate carefully. We must seek those that have the ability to add to our understanding rather than those viewpoints that confirm our own (a phenomenon known as confirmation bias that we will revisit in Chap. 15). Further, the more disparate our perspectives, the more potentially enlightening the information we obtain. In this way, we can treat this effort in the same manner we would treat a hypothesis test. We wish to collect information that has the potential to disconfirm our hypothesis. If the hypothesis that we have formulated stands up to scientific scrutiny, in this case multiple perspectives, then we have greater confidence in its validity. If not, then perhaps our initial assumptions were incorrect. At the very least, conflicting perspectives may demand additional investigation.

Our ideas about the inclusion of multiple perspectives are echoed by two outstanding systems thinkers, Ian Mitroff and Harold Linstone. Mitroff is a long-time advocate for systemic thinking (Mitroff, Alpaslan, & Green, 2004; Mitroff & Kilmann, 1977) and was the first to formally characterize the Type III error (Mitroff, 1998; Mitroff & Betz, 1972; Mitroff & Featheringham, 1974; Mitroff & Silvers, 2010), as discussed in Chap. 1. Linstone has been a strong proponent of the use of multiple perspectives in problem investigation (Linstone, 1985, 1989; Linstone et al., 1981). In their book *The Unbounded Mind* (Mitroff & Linstone, 1993), they make this important point:

> "everything interacts with everything," that all branches of inquiry depend fundamentally on one another, and that the widest possible array of disciplines, professions, and branches of knowledge—capturing distinctly different paradigms of thought—must be consciously brought to bear on the problem. (p. 91)

2.3 Holistic Understanding

Holistic understanding of systems age messes requires problem solvers to formally account for elements contained in both hard and soft approaches to complex problems. A hard system perspective includes notions such as objectivity, unitary viewpoints, and quantitative assessment; while a soft systems perspective evokes subjectivity, pluralistic perspectives, and qualitative assessments. The attributes of the hard and soft systems approaches are depicted in Table 2.2.

The contrast between the views represented by the soft and hard systems approaches leads to significantly different perspectives of the problems encountered by the problem solver or problem solving team. The soft perspective considers organizational, managerial, policy, political, and human factors, while the hard perspective tends to deal with only technical elements, those that can be reduced to

Table 2.2 Attributes of hard and soft systems approaches (Adams & Meyers, 2011, p. 167)

Attributes	Hard systems view	Soft systems view
Worldview	A real world exists external to the analyst	Perspectives of reality are dynamic and shifting
Data	Factual, truthful, and unambiguous data can be gathered, observed, collected, and objectively analyzed	Data are subjective in collection and interpretation—analysis strives for transparency
System	The system in focus is unaffected by either the analysis or the analyst	The system in focus is affected by both the analysis and the analyst
Analysis results	The results of analysis are replicable	Results of analysis are *credible* and capable of compelling *reconstruction*
Value	The analysis can be conducted free of value judgments	The analysis and interpretation of analysis is value-laden
Boundaries	The system in focus can be bounded and the analysis can be controlled—this is both possible and desirable	Bounding of the system in focus is problematic, control of the analysis is questionable—emergence is dominant

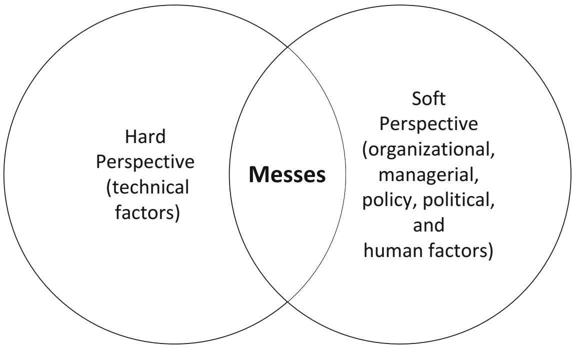

Fig. 2.3 Messes as the intersection between hard and soft perspectives

objective measures. The hard perspective is more appropriate as a stand-alone approach for dealing with machine age problems concerned primarily with technical solutions, whereas the soft perspective is more concerned with social systems, ones that are primarily devoid of technical considerations. Figure 2.3 shows how both approaches contribute to the development of understanding for systems age messes. Messes occur at the intersection of these two perspectives and thus, require both soft and hard perspectives to be considered in order to achieve an appropriate level of understanding.

The most fundamental, and therefore first, step in achieving a holistic understanding of a mess is to first formulate articulate its constituent problems in a manner that is conducive to further exploration.

2.4 What's the Problem?

It is one of the most fundamental questions we are routinely faced with and yet one of the most vexing—*what's the problem*? In order to begin a discussion of *problems*, we first define what we intend when we use the term. Smith (1988) defines three criteria for a problem: (1) a gap between current and desired state, (2) there is some difficulty in bridging that gap, and (3) someone must wish to bridge the gap. While it seems straightforward, in practice, it is anything but. "In any complex, real world, situation, there are an unlimited number of concerns which could be identified as problems, but there are none which absolutely must be so identified" (Smith, 1988, p. 1491).

Duncker (1945) offers a complementary definition of the term:

> A problem arises when a living creature has a goal but does not know how this goal is to be reached. Whenever one cannot go from the given situation to the desired situation simply by action, then there has to be recourse to thinking. (By action we here understand the performance of obvious operations.) Such thinking has the task of devising some action which may mediate between the existing and the desired situations. (p. 1)

Similar to Smith (1988), Sage (1992) succinctly defines a problem as "an undesirable situation or unresolved matter that is significant to some individual or group and that the individual or group is desirous of resolving" (p. 232). In defining a problem in this manner, Sage focuses on a problem as something which is undesirable. Sage (1992) goes on to define four basic characteristics of problems. The first three of his criteria are the same as Smith (1988), but he adds the following criterion:

> The situation is regarded as resolvable by an individual or group, either directly or indirectly. Solving a problem would constitute a direct resolution. Ameliorating or dissolving a problem, by making it go away, is an indirect resolution of a problem. (p. 232)

So, a problem is difficult to resolve, but resolution is perceived as achievable.

Pidd (2009) offers another take on terminology, distinguishing between puzzles, problems, and messes, noting the following:

Puzzles are a

> …set of circumstances where there is no ambiguity whatsoever once some thought has been given to what is happening or needs to be done. The issues that need to be faced are entirely clear, the range of options is completely known, and there exists a single correct solution to the puzzle. (Pidd, 2009, pp. 43–44)

Examples of puzzles include jigsaw puzzles and crossword puzzles. Arriving at a solution is straightforward as it requires us to apply known methods to arrive at a singular correct answer. This class of situations is of no interest in the context of this book and will not be discussed further.

Problems have "no single answer that is definitely known to be correct…it depends on how you, or someone else, decides to construe it" (Pidd, 2009, p. 44). This again evokes notions of context. Thus, there may be agreement about the issue to be addressed, but there may be numerous, equally valid, solutions to the problem.

An added complication is that the solution approach used to address a problem may yield unique results from another, equally appropriate approach. In this case, the problem is well structured, but "considerable ingenuity and expertise may be needed to find an acceptable, let alone optimal solution" (Pidd, 2004, p. 7).

A problem has one or more *owners*, or those that recognize its existence as a problem. The idea of ownership is reflected in Smith's definition of a problem: "Problems are conceptual entities defined as a way of allocating attention to unsatisfactory aspects of reality that one hopes to improve through action" (1988, p. 1492). Ownership involves a desire to see a problem resolved and a willingness to allocate resources (i.e., time, money, and intellect) to do so. It is worth noting that the owner of a problem is not necessarily the decision maker. An individual or group can be the owner of a problem yet not have the resources to resolve it. The decision maker is the individual who has the authority to allocate resources in an effort to resolve a given problem. One example where the problem owner is not the decision maker is that in which a teenager desires to go out and see a movie with his friends on a Saturday night. That is to say, he wishes to move from his current state of boredom to an ideal state of enjoyment with friends. However, if he lacks the authority to go out and he is denied his request for doing so due to being grounded, then his decision has been made for him. Thus, he is not the decision maker. He does not control the resources (e.g., the car or the money to buy a ticket). Another example might involve commuters who drive along a failing highway daily (thus they *own* the problem) and yet whose elected officials reside in an altogether different geographical region (i.e., the state capital) and thus, have no problem ownership, yet they control the financial means to remedy the situation through state budget allocation (thus, they are the decision makers).

Messes are systems of problems "with multiple stakeholders who may hold quite different views on what is feasible and desirable" (Pidd, 2009, p. 44). There may also be debate as to what the definition of the issue is. Thus, both the problem formulation and methods to address it are potentially in conflict. As opposed to problem definition, mess articulation cannot easily be represented in a succinct form. "Indefinite goals seem to be an important factor in producing the weakness of structure in many ill-structured problems" (Greeno, 1976, p. 480). The delineation between a mess and a problem boils down to this definition. The goal (i.e., objective) of a mess is unable to be stated succinctly as it does not exist. If it can be stated as a singular objective, then it is merely a problem, albeit perhaps a complex one. Each constituent problem, however, should be capable of being captured as a concise statement of an objective such as *Find the best route to work* or *Select a job*. A mess is better articulated not linguistically, as in the case of a problem, but graphically. While we can certainly identify a mess linguistically, (i.e., this traffic is a *mess*), this simple statement fails to capture the intricacies that only a graphical depiction can. We will return to this notion later in Chap. 5 as we discuss complex systems modeling.

Others view the notion of a problem more pragmatically. Newell, Shaw, and Simon (1959), studying problem solving and formulation, define a problem as existing "whenever a problem solver desires some outcome or state of affairs that he does not immediately know how to attain" (p. 1). This perspective motivated their work in developing a General Problem Solver, their attempt to generate a universal problem-solving computer algorithm. This work introduced the notion of means-ends analysis, whereby a goal is established (this can be thought of as Smith, Duncker, and Sage's notions of a goal or desired state) for a situation. This desired state is contrasted with a current state. Your problem represents your difference, or delta, between the two. If your current state is equal to your desired state, then you do not have a problem. Newell et al. (1959) discuss a simple example which explains means-ends analysis:

> I want to take my son to nursery school. What's the difference between I have and what I want? One of distance. What changes distance? My automobile. My automobile won't work. What's needed to make it work? A new battery. What has new batteries? An auto repair shop. I want the repair shop to put in a new battery; but the shop doesn't know I need one. What is the difficulty? One of communication. What allows communication? A telephone…And so on. (pp. 8–9)

The universe of acceptable decisions available to you to move from your current state to desired state is your *problem space*. This problem space may include several intermediate steps which each move your current state some amount closer to your desired end state. Identification of the delta between our current and desired states is a useful and practical means for us to articulate our problem. Readers interested in more information on means-ends analysis, problem-solving computer algorithms, and early developments in artificial intelligence are referred to Newell and Simon (1972).

Before proceeding, it is imperative that a consensus on terminology be reached. Thus, with this discussion in mind, we adopt the following definitions for the remainder of this text:

> A *problem* is an undesirable situation without a clear resolution that an individual or group wishes to see resolved. The same problem can be owned by more than one person (which may lead to discordance regarding the resolution of said problem).

Adopting the definition of a complex system found in Hester (2016):

> A *mess* is a purposeful collection of problems whose initial conditions give rise to emergent behavior not present at other levels of problem abstraction. A mess is comprised of two or more uniquely owned problems that interact in some capacity.

A point of clarification is necessary before proceeding. Two problems with the same owner do not represent a mess. Any two problems owned by the same individual or group can be redefined as a multiobjective problem. Thus, there must be multiple problem owners (whose problems interact) to constitute a mess.

We now turn to the issue of problem structuring in an effort to understand how to formulate problems for investigation and potential resolution.

2.5 Problem Structuring

Research has shown the importance of focusing on avoiding the Type III error before attempting to address a problem (Adams & Hester, 2012, 2013; Hester & Adams, 2014). This is not a novel idea to practitioners. "The risk of solving the 'wrong problem' is generally acknowledged and discussed by practitioners" (Woolley & Pidd, 1981, p. 197). Yet, we often fail to correctly identify a problem before attempting to address it. Why?

> Three principal reasons why persons fail to identify accurately problems and their causes are: (1) the problem solver doesn't actually perceive the problem - he is blind to it; (2) the wrong problem or the wrong causes of it (or both) are identified; and (3) the problem identification phase is skipped over and ignored-efforts are immediately made to solve 'the problem'. (Watson, 1976, p. 88)

The most fundamental, and therefore first, step in achieving a holistic understanding of a mess is to first articulate its constituent problems in a manner that is conducive to further exploration. This process is known as problem structuring (or alternatively, as problem formulation, identification, or definition). Problem structuring methods (PSMs) are a class of methods that help a series of divergent stakeholders to understand the complex problem they face *before* attempting to resolve it, thereby hoping to avoid a Type III error. Woolley and Pidd (1981) highlight the importance of structuring in dealing with messes, describing it as "the process of arriving at a sufficient understanding of the components of a particular problem to proceed to some sort of useful operational research work" (p. 198). It helps us to reveal the *real problem*, as opposed to the *perceived* or *reported problem*. This is important as problem articulation is a subjective undertaking. Just as there many models that can be used to describe a given situation, there are many problems that can be identified to describe a given situation (Ackoff, 1974a).

Problem structuring is fundamentally a systems thinking-derived concept. Pidd (1988) elaborates:

> The aim is to take the richness of the presenting mess, and from this to extract research tasks which can be regarded as reasonable units [see Fig. 2.4]. This does not imply that these research tasks, and the issues which they address, are disjoint. To imply that would be totally to ignore all the insights of systems thinking. Rather, these tasks are linked together by assumptions which form a structure which permits further detailed research and which prevents the research tasks from being isolated from one another. (p. 116)

Rosenhead (2006) discusses the situations for which PSMs are advantageous as those having multiple actors, differing perspectives, partially conflicting interests, significant intangibles, and perplexing uncertainties. Even knowing these basic characteristics does not make problem structuring any easier. It is not a straightforward endeavor, for many of the reasons we have talked about so far, e.g., any time we have multiple divergent perspectives, the complexity of our situation increases substantially. Vennix (1996) agrees, stating of messy problems:

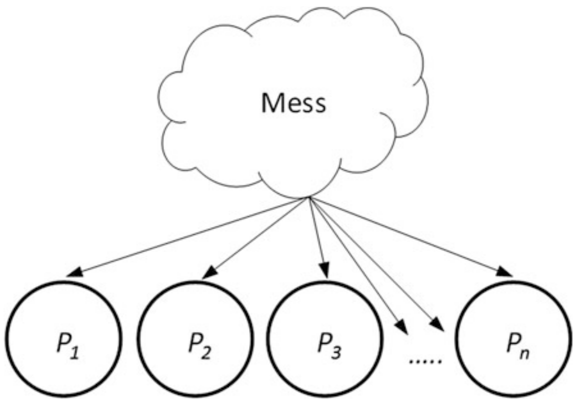

Fig. 2.4 Problem structuring illustration (adapted from Pidd, 1988)

> One of the most pervasive characteristics of messy problems is that people hold entirely different views on (a) whether there is a problem, and if they agree there is, and (b) what the problem is. In that sense messy problems are quite intangible and as a result various authors have suggested that there are no objective problems, only situations defined as problems by people. (p. 13)

As such, problem identification is not trivial. Further, the question of problem identification can have different levels of importance depending on the situation that we are facing—discerning that the stomach pains we are experiencing are really appendicitis likely is more important than choosing what we will have for dinner, and yet both situations may be perceived to meet our earlier definition of a problem as an undesirable situation without a clear resolution that an individual or group wishes to see resolved. Indeed, problems are omnipresent and, often times, overwhelming.

To assist individuals in dealing with their problems (or more appropriately, their messes), we suggest modern approaches to reductionist problem solving are insufficient, not because they suggest we decompose a problem, but because, after analysis of this singular problem, they often ignore the reintegration of this problem into the context of which it is a part. Just like no man is an island, no problem exists in isolation. Our appendicitis problem must also consider insurance, transportation to the doctor, family history, alcohol and drug use, and diet, while our dinner choice must consider our finances, social obligations, fellow diners, availability of cuisine, allergies, and time constraints.

In order to identify and formulate our problem (and surrounding mess), one must appreciate the underlying purpose of its associated system. It is in our best interest to ensure that our stated problem truly reflects the concerns of relevant stakeholders. This is sometimes easier said than done as we do not always have complete latitude over this exercise, however. In fact, our problem may be predefined by some authority (such as a customer) or the organization in which we work. Using our earlier terminology, the decision maker (i.e., customer) may not be the owner of the problem (i.e., the user who wishes to see the problem resolved but does not have the financial means to do so). Hammond, Keeney, and Raiffa (2002) agree, urging decision makers to consider the trigger, the initiating force, behind their problems. They caution, “Most triggers come from others…or from circumstances beyond your control…Because they’re imposed on you from the outside, you may not like the resulting decision problems” (pp. 18–19). In this case, at a minimum, we should work with other stakeholders to refine the problem in a manner conducive to gaining further understanding. If we can influence our problem formulation, we need to consider what triggered the problem so that we can ensure we have identified the root problem.

Hammond et al. (2002) echo the importance of problem formulation: “The way you state your problem frames your decision. It determines the alternatives you consider and the way you evaluate them. Posing the right problem drives everything else” (p. 15).

In all, problem formulation is neither trivial nor to be taken lightly. “Defining the problem is sometimes the most difficult part of the process, particularly if one is in a rush to ‘get going’” (Blanchard, 2004, p. 48); recall the notion of humans’ bias for action discussed in the Preface. Hammond et al. (2002) warn of the pitfalls of taking problem formulation lightly:

> Too often, people give short shrift to problem definition…In their impatience to get on with things, they plunge into the other elements of decision making without correctly formulating the problem first. Though they may feel like they’re making progress in solving their problem, to us they seem like travelers barreling along a highway, satisfied to be going 60 miles an hour - without realizing they’re going the wrong way. (p. 26)

One final point on problem formulation. We should be careful to specify a problem that is unique enough to be relevant to our concerns, yet not so specific that it predefines a solution. This is important because a true problem may have predispositions toward a solution, but if we already have a solution, then we do not have a problem; rather, we have a puzzle and its resolution is merely a matter of correct implementation.

Only once we have formulated our problems and are satisfied they are representative of the concerns we wish to explore, can we begin to change our way of thinking about, acting on, and observing the problems in question. At this point, we are ready to make systemic decisions. This is reflected in the modification of Chap. 1’s TAO Process Figure as shown in the systemic decision making process in Fig. 2.5.

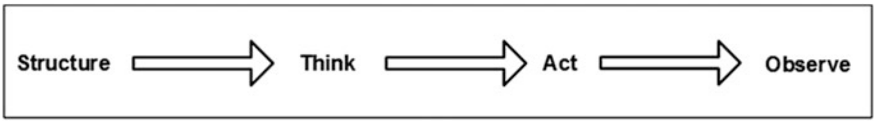

Fig. 2.5 Systemic decision making steps

2.6 Summary

The prevalence of complex problems is increasing, no matter how we measure it. Simply adopting a single technical perspective has been unsuccessful in addressing these ill-structured, wicked, or messy problems. The application of multiple perspectives and the inclusion of soft techniques offers a more inclusive framework through which complex problems may be viewed.

The integration of technical, organizational, political, and human perspectives during problem structuring and resolution widens the aperture and provides an increased probability of correctly addressing systems age problems. Finally, it is worth noting that the range of variability of individual perspectives, objectives, and perceived interests may be so divergent that sufficient alignment necessary to move forward may be unattainable. Many traditional approaches assume a unitary perspective where there is assumed agreement on the problem. We have found that most systems age problem domains have deeply rooted or philosophical divergence which add to the difficulty in developing a mutually agreeable problem formulation. Divergence may involve such issues as allocation of scarce resources, power distribution, control, personal preferences or interests, and other areas that may exist at a tacit level. Assuming alignment in systems age problems may be problematic.

In order to move forward, we must decompose the messes we wish to further understand into tractable problems about which we may reason, making sure to pay deliberate attention to their structuring, and then reconstruct them in order to obtain systemic understanding of our mess. Simply decomposing them, as many methods do, is insufficient, as it fails to holistically consider the context in which each problem operates.

After reading this chapter, the reader should:

1. Understand the difference between systems age problems and machine age messes;
2. Appreciate the importance of considering multiple perspectives in a system's effort;
3. Understand the characteristics of hard and soft perspectives; and
4. Be able to identify a mess and structure its constituent problems.

References

Ackoff, R. L. (1974a). *Redesigning the future: A systems approach to societal problems*. New York: Wiley.

Ackoff, R. L. (1974b). The systems revolution. *Long Range Planning, 7,* 2–20.

Ackoff, R. L. (1979a). The future of operational research is past. *Journal of Operational Research Society, 30*(2), 93–104.

Ackoff, R. L. (1979b). Resurrecting the future of operational research. *Journal of the Operational Research Society, 30*(3), 189–199.

Adams, K. M., & Hester, P. T. (2012). Errors in systems approaches. *International Journal of System of Systems Engineering, 3*(3/4), 233–242.

Adams, K. M., & Hester, P. T. (2013). Accounting for errors when using systems approaches. *Procedia Computer Science, 20,* 318–324.

Adams, K. M., & Hester, P. T. (2016). *Complex problems: The philosophical underpinnings for a transdisciplinary approach*. Paper presented at the 2016 Industrial and Systems Engineering Research Conference, Norcross, GA.

Adams, K. M., & Meyers, T. J. (2011). Perspective 1 of the SoSE methodology: Framing the system under study. *International Journal of System of Systems Engineering, 2*(2/3), 163–192. doi:10.1504/IJSSE.2011.040552.

Bar-yam, Y. (1997). *Dynamics of complex systems*. Reading, MA: Addison-Wesley.

Blanchard, B. S. (2004). *Systems engineering management* (3rd ed.). Hoboken, NJ: Wiley.

Bohr, N. (1928). The quantum postulate and the recent development of atomic theory. *Nature, 121* (3050), 580–590. doi:10.1038/121580a0.

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organizational analysis: Elements of the sociology of corporate life*. London: Heinemann.

Cilliers, P. (1998). *Complexity and postmodernism: Understand complex systems*. New York: Routledge.

Duncker, K. (1945). On problem solving. *Psychological Monographs, 58*(5), 1–113.

Gershenson, C. (2007). *Design and control of self-organizing systems*. Mexico City, Mexico: CopIt ArXives.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory, strategies for qualitative research*. Chicago: Aldine Publishers.

Greeno, J. G. (1976). Indefinite goals in well-structured problems. *Psychological Review, 83*(6), 479–491.

Hammond, J. S., Keeney, R. L., & Raiffa, H. (2002). *Smart choices: A practical guide to making better life decisions*. New York: Broadway Books.

Hester, P. T. (2016). *Unraveling complexity*. Paper presented at the 2016 Industrial and Systems Engineering Research Conference, Norcross, GA.

Hester, P. T., & Adams, K. M. (2014). *Systemic thinking: Fundamentals for understanding problems and messes*. Cham, Switzerland: Springer International.

Hughes, A. C., & Hughes, T. P. (Eds.). (2000). *Systems, experts, and computers: The systems approach in management and engineering, World War II and after*. Cambridge, MA: MIT Press.

Kuhn, T. S. (2012). *The structure of scientific revolutions: 50th anniversary edition* (4th ed.). Chicago: University of Chicago Press.

Linstone, H. A. (1985). Multiple perspectives: Overcoming the weaknesses of MS/OR. *INTERFACES, 15*(4), 77–85.

Linstone, H. A. (1989). Multiple perspectives: Concept, application, and user guidelines. *Systemic Practice and Action Research, 2*(3), 307–331.

Linstone, H. A., Meltsner, A. J., Adelson, M., Mysior, A., Umbdenstock, L., Clary, B., … Shuman, J. (1981). The multiple perspective concept: With applications to technology assessment and other decision areas. *Technological Forecasting and Social Change, 20*(4), 275–325. doi:10.1016/0040-1625(81)90062-7.

Mitchell, M. (2009). *Complexity: A guided tour*. New York: Oxford University Press.

Mitroff, I. I. (1998). *Smart thinking for crazy times: The art of solving the right problems*. San Francisco: Berrett-Koehler Publishers.

Mitroff, I. I., Alpaslan, M. C., & Green, S. E. (2004). Crises as ill-structured messes. *International Studies Review, 6*(1), 165–194. doi:10.1111/j.1521-9488.2004.393_3.x.

Mitroff, I. I., & Betz, F. (1972). Dialectical decision theory: A meta-theory of decision-making. *Management Science, 19*(1), 11–24.

Mitroff, I. I., & Featheringham, T. R. (1974). On systematic problem solving and the error of the third kind. *Behavioral Science, 19*(6), 383–393.

Mitroff, I. I., & Kilmann, R. H. (1977). Systemic knowledge: Toward an integrated theory of science. *Theory and Society, 4*(1), 103–129. doi:10.1007/BF00209746.

Mitroff, I. I., & Linstone, H. A. (1993). *The unbounded mind: Breaking the chains of traditional business thinking*. New York: Oxford University Press.

Mitroff, I. I., & Silvers, A. (2010). *Dirty rotten strategies: How we trick ourselves and others into solving the wrong problems precisely*. Stanford, CA: Stanford University Press.

Newell, A., Shaw, J. C., & Simon, H. A. (1959). *Report on a general problem-solving program (Technical Report No. P-1584)*. Santa Monica, CA: RAND Corporation.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Ozbekhan, H. (1970). *The predicament of mankind: Quest for structured responses to growing world-wide complexities and uncertainties (A proposal)*. Rome, Italy: Club of Rome.

Pidd, M. (1988). From problem-structuring to implementation. *The Journal of the Operational Research Society, 39*(2), 115–121.

Pidd, M. (2004). Complementarity in systems modelling. In M. Pidd (Ed.), *Systems modelling: Theory and practice*. West Sussex, UK: Wiley.

Pidd, M. (2009). *Tools for thinking: Modelling in management science* (3rd ed.). West Sussex, UK: Wiley.

Ravetz, J. R. (1971). *Scientific knowledge and its social problems*. Oxford, UK: Oxford University Press.

Rickles, D., Hawe, P., & Shiell, A. (2007). A simple guide to chaos and complexity. *Journal of Epidemiology and Community Health, 61,* 933–937.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(1), 155–169.

Rosenhead, J. V. (2006). Past, present and future of problem structuring methods. *Journal of the Operational Research Society*, *57*, 759–765.

Rosenhead, J. V., & Mingers, J. (2001). *Rational analysis for a problematic world revisited* (2nd ed.). Chichester, England: Wiley.

Sage, A. P. (1992). *Systems engineering*. New York: Wiley.

Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books.

Simon, H. A. (1973). The structure of ill structured problems. *Artificial Intelligence, 4*(3/4), 181–201.

Smith, G. (1988). Towards a heuristic theory of problem structuring. *Management Science, 34*(12), 1489–1506.

Vennix, J. (1996). *Group model building: Facilitating team learning using system dynamics*. Chicester, UK: Wiley.

Watson, C. E. (1976). The problems of problem solving. *Business Horizons, 19*(4), 88–94.

Woolley, R. N., & Pidd, M. (1981). Problem structuring—A literature review. *The Journal of the Operational Research Society, 32*(3), 197–206.

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