Chapter 6: Technical Communication Reimagined Through a Socio-Technical Problem-Solving Lens

Michael J. Albers
East Carolina University

Abstract: Designing, writing, and reading a text—of any realistic complexity—is a constant problem-solving and decision-making process. Providing quality content in a complex information environment means providing information for problem-solving within the situation's context. Writing for the socio-technical situation and for problem-solving means positioning the content in terms of the needs of people within that situation and the overall implications of how/why content is needed, used, and how it interacts with other information. A foundational idea of socio-technical theory is that the design of any system can only be understood and improved if both "social" and "technical" aspects are considered together as interdependent elements of a complex situation. The communication situation commonly involves the relationships between people (social systems) and technology (technical systems) and how those systems interact and evolve. Communicating information within a socio-technical environment requires drawing the proper boundaries to make the overall problem manageable and providing the information the reader needs. The socio-technical situation tends to be larger than what is normally considered within technical communication audience analysis and rhetorical studies. For the writer, restructuring the information to meet the needs of the socio-technical environment requires a deep rethinking of how we understand writing, communication, and audiences.

Keywords: socio-technical situation, complex information, decision-making, problem-solving

Jared Spool (2014) tells a story about an auto repair shop and how a person's use of a software estimating application was very different on Friday (with low customer numbers) and Saturday (with high customer numbers). Basically, on Friday, the owner was gushing about how much he loved the application because of the good estimates it provided. On Saturday, he abandoned it for paper because it got in his way.

The difference was not that the software had to be used differently or that the user was different. They were the same task and same person on both days—which reveals the flaw of collecting tasks and audience demographics and calling the analysis complete.

DOI: https://doi.org/10.37514/TPC-B.2022.1381.2.06

Spool (2014) talks about this response as an example of what he calls service design. Within this chapter, I'll be looking at the same set of issues from a technical communication perspective, not just for a focused application, but for dealing with corporate reports used for decision-making or other non-task-based types of technical communication.

As with Spool's (2014) example, too often, technical communication is written for the ideal situation and then everyone wonders why it collapses so easily and fails to provide useful information (Albers, 2012; Redish, 2007). Or it dumps all the information, and everyone wonders why the reader can't integrate it and use it (Terveen et al., 1995). The basic problem: it failed because it didn't address how both the social aspects and the technical issues of the overall situation—the socio-technical situation—worked as an integrated whole (Trist, 1981; Woods & Roth, 1988.) The main argument of this chapter is the need to bring the socio-technical to the forefront of technical communication analysis.

Both a text's writer and reader confront essentially the same problem. To design and write a text—of any realistic complexity—is a constant problem-solving and decision-making process. To read a text—of any realistic complexity—is a constant problem-solving and decision-making process. In other words, both creating and reading a text can be considered as variations of the same problem. Once a text moves beyond procedural instructions, it must contain information both relevant to the situation and formatted in a way that addresses the reader's needs (Albers, 2004; Wickman, 2014). A trivial-sounding statement, but one which often explains the underlying communication failure of many documents. For concrete examples, see the multitude of "why the document failed" analyses published within the technical communication literature.

All of the reader's information needs, text constraints, and content decisions exist within the situation's problem space. A writer must map that problem space onto the text design space. Both writer and reader must map both problem space and text design space onto the reader's goal space. Taken together, they form a complex socio-technical environment; effective communication within that socio-technical environment requires understanding the integration of people (and their individual response), their social interactions, and technical (technology) aspects. Information and needs within the problem space and goal space shift and change as the situation develops (Cilliers, 1998; Klein, 2014). Sidney Dekker's (2011) book on major failures (airline and major industrial disasters) repeatedly describes the basic problem as thinking about the problem in too narrow of terms with a resulting catastrophic failure.

A foundational idea of socio-technical theory is that the design and performance of any system can only be understood and improved if both "social" and "technical" aspects are considered together and treated as interdependent elements within a complex situation (Trist, 1981). Lisl Klein (2014) considers how socio-technical theory explicitly connects people and technology into an interdependent web—a web where any change to one point ripples out and causes changes to *all* the other points (Albers, 2010). Dekker (2011) did not find single "this failed and caused the disaster" points, but rather, he found long cascades of interdependent events all embedded within a socio-technical context.

Writers face the problem that any complex socio-technical situation has essentially infinite information available. Developing information carries with it a specific representation of that information. Previous work has shown that people define their own tasks and needs in terms which fit their goals (Mirel, 1992). The fit between that specific representation of information and the person's self-defined needs strongly influences its effectiveness. Clearly, developing information to support decision-making requires understanding how they interact within a socio-technical environment (Klein, 2014).

Decision-making within a socio-technical environment requires understanding the relationships within the information (Albers, 2009, 2010). Gary Klein's (1999) naturalistic decision-making model provides the best explanation of how people grasp and use relationships to make decisions (as opposed to the too-common optimized decision matrix methods). Writers tasked with communicating this information must ensure the person knows both the information and how to use/integrate it toward their goals (Robertson et al., 1993; Woods & Roth, 1988). Creating the proper view for the reader requires defining the information boundaries (Laplante & Flaxman, 1995) and knowing how those boundaries affect understanding—boundaries that must be defined by the situation and not by the technical system structure or writer/organizational wants (i.e., providing the easy-to-get stuff; Dekker, 2011).

Writing for decision-making and problem-solving requires understanding the socio-technical situation. However, technical communication is rarely presented through a problem-solving lens suited to working within that complex socio-technical environment. Instead, analysis is defined based on breaking down into single units. Decomposition and analysis of individual pieces works for simple actions and pure technical systems, but fails miserably when people and their social interaction become integral to the situation (Albers, 2009). (Think IKEA instructions versus a five-million-dollar business decision or making a healthcare choice.) Unfortunately, designing for expected or best-case scenarios fails to address the information needs when they move beyond those scenarios (Vicente, 1999).

Within a socio-technical writing situation, technical communication needs to reshape its questions so they are proposed in human-information interaction (HII) terms (Albers, 2012) and focus on defining how the audiences will *interact with the information*, how the audiences will *use it*, and how the various parts of the situation *influence that interaction and use*. Only then will the information work within its socio-technical situation.

Socio-technical research is rapidly developing into its own field, but unfortunately, I don't see technical communication even acknowledging its existence, much less making use of its findings. This chapter strives to begin making the case for considering the socio-technical aspects when creating technical documents.

Terms

I begin with defining my terms. Granted, term definition is a standard rhetorical move, but, in this case, it is important because some of these terms are used within technical communication in ways that are not quite how I use them. Obviously, following this chapter's overall argument while using different definitions could prove difficult to impossible. The first part of the chapter—most of it actually—considers the terms we need to define. Each of these terms will be defined and discussed, and then in the later part of this chapter, their interrelationships will be discussed.

The terms to be considered and short definitions are given here. The next sections expand on them.

Complexity	Situations and their information are highly interconnected and any change affects everything.
Writing environment	The environment in which the communication occurs. The type of content—simple or complex— and the reader's use of the information within their situation. (Note that this has nothing to do with how/where the writer produces content.)
Situation	The overall environment in which readers find themselves as they read/research the information. It includes both the technology used to access the information and their overall environment (i.e., corporate directives, what the boss wants, asking others for input, prior knowledge, etc.)
Socio-technical	Communication happens within and depends on an integrated combination of social and technical aspects of the situation.
Decision-making and problem-solving	The ways people make choices to influence the evolution of a situation.

Definition of Complexity

Complex information contains lots of ambiguity and subtle nuances within its content. The information interacts with its environment and changes as the situation changes or evolves. Because of these factors, it is impossible to define a "complete set of information" or to completely analyze the situation or provide all paths through it.

Paul Cilliers (1998) described a complex situation by saying,

> The interaction among constituents of the system, and the interaction between the system and its environment, are of such a nature that the system as a whole cannot be fully understood simply by analyzing its components. Moreover, these relationships are not fixed, but shift and change. (p. viii)

In a complex situation, the problem will almost always include factors or circumstances not foreseen as part of the original analysis. "As a result, information system design cannot be based solely on expected or frequently encountered situations" (Vicente, 1999, p. 17).

I have previously described complex situations as having six characteristics (Albers, 2004). These factors influence how information must be provided and what information is relevant to a reader.

Characteristic	**Explanation**
No single answer	There is no single answer or "correct" way to approach a problem.
Open-ended	The proper amount of information cannot be predefined. People collect and analyze information until they are satisfied and then make a decision.
Multidimensional	Multiple factors influence the situation and affect what information is relevant and how the situation will evolve.
History	The previous state of the system influences how the system evolves. Two situations that look identical in a current snapshot, but with different histories, may end up looking very different in the future.
Dynamic	Information does not have a fixed value. It changes as the situation evolves. Likewise, the reader's goals and information needs change.
Non-linear	The overall situation is sensitive to the initial starting conditions, and small changes can result in big differences later.

Definition of Writing Environments

At the high level, writing can occur in either highly structured or ill-structured environments. An effective writing methodology and reader expectations are radically different between them.

Writing in a Highly Structured Environment

A highly structured environment has clear reader expectations and a clear way of determining if the information is complete and correct. In a highly structured environment—an underlying assumption of most technical communication pedagogy—the reader's basic goal is efficiently completing a task. A step-by-step route can be predefined as the correct path to an answer, and that path can be supported and enforced by a computer system. The high structure means the end result can be judged as a yes/no or correct/incorrect answer.

If the task is to assemble a bookcase, then the writing fits the definition of highly structured. The reader approaches to how to assemble the bookcase are limited and can be fully defined by the writer. The final result can be judged: the bookcase is assembled correctly or not.

Unfortunately, well-defined does not describe most realistic writing situations.

Writing in an Ill-Structured Environment

An ill-structured environment lacks the clear-cut answers that were evident in the highly structured environment. The reader's overall goals may be defined, but the paths to achieving those goals and what information is required cannot be fully defined.

In the ill-structured environment—the norm with real-world problems— the reader's goal is one of analysis and problem-solving. The task is not to assemble a bookcase, but to plan next summer's vacation, figure out why sales are down in the west, understand a medical condition, or determine how to improve X (traffic flow, employee morale, course design, etc.). Rather than simply completing a task, the reader needs to be aware of the entire situational context in order to make good decisions. In an ill-structured domain, instead of following a set path, the reader continuously adjusts their path as new information presents itself. As a result, each reader takes a slightly different path and uses slightly different information.

In other words, the writer can't even assume that the information needs are consistent between readers or what information a reader will view before making a decision. Yet, the writer is tasked with creating a design which communicates the information when and how the reader wants it.

Situation

The opening definition explained situation as the overall environment in which readers find themselves as they read/research the information. It includes both the technology used to access the information and readers' overall environment (i.e., corporate directives, what the boss wants, asking others for input, prior knowledge, etc.)

The bigger picture can be described by an image (see Figure 6.1) that captures the entire environment. Many technical communication sources seem to work from the view that a person uses one and only one source (the text being currently written) as the information source. But this is rarely true. Instead, a reader uses many sources, only some of which are explicit (documents or asking other people), and some that are implicit (knowledge of "how things are done").

A highlight in Figure 6.1 is that the system—the thing on which most writers and their associated developers focus—is pretty much outside the reader's concern. True, they want it to work smoothly, but they also expect it to just be another source of potential information.

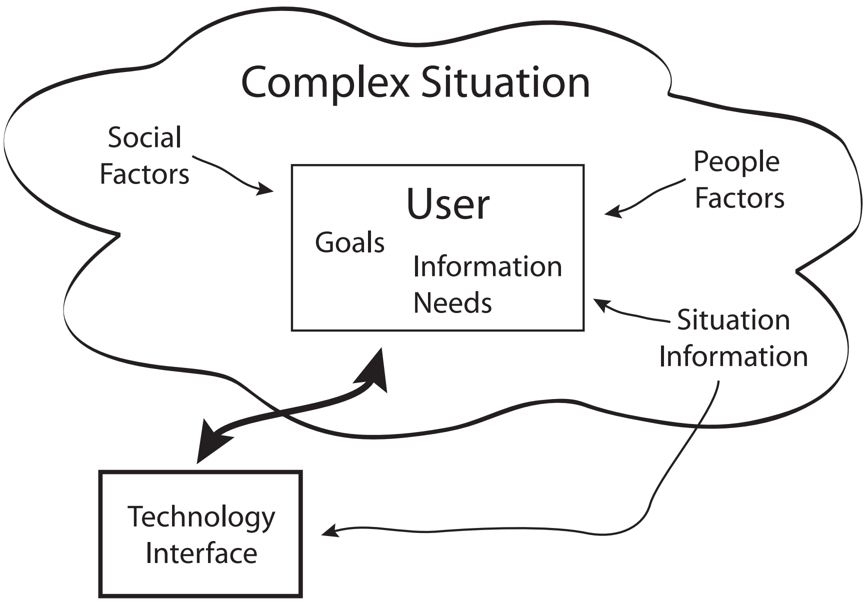

Figure 6.1. Overview of the complex situation. Notice how the system exists almost outside of the situation. Too often design teams place the computer interface front and center while ignoring the rest of the situation (adapted from Albers, 2004).

As a side note, most of the socio-technical literature uses the term *system* and says socio-technical situations operate within a system. That literature, loosely defined, considers system as the entirety of what the reader (and writer) is interested in. However, the word *system* is too easily equated to technology: system equals computer. But that is not what system means in this instance. It is the entire thing—the entire problem space the reader operates within— which a writer must draw boundaries around and within, that matters to the reader. It becomes too easy in discussions of socio-technical systems for participants to start talking past each other because they use different definitions of *system*. Because of that, I use the term *situation*.

Definition of Socio-Technical

Klein (2014) sums up the interrelationship of both people and technology:

> Sociotechnical theory makes explicit the fact that the technology and the people in a work system are interdependent. Each affects the other. Technology affects the behaviour of people, and the behaviour of people affects the working of the technology. It is inevitable, it is a real part of the situation, and one therefore needs to take account of how they affect each other. (p. 138)

Most importantly, she emphasizes the relationship. It is flatly impossible to understand either the technology or how people interact with it without considering them together. Any change to one results in a change to the other (which feeds back into a change to the first one . . .).

In 1996, I attended the *HCI International Conference*, and the topic had its own track. The researchers seemed to be totally focused on using the word *socio-technical* in every other sentence. Since then, it has continued to develop into a field with its own research agenda. However, *socio-technical* has had minimal impact within technical communication, much to the determent of technical communication's development as a field.

The idea of socio-technical systems is not new, even back in 1996 when I first encountered it. Russel Mumford (1987) was an early researcher to discuss how having adequate technology without considering the social could still cause poor results.

Let's look at a couple of definitions of *socio-technical* that have been proposed. Wikipedia gives a definition as:

> Socio-technical systems pertain to theory regarding the social aspects of people and society and technical aspects of organizational structure and processes. Here, technical does not necessarily imply material technology. The focus is on procedures and related knowledge, i.e. it refers to the ancient Greek term *logos*. "Technical" is a term used to refer to structure and a broader sense of technicalities. Socio-technical refers to the interrelatedness of *social* and *technical* aspects of an organization or the society as a whole. Socio-technical theory therefore is about *joint optimization*, with a shared emphasis on achievement of both excellence in technical performance and quality in people's work lives. Socio-technical theory, as distinct from socio-technical systems, proposes a number of different ways of achieving joint optimization. (Wikipedia, n.d.)

The Interaction Design Foundation gives a more concise definition but still captures the overall idea.

> A socio-technical system (STS) is one that considers requirements spanning hardware, software, personal, *and* community aspects. It applies an understanding of the social structures, roles and rights (the social sciences) to inform the design of systems that involve communities of people and technology. (Interaction Design Foundation, n.d.)

Characteristics of Socio-Technical Systems

In the following passage, Dekker (2011) is talking about failures (major failures; think airplane crashes), but his words also describe the problem with thinking in terms of documenting a narrow topic, rather than considering the entire socio-technical situation:

> The problem with this was that greater complexity leads to vastly more possible interactions than could be planned, understood, anticipated or guarded against. Rather than being the result of a few or number of component failures, accidents involve the unanticipated interaction of a multitude of events in a complex system—events and interactions, often very normal, whose combinatorial explosion can quickly outwit people's best efforts at predicting and mitigating trouble. Interactive complexity refers to component interactions that are non-linear, unfamiliar, unexpected, or unplanned, and either not visible or not immediately comprehensible for people running the system (p. 128)

Two significant characteristics of socio-technical systems are:

> *Non-deterministic:* The same inputs at two different times do not produce the same output. The myriad of subtle (and not so subtle) factors, many of which are not directly accounted for, interact with the situation and prevent it from repeating. At the very basic level, people are involved, and people are highly non-deterministic.
>
> A situation's history gives it a trajectory and momentum, and although that trajectory might pass through the same point twice, the trajectory itself is different. Thus, the response and results are different.
>
> *Emergent properties:* The overall performance depends on both the system parts and their relationships, which all operate in a non-deterministic manner. The resultant behavior of a simple system can be predicted based on understanding the parts. Socio-technical systems and their emergent behavior cannot. Emergent properties are bottom-up, highly non-linear, and non-deterministic, which makes them impossible to model (Easterling & Kok, 2002).

> "System-level behaviors emerge from the multitude of relationships, interdependencies and interconnections inside the system, but cannot be reduced to those relationships or interconnections" (Dekker, 2011, p. 201).

Examples of emergent properties are things such as a wave at a baseball stadium. No amount of analysis of one person jumping up and sitting down will predict that a bunch of people doing that in a coordinated fashion will produce the appearance of a wave. Likewise, pictures made up of many small images—e.g., pictures of Elvis made of tiny images of his album covers.

Adverse events in complex systems are produced by a complicated combination of events that may never congeal in the exact same way again—the emergent property. Yet, the decision-makers strive to ensure the adverse event will never repeat, which risks making decisions that ripple outward and cause new adverse events. Emergent issues stem not from the event itself, but from the processes that lead up to it. What decisions were made, what events occurred, what assumptions were people working from? What taken-for-granted assumptions were not considered in the decisions?

Decision-Making and Problem-Solving

Decision-making involves analyzing options and making choices. Problem-solving focuses on making a choice to control the trajectory of a situation. Decision-making differs from problem-solving because it focuses on making choices to direct and control a situation, rather than adjusting from undesirable outcomes. On the other hand, they are closely related and can often be used interchangeably without major issues.

In solving the complex problem, the potential choices and reasons for making the choice become of dominating importance. Because people rarely base decisions on simple look-ups (it says 6 here, so the answer is no), the content must support helping them solve a complex problem. Both decision-making and problem-solving tend to be the purpose of information-seeking in complex situations because the reader needs to understand what is happening and make decisions that will support a favorable result.

Fundamentally, decision-making requires integrating the results of multiple queries (Ebert et al., 1997). The question has shifted from a simple "Does this exist?" to much more complex formulations such as "I need to analyze these documents to understand about X. They all discuss X, but which ones contain relevant information? And, more importantly, what is the relevant information for *my* specific needs right now?" That last question is highly pertinent since the relevant information changes as a situation evolves.

Complex situations requiring complex information presentation are a way of life in the modern world. Part of the frustration many people feel searching for information in a computer system arises because the required information they need is hard to integrate into a coherent whole. Loren Terveen et al.'s (1995) work revealed that

> The pragmatics of knowledge use are critical. Simply recording a factor is not enough; issues such as where in the process knowledge is to be accessed, how to access relevant knowledge from a large information space, and how to allow for change also must be addressed. (p. 3)

In other words, socio-technical situations do not lend themselves to the basic task analysis that appears in textbooks. That task analysis is appropriate for step-by-step processes, but fails when the process gets more complex. Instead, communicating technical information through a socio-technical lens requires supporting the way people rapidly assess situations and make decisions based on theories such as Klein's (1999) recognition-primed model rather than classical decision matrix models or simple task analysis (Albers, 1996).

The question concerns not merely whether the readers know some particular piece of domain knowledge, but whether they understand the relationship between different pieces of information. Do they know "that it is relevant to the problem at hand and does he or she know how to utilize this knowledge in problem solving" (Woods & Roth, 1988, p. 420)? People require information that relates to the overall situation, and they need to understand that relationship (Robertson et al., 1993).

Likewise, across multiple studies Barbara Mirel found that users have different conceptions of how to accomplish a task. "In actual work settings, users define their own tasks and task needs according to situational demands, not program design" (Mirel, 1992, p. 15). The design of those systems must encompass a total system that revolves around the goals and information needs of a human and supplies information that makes sense within the person's real-world situation. Felipe Castel (2002) aptly summed up my argument when he said, "Computing does not merely process information, it commits to a certain representation of information" (p. 30). Technical communicators make many of the decisions about that representation; we must make good choices.

Bringing Socio-Technical Reasoning into Technical Communication

In science class, we learned that a rock and a feather fall at the same rate (in a vacuum). Yet, hold a rock and a feather, drop them, and clearly, they fall at different speeds. This obviously means that whatever is attracting them must vary depending on the material—hey, it did to ancient and medieval philosophers, who were adherents of Aristotelian physics. Of course, now we understand the difference is because of air resistance.

The rock and feather example really is relevant to technical communication because too often we risk saying situations are very different because we don't know about/understand the air resistance. In a physical system, air resistance is obvious and easy to measure. In the social sciences, including in technical communication, the stand-in for air resistance may not be obvious. Actually, it probably consists of many different things; some easy to measure, some difficult to measure, some we (erroneously) don't consider worth measuring, and some we don't even know we should measure. But they all define and influence the relationships and, consequently, influence how people understand information and how the overall situation evolves.

Technical Communication Writing Environment

Writing that addresses complex problems and which addresses socio-technical issues is ill-structured. There are too many interrelations within the content for it to be anything else.

The ill-structured environment equates to a wicked problem. Wicked problems—to use Chad Wickman's (2014) term—are a given in technical communication, but we try too hard to reduce them to simple problems. On the other hand, many writers claim they are not really writing in an ill-structured environment, or will acknowledge that the entire process is, but point out that they are working in a small area. They could be better characterized as having rationalized their ill-structured environment into a simple one, a rationalization that proves problematical and which I have discussed on different occasions (Albers, 2004). The decision-making process and information needs for simple (highly structured) and complex (ill-structured) problems are different. We need to acknowledge that difference and provide content differently.

As a field, technical communication has stubbornly refused to move beyond a view of writing as highly structured. This highly structured view permeates technical communication pedagogy, including how we define "what is technical writing."

David Dobrin (2004) put forth a brief definition that "technical writing is writing that accommodates technology to the user" (p. 118). Unfortunately, within the current world, any definition with a strong technology connection must be suspect as too limiting.

Likewise, two of the major introductory textbooks offer these definitions:

> Technical communication encompasses a set of *activities* that people do to discover, shape, and transmit information. . . . The biggest difference between technical communication and other kinds of writing you have done is that technical communication has a somewhat different focus on *audience* and *purpose*. (Markel & Selber, 2019, p. 2)

> Technical communication is a process of managing technical information in ways that allow people to take action. (Johnson-Sheehan, 2005, p. 6)

Both definitions are very writer focused. They describe what a writer must do, rather than focus on communicating information. I also looked for definitions in other major textbooks and found, rather than concise definitions suitable for quoting, longer discussions of what technical communication is and is not. But they still presented those definitions in writer-focused terms. Missing is the acknowledgement about meeting people's information needs when the situation has changed—the Friday and Saturday differences of the opening example.

All of the textbooks' views are tightly tied with the production of artifacts (one or more documents, loosely defined as whatever the audience is expected to read). I'm wondering why we are focused on the production of artifacts. Why are we not focused on communicating the information behind the reason for producing the artifacts? People don't want artifacts; they want information. People do not want a document; they want the information within the document. The document is simply the easiest method of obtaining that information. From a writer's viewpoint, some may consider the document and the information as the same thing, but I think the mindsets of developing an artifact and communicating information are very different. In the one, we are concerned with producing something . . . a something that gets tweaked for the sake of being a good artifact. Whether or not that tweak is meaningful with respect to its communication value can get lost. These types of problems make me think of the book *The Design of Everyday Things*, where Don Norman (2002) disparagingly described many deeply flawed designs with "probably won a prize," because many flawed designs he critiques did, in fact, win design awards.

From a technical communication perspective, along with the standard issues such as audience analysis, defining the socio-technical situation involves understanding the relationships between the information elements and defining the boundaries of interest. These two issues, relationships and boundaries, are typically ignored in both practice and within technical communication pedagogy. Yet, together, they make or break the text's ability to effectively communicate its information. We must understand their importance, determine them during the analysis, and create content that reflects how we defined them.

Relationships

Relationships form the foundation on which people understand complex information (Albers, 2009, 2010). It is not the pieces of information but the relationships between them that provide the understanding. The analysis must capture both the information and the relationships. In capturing the relationships, the analysis captures how people understand and interpret the information. That understanding and interpretation is not about the information per se but about the relationships within the information. Understanding relationships forms a simplified explanation of why an experienced person can look at a collection of data and know what's happening while an inexperienced person can recite all the data but still lacks an understanding on which to base decisions. Being able to quickly understand the relationships is a major aspect of naturalistic decision-making (Klein, 1999).

Much of a reader's comprehension exists in their understanding of the relationships between and within pieces of information. The reductionist approach of breaking problems into smaller pieces breaks up those relationships and interactions. After understanding the smaller pieces, the analysis must then work back outward or risk failing because it failed to capture the relationships and interactions which make up the situation. It fails because it fails to capture the essential elements needed to understand a situation.

Thus, information relationships are not just a nice-to-know thing. The information understanding exists within the relationships, not with the individual text elements. Without understanding the relationships, people cannot make good decisions. Thus, writing from a socio-technical lens means understanding

- how those relationships form,
- what makes them form,
- how changes to the relationships propagate through the system,
- the biases people exhibit in understanding them,
- how the relationships change as the situation changes, and
- how they differ between related situations.

Unfortunately, too often an attempt at an analysis measures the easy-to-measure and disregards the rest. And often jumps right in to measure the easy-to-measure and doesn't try to define what should be measured. The result describes the overall situation very poorly, and the idea of deep analysis gets a bad reputation. The problem was not in the data collection or in the analysis but in what data was collected.

Relationships come in two major types: functional and non-functional. Functional relationships are directly connected— Such as, if we increase X, then we know Y will change. Non-functional relationships are more situation dependent—Such as, "we can't put a new parking lot there because it encroaches on a natural wet area and we risk an environmental lawsuit." Some information elements have nothing to do with building a parking lot, but the overall social aspects build a relationship between environmental groups and parking lot location. Clearly, non-functional relationships can have a major impact on decision-making, but they are easy to ignore since they rarely appear in system block diagrams. At first glance, they appear outside of the problem scope, or they never get mentioned to the people doing the analysis.

Relationships and Feedback Loops

The analysis leading up to content development needs to consider the entire situation at multiple levels. Relationships form and exist for both macro- and micro-levels of both social and technological interactions.

Relationships form a two-way integration, and changes to a piece of information ripple out; the resultant change can ripple back, again changing the original information. In other words, the relationships within the situation are part of the feedback loops that control and (de)stabilize the situation.

The feedback loops within relationships allow the system to adapt. As part of the change, an information element itself may/may not change, but its relationship to other elements will change. With the overall web formed from the relationships, the strength and type of changes are very difficult to predict. Consequently, how the socio-technical situation will react is very difficult to predict.

A bunch of blocks connected with springs and sitting on a surface act as a metaphor for the socio-technical situation (see Figure 6.2). They must be on a surface because it represents the internal friction and unknowns within the situation.

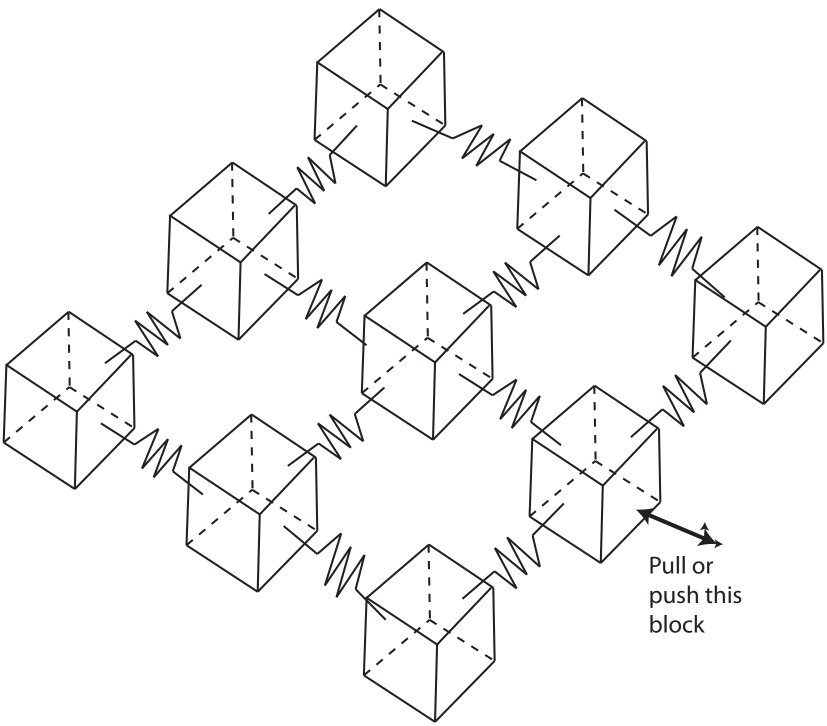

Figure 6.2. Blocks connected by springs. Movement of the marked block makes all the other blocks move. Thinking in terms of a larger number of irregular and varied sized blocks makes the concept more realistic for visualizing the issues of communicating complex information.

The overall readjustment occurs because a dynamic stable system is kept in equilibrium though a set of feedback loops of information and control. Each block movement affects other blocks, which changes the spring tension (relationships) between them. Each move results in the entire system readjusting itself to a new position that minimizes the overall tension. The proper level of analysis is not individual components and how they break but system constraints and objectives.

The friction element introduces the non-linear response. If they were suspended from a frame (or any other way that minimizes friction), displacing a block and then moving it back would result in the overall system returning to the previous point. Once friction is introduced, then it will not return to the starting position but some position different from both the starting and pre-return position. This is the critical factor ignored in too many decisions made with the belief of "if it doesn't work, we'll just go back to what we had before."

> It is impossible to move a block without the change rippling through the system. Complex systems operate under conditions far from equilibrium. Inputs need to be made the whole time by its components in order to keep it functioning. Without the constant flow of actions, of inputs, it cannot survive in a changing environment. The performance of complex systems is typically optimized at the edge of chaos, just before system behavior will become unrecognizably turbulent. (Dekker, 2011, p. 138)

One way to think about the system operating far from equilibrium is to think of the spring diagram with most of the springs stretched to the point where any less/more tension will cause the block to move. It also means the overall system is not just hanging there, steady, waiting for the block to move. Instead, the dynamic nature of the situation is constantly slightly moving different blocks, and the overall system is in a state of constant readjustment.

From a design perspective, this means you can't understand the entire situation or predict the effect of a change. It might seem like it will have minimal effect, but if combined with some other random changes, it risks tossing the system into violent gyrations before reaching a new equilibrium point—with no guarantee that the new point will be desirable or expected.

On the other hand, this block system (and complex systems in general) tends to be highly resilient to the loss of any one part (remove a block); it will adapt and reach a new equilibrium point which does not include the part. The non-symmetry aspects of a complex system mean that if the part is reintroduced, rather than returning to the old equilibrium point, it will rebalance itself from the current point and will end up with a new equilibrium point. Decisions cannot be simply reversed.

Boundaries

We must consider how and why we are drawing the boundaries at the beginning of any design process. The boundaries *define* the system of interest. They should, of course, be based on the reader's information needs, which, almost by definition, make defining the boundaries a non-trivial problem. The relationships and the potential ripple effects help to define where the boundaries should be drawn.

Based on how a boundary gets defined, both the relevant information and its presentation change. Misdefining a boundary redefines how the person views and understands the situation (Laplante & Flaxman, 1995; Robertson et al., 1993). Contrary to the common practice, writing with a socio-technical lens means acknowledging that the area inside the boundary includes both the system and the social situation in which the system is embedded. "Define the boundaries not by the system itself, but by the purpose of the description of the system" (Dekker, 2011, p. 139).

The old style of writing manuals that provided a menu option by menu option description (start at File-new and write through Help-about) drew the boundaries too small (see Figure 6.3). Here, the relevant information is just information about the operation of one menu option. No connection to other menu options; no connection to the tasks in which people would use it. It's easy to write up each item, but people rarely address problems with just one menu option. The narrow boundary ignores the actual problem embedded within a socio-technical situation and, instead, simplifies it into a straightforward technical description problem.

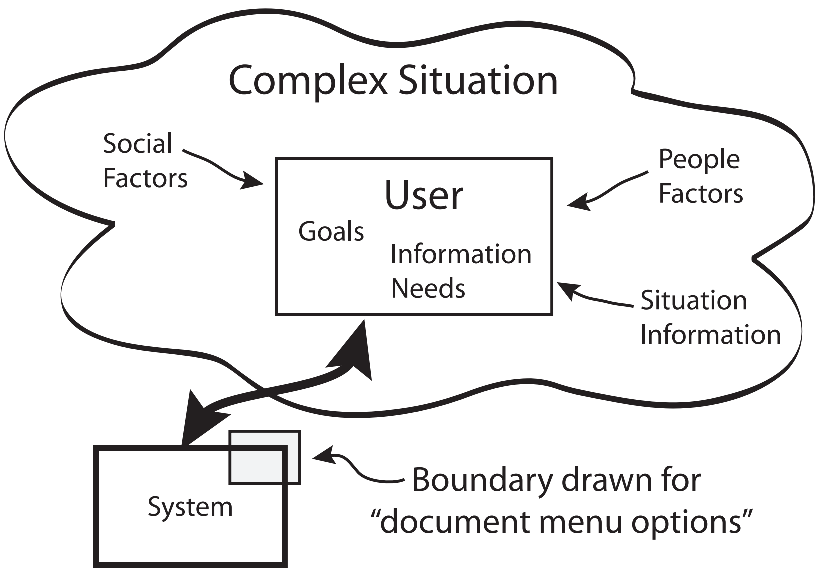

Figure 6.3. Drawing too small boundaries. To make the document highly structured, the boundaries get defined with respect to the system. The result is correct and usable, but generally useless, documentation.

I've said multiple times in different writings that people have no desire to use any software system and that they don't care about the menu options (Albers, 1996, 2010). What they do care about is accomplishing a task, and the software system happens to be the easiest route. By drawing the wrong boundaries, technical communication has managed to have minimal impact by not helping people accomplish the task.

Expanding beyond simple system interface explanations requires looking at the bigger picture and much deeper understanding of both audience and the socio-technical situation that is common (see Figure 6.4). It requires understanding what decisions the audience wants to make and how they tend to go about making them. Note that I'm not talking about a fancy artificial intelligence (AI) system that makes the decisions. If the system provides sales information for both sales staff and management, it cannot make decisions about how to focus sales. However, the upfront analysis and design should consider how the readers go about looking at various pieces of information and synthesizing them. In this case, the goal of a good socio-technical communication would be to help with the synthesis and resulting decisions.In any writing or designing situation, we must define boundaries. Draw them too small and we only look at isolated tasks/events and don't see the big picture. Draw them too large and we get buried in an exponentially growing collection of relationships, most of which are irrelevant.

One often-voiced complaint with any view of drawing inclusive boundaries, including a socio-technical view, is that determining the boundaries is impossible. The spring diagram in Figure 6.2 can correspond to the boundaries. As changes ripple out, they should get less and finally make little change. Defining the boundaries to match the decrease in the ripple provides a workable boundary in terms of both containing effects and providing information.

Too often, complaints focus on the edge cases, with comments such as "Well, yes, this is good, but I have *one* client where it doesn't apply; therefore, the entire thing is crap." In the end, dealing with people ends up being probabilistic, and the 80/20 rule applies. It is impossible to make 100 percent of the readers happy. The analysis and writing must focus on the 80 percent, where most of the information needs are. When people enter the situation, 100 percent will never happen.

Writing (Reading) Within a Complex Socio-Technical Environment

Looking at writing (reading) within a complex socio-technical environment, we encounter a disconnect. Technical communication and technical communication pedagogy are rarely presented through a problem-solving lens suited to working within that complex socio-technical environment. Providing content in a complex information environment means providing information for decision-making or problem-solving within the situation's context.

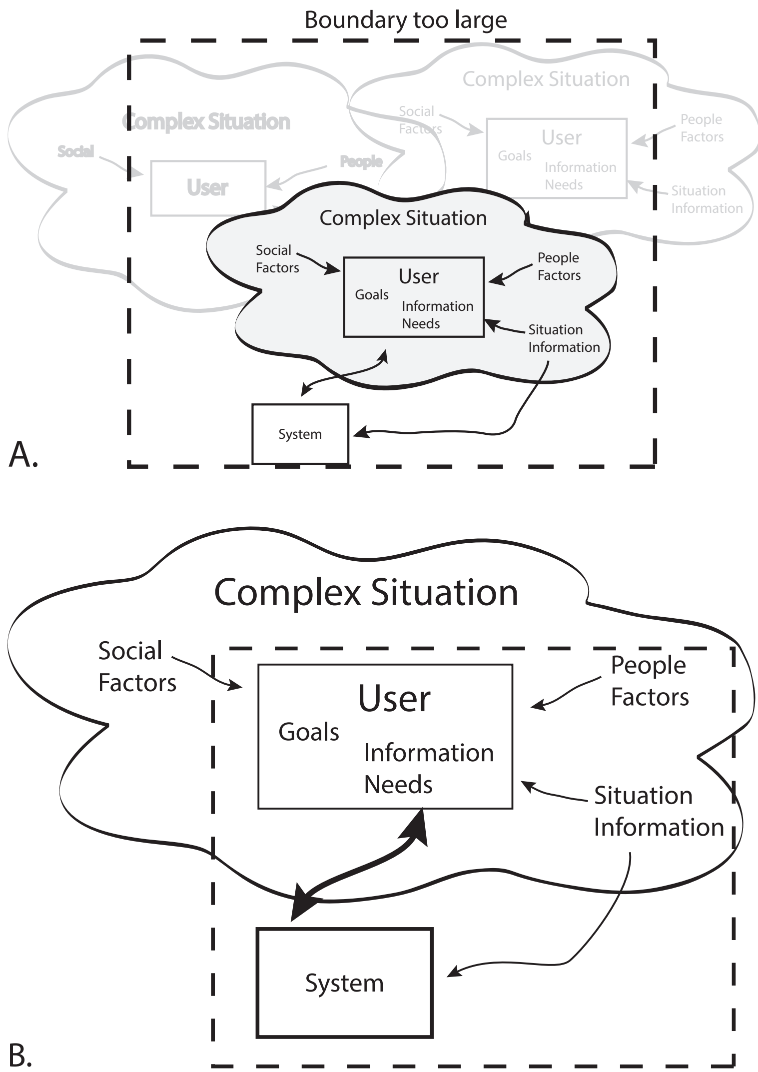

Figure 6.4. Drawing boundaries. A. has pushed the boundaries too far out and is typically what the person who claims they can't draw boundaries outside of the system box views. B. does not include the entire complex situation, but does bring the boundaries into a manageable size.

Writing for decision-making and problem-solving means positioning the content in terms of the socio-technical situation. Unfortunately, too much information is provided as a data dump and not as information structured to assist the readers in achieving their goals. Clearly, a writer needs to use critical thinking skills to reflect on the needs of people within that situation and the overall implications of how/why content is needed and used. For the writer, restructuring the information to meet the socio-technical environment needs requires a deep rethinking of what we mean by understanding, communicating, writing, and audiences.

We have seen that the system boundaries and the information relationships drive the overall problem space of what is defined as relevant. That problem space of any socio-technical system is made up of a set of interacting sub-systems (which may themselves contain sub-systems). These sub-systems contain people, the environment, the flow of data, and the systems delivering that data within the situation. Understanding the socio-technical situation in which the person operates requires understanding how they interact with, how they trust, and how they use those sub-systems. Communicating information within that situation requires drawing appropriate boundaries across those sub-systems.

Sub-systems must be identified as part of the early content analysis, and, more importantly, their interactions must be defined. There are also the information influencers that are not a specific source but which influence how a source is understood and used. Examples of influencers are bosses that insist certain information be considered (even if it is more/less irrelevant), power structures that affect how people perceive the information source, or technical system interactions that strongly control data flow (poor interface design, cumbersome approval/release of information process, strong and restrictive data security, etc.).

The analysis of a communication situation aims to provide a foundation for an optimized communication. Socio-technical system optimization requires a joint optimization. Although it is easier to optimize either the social or technical sides (or some subset of factors within each), the result will not be a highly efficient or effective system. Too many sources (for instructors, students, and practitioners) describe technical communication as being about understanding the audience and explaining the material clearly—a view which oversimplifies reality. This view gives a starting point but fails to produce texts that provide a high-quality reader experience. The initial pre-writing analysis can begin at this simplified starting point, but it then needs to transition into the messier view of how communication really happens. The analysis now needs to consider the common factors within the relationships between people (social systems) and technology (technical systems) and how those factors interact and evolve.

Many post-failure reports bear out how problems cascaded through a system where some parts worked wonderfully, yet the system as a whole failed miserably. Documentation failure can often be traced to a focus on one aspect, typically a narrow view of the technical aspects (as marked in Figure 6.3). It could be described as written from a view of "I'm describing the system. How it gets used is not my concern." The document fails because the analysis and content failed to address the complex interdependencies that exist within the reader's socio-technical environment. The entire complex situation cloud in Figure 6.1 got ignored during the writing process.

Within that socio-technical writing situation, technical communication needs to reshape its questions in human-information interaction (HII) terms (Albers, 2012) and focus on defining how the audiences will *interact with the information*, how the audiences will *use it,* and how the various parts of the situation *influence that interaction and use*. All three factors must be considered equally.

All Decisions Are Local and All Implications Are Global

Receiving information which properly delineates the relationships and boundaries can help improve the decisions. With few exceptions, decision-makers are not trying to sabotage a system/process; they want to make good decisions, and they want the overall project to succeed. Even for those that are trying to sabotage it (or don't care if they run it into the ground in the long term), the decisions make sense within their agenda and priorities. In other words, decisions exist as a snapshot of a single instance and are made with the belief that they are the best possible (best compromise) decision reflecting the decision-maker's goals. The future may reveal them as horrid or wonderful, but when they are made, they are considered good.

Although I doubt many people take issue with the previous paragraph, it hides a significant issue that has a major impact on the decision-making process: decisions are local; implications are global. Decision-making research has concluded that essentially all decisions are local. Unfortunately, decision implications are global—the rippling that occurs because of any, even minor, change. "Behavior that is locally rational, that responds to local conditions and makes sense given the various rules that govern it locally, can add up to profoundly irrational behavior at the system level" (Dekker, 2011, p. 159). It is only later, when viewed with hindsight and viewed from a larger viewpoint, that we can see the flaws in the logic and the poor decision path that the people followed. The post-failure analysis that discusses the lack of information or poor presentation of proper information can trace the failure back to designs that never connected information to the larger picture. The analysis must consider and expect that people make choices and decisions in isolation based on considerations of individual parts. In addition, the content developers must acknowledge that although they may have a view of the overall relationships, the people making the decisions will not.

People try to make decisions as if they are adjusting to a static system and forget that they are adjusting to a dynamic, highly interconnected system (see Figure 6.2). They think in terms of a simple system and take a highly local view of the change (see Figure 6.5). The thought process follows along the lines of "We are only making a minor change. It will never affect anything else." But the springs are all under tension and the other blocks move. That movement of the other blocks, the ripples through the overall situation, may push it over the edge of stability and cause profound changes. Effective writing about the situation needs to bring the dynamic nature front and center to remind the decision-makers that there will be ripple effects and the potential ripples must be considered.

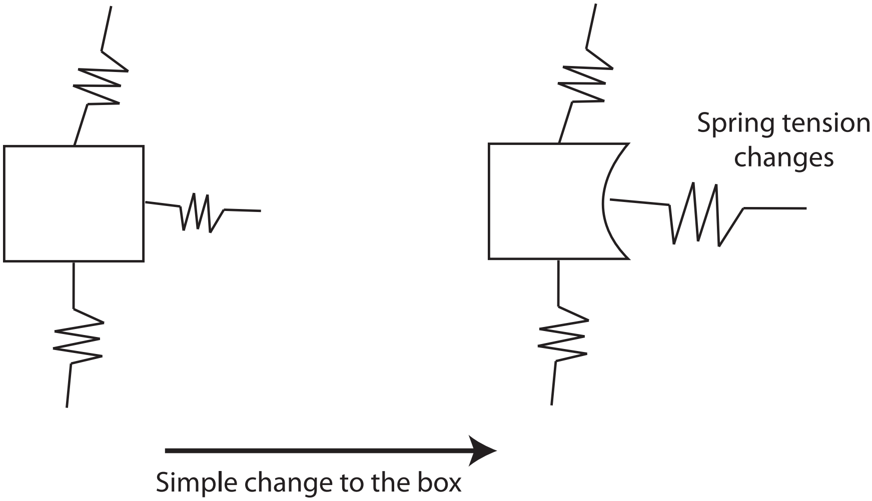

Figure 6.5. Making a change to just one box. It is easy to have an attitude of "pay no attention to that spring (relationship), for we only care about this box." But the spring tension (relationships) change and, consequently, the entire situation changes.

Figure 6.5 shows the problem of a decision-maker only worrying about their one small box. (High-level decision-makers—executive-level—may be making decisions about multiple boxes, but they still make decisions about their group of boxes.) Their decision is local. These decisions are all local decisions, made to optimize the current local point. They are all sensible and logical within the current local conditions. Discussions which raise questions about interconnections are often shut down with comments along the lines of "Yes, that may be important, but today we are only concerned about . . ." Consideration of the longer-scale dependencies is deferred to another day or, more realistically, deferred forever. The boundaries are redrawn small, and the relationships/ripple effects of the decision are ignored.

Complexity, essentially by definition, means a huge number of interacting parts that give rise to unpredictable outcomes. Each new component or layer of organization creates an explosion of new relationships and a myriad of new ways to draw boundaries. A problem is that the analysis tends to rationalize that it's analyzing a simple system with only a few parts; we see only the parts directly of interest to us *now*. When viewed small piece by small piece, then, yes, it might look simple, but that is like examining the fuel pump on a car and forgetting that it connects to the rest of the engine. We rationalize the small view and ignore the large view. We focus on the block and forget the springs.

Technical communicators need to draw proper boundaries to reveal the influence and potential ripple paths. Writing through the socio-technical lens captures the complexity of the situation and helps to force readers to consider how their item of interest sits within and affects a bigger situation. The end goal of developing content is to best communicate it to the readers. Making sure that communication supports making complex decisions requires using a socio-technical lens.

Example: Wolves in Yellowstone

One compelling example of the interconnections can be seen by looking at the reintroduction of wolves back into Yellowstone. Some researchers claim they significantly changed the landscape. It's a long sequence that looks obvious in retrospect, but since there were essentially an infinite number of ways their introduction could have gone, it was not predictable (the single path is traced out in Figure 6.6).

The compressed version: Before wolves, deer ate the trees at stream banks so nothing grew to stabilize the ground, and streams became fast moving and eroded their banks. Wolves pushed the deer away from the streams (but didn't actually eat many of them); ground cover came and stabilized the soil, trees grew, beavers came, the stream got dammed and turned into slow-flowing streams, amphibians and wetland reptiles/mammals came; stream banks overgrew; erosion stopped. Obviously, wolves have no direct effect on a stream, but introducing the wolves started a chain of ripples that changed fast, free-flowing, eroding streams to slow, meandering streams.

Some decisions have minor ripples and may cause the situation to bounce back to almost the starting position (adding beavers when there are not enough trees would not fix the problem). Others cause an avalanche of changes (adding the wolf) that may be far removed from the initial goal and totally not a concern of the decision-maker (the group who added wolves). The key item which can cause the avalanche may not appear remotely related to later developments.

This example itself may or may not be true (Fong, 2018; Kuhne, 2019). But it still shows a potential train of relationships rippling through a complex system—interactions that would never be predictable at the beginning of the process. They cannot be predicted because the non-linear aspects of the situation make it sensitive to the initial conditions, and uncontrolled factors also have an influence. Afterwards, it looks like a straightforward chain of events, but the reality is that a large event tree is constantly pruned down to give "what really happened" (see Figure 6.6).

This example talks about wolves, but a similar string of events can occur whenever major decisions are made—when a new software system is implemented, major hiring policies are changed, or a company's focus shifts between products. These are all company-wide decisions and affect the entire corporate environment. But, likewise, decisions made at a much lower level can ripple through and have profound effects on a specific unit.

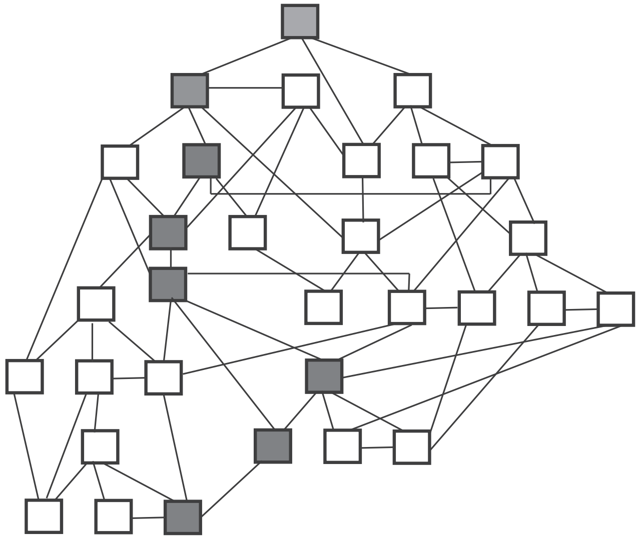

Figure 6.6.: Chain of events. All of the outcomes make up the large tree, but only a single chain actually occurs (the gray boxes). Many socio-technical factors combine to drive which specific chain occurs for a process.

As technical communicators, when we develop content, we need to ensure it provides the reader with a good view of the potential consequences; the content must capture the socio-technical situation. It is very easy for expectation bias to consume the reader. They only see what they expect to see and foresee that their decisions will unfurl as they expect. Potential unintended consequences are ignored.

Looking Ahead

Research Needed

While research often looks at decision-making in isolation, in reality, decision-making occurs as part of larger tasks and makes up only a single element in achieving a larger goal (Orasanu and Connolly (1993). Decisions occur within a cycle which "consist[s] of defining what the problem is, understanding what a reasonable solution would look like, taking action to reach that goal, and evaluating the effects of that action" (Orasanu & Connolly, 1993, p. 6). Although they were talking about decision-making research, the statement applies equally to much technical communication research. The analysis and documentation focus on one component and miss that they are embedded within and constantly react to a much larger framework.

Complex situations and their complex information presentation needs have become the norm. Yet, as people search for and interact with information in a computer system, they feel frustrated because the information they need is hard to integrate into a coherent whole. Back in 2007, Janice Redish (2007) discussed how the usability of complex systems is not the same as the usability of simple systems, but a fundamentally different beast. Yet, over ten years after Redish made her call for the development of complex usability methods, little has changed. It appears her message has been lost. We seriously need to begin the research needed to handle information communication within a complex situation.

Current technical communication analysis methods are focused on how to communicate about the one component—in other words, dealing with simple systems with their right/wrong answers. Our task analysis methods are good for what they are designed for but do not go far enough. They fail to capture the bigger picture in which the information need is embedded—note the term *information need* and not *task*. When the communication goal moves beyond tasks and into decision-making, we have essentially no methods that go beyond high generalities of "understand your audience." A true statement, but not one that provides methods for determining the socio-technical needs of the audience within a decision-making environment. The audience, the environment, and the technical systems all interconnect and interact with each other. We need methods of how to consider those relationships when creating information. Returning to the Spool (2014) story which started this chapter, we need methods to help distinguish the different information needs on different days and how to address them.

Pedagogy

Moving to a problem-solving view is not simply a teaching problem but, rather, a mindset of shifting from providing information to asking why the person needs the information in the first place and how they are going to use it, and what problem they are solving. It is about understanding the entire situation. An important question that must be answered at a deep level is what drives why people are looking at the information in the first place. The need for information should not be viewed as a simple need.

Instead of dealing with the real goals, too much technical communication takes the simple view and writes about "how to retrieve the information" or "how to perform X." What it means, how to interpret X, and how X connects to other information are defined as outside of scope. The complex problem of the reader's situation has been redefined to a simple problem. And then the writers wonder why no one values their work. Within the classroom, we need to discuss these bigger issues and ensure the students understand that a simple "I'll just write up all the information about it" or "I'll write 14 different sections, one for each audience" will never communicate the information in a way that fits the reader's needs.

We also need to make students realize that complex situations cannot be broken down into individual pieces—this works wonderfully in the hard sciences and in computer science but fails miserably in the social sciences. The deconstruction approach fundamentally changes the problem because it loses the relationships (Albers, 2009). Once, in a discussion of complex relationships, a student was adamant that everything within them could be broken down into a series of simple actions that could be understood and/or documented. Not really. Yes, each identified action/problem can be solved, but within the complex problem space, the problems that need to be solved change. It is not the same sequence each time. And often, those simple actions become too soft and have no real specific action. Not unlike a command to "now research your topic." True, but it doesn't give guidance on how/what to research, or how to know if the results are valid and/or sufficient.

The ideas of defining relationships or drawing boundaries within a situation seem to be completely off the technical communication radar. Task analysis teaches us to collect the steps or required information. It doesn't explicitly contain the additional factor of defining the relationships, which is essential to understanding a complex situation. Rhetorical analysis has too much desk work (sitting at a desk and thinking/reflecting) rather than interacting with people to collect data.

Conclusion

Transiting technical communication to a problem-solving view using a socio-technical lens is not simply a teaching problem. Rather, it's a change in the discipline-level mindset that requires shifting from providing information—typically in a step-by-step fashion of highly structured writing— to asking why the person needs and uses the information in the first place, how and where they are going to use it, and what problem they are solving, and *then* providing them with the information presented in a manner relevant to their needs (see Figure 6.1). Technical communication needs to reshape its basic conception of communicating information to one that privileges problem-solving and decision-making rather than simply providing information or procedures. The writing goal of being clear, complete, and correct becomes much fuzzier within this world. None of these three terms has clear, complete, and correct answers, something which causes cognitive dissidence for everyone—students, instructors, and practicing professionals.

A foundational idea of socio-technical theory is that the design and performance of any system can only be understood and improved if both "social" and "technical" aspects are considered together and treated as *interdependent* elements within a complex situation. Although at this point in this chapter, the previous sentence should be obvious, the socio-technical situation tends to be larger than what is normally considered within audience analysis, much of technical communication, or studies of the rhetorical situation. These two sentences sum up the essence of this chapter, and I hope they become the most quoted lines. Fully understanding them requires understanding what needs to change to create content through a socio-technical lens. Within a complex situation, the social and the technical are highly interdependent. Creating content requires teasing out those interdependencies and the relationships that form them. Audience analysis must be more than basic demographics and must get at the fundamentals of how/why the audience needs the information. As part of that defining of how/why, the problem space must be defined. Boundaries must be drawn to make the problem manageable for the writer but still relevant for the reader. The boundaries must include the important relationships, which can give the impression of expanding the problem beyond the "I need this information" view. Yes, the writer must provide that information, but they must also ensure it remains within the context of the entire socio-technical situation. Without that context, the reader lacks the full information required to make a high-quality decision.

Final Thoughts

Looking back, I realize that when I wrote the books *Communication of Complex Information* (2004) and *Human-Information Interaction* (2012), I had too strong of a focus on the writer conveying information to a reader aspects of the communication situation. In other words, assuming in Figure 6.1 that the arrowhead size denotes significance, the arrows pointing at the reader were much larger than the arrows going outward from the reader. But thinking of this in socio-technical terms requires rethinking their relative size. In fact, they must be either the same, or, perhaps, the outward arrows are actually larger.

Why larger? Because the reader will be taking the information, making decisions, and affecting the situation. Technical communication through a socio-technical lens is not about providing information to a reader but about understanding how that reader will be influencing the situation. Yes, there are feedback loops with information coming to and from the reader, but, ultimately, it's how the reader changes the situation that matters.

The technical communicator's job is to provide the information needed to allow the reader to make decisions that change the situation in a manner they desire, and to monitor that the changes are processing as expected. Accomplishing this task requires understanding the situation in which the information is used—what information is relevant, how it interconnects, where it comes from, how both the information and the relationships evolve as the situation develops, and how to draw the boundaries to define the situation.

References

Albers, Michael. J. (1996). Decision making: A missing facet of effective documentation. In *Proceedings of the 14th Annual International Conference on Systems Documentation: Marshaling New Technological Forces: Building a Corporate, Academic, And User-Oriented Triangle (SIGDOC '96) (pp. 57–65).* Association for Computing Machinery. https://doi.org/10.1145/238215.238256

Albers, Michael. J. (2004). *Communication of complex information: User goals and information needs for dynamic web information*. Erlbaum.

Albers, Michael. (2009). Information relationships: The source of useful and usable content. In *SIGDOC '09: Proceedings of the 27th ACM International Conference on Design of Communication (pp. 171-178).* Association for Computing Machinery. https://doi.org/10.1145/1621995.1622027

Albers, Michael J. (2010). Usability and information relationships: Considering content relationships when testing complex information. In M. J. Albers & B. Still (Eds.), *Usability of complex information systems: Evaluation of user interaction.* (pp. 109-132) CRC Press.

Albers, Michael J. (2012). *Human-information interaction and technical communication: Concepts and frameworks.* IGI Global.

Castel, Felipe. (2002). Ontological computing. *Communications of the ACM, 45*(2), 29-30.

Cilliers, Paul. (1998). *Complexity and postmodernism: Understanding complex systems*. Routledge.

Dekker, Sidney. (2011). *Drift into failure: From hunting broken components to understanding complex systems*. CRC Press.

Dobrin, David. N. (2004). What's technical about technical writing? In J. Johnson-Eilola & S. A. Selber (Eds.), *Central works in technical communication* (pp. 107-123). Oxford University Press.

Ebert, David, Zwa, Amen, Miller, Ethan, Shaw, Christopher, & Roberts, D. Aaron. (1997). Two-handed volumetric document corpus management. *IEEE Computer Graphics and Applications, 17*(4), 60-62.

Easterling, William E., & Kok, Kasper. (2002). Emergent properties of scale in global environmental modeling - Are there any? *Integrated Assessment*, *3*(2-3), 233-246.

Fong, Maria. (2018). *Wolves change ecosystem and geography in Yellowstone*. Tufts University. http://sites.tufts.edu/tuftsgetsgreen/2018/02/27/wolves-change-ecosystem-and-geography-in-yellowstone/

Interaction Design Foundation. (n.d.) *What are socio-technical systems?* Retrieved January 28, 2019 from https://www.interaction-design.org/literature/topics/socio-technical-systems

Johnson-Sheehan, Richard. (2005). *Technical communication today*. Pearson.

Klein, Gary. (1999). *Sources of power: How people make decisions.* MIT.

Klein, Lisl. (2014). What do we actually mean by "sociotechnical"? On values, boundaries and the problems of language. *Applied Ergonomics*, *45*, 137-142.

Kuhne, Michael. (2019). *Scientists debunk myth that Yellowstone wolves changed entire ecosystem, flow of rivers*. AccuWeather. https://www.accuweather.com/en/weather-news/scientists-debunk-myth-that-yellowstone-wolves-changed-entire-ecosystem-flow-of-rivers/70004699

Laplante, Phil, & Flaxman, Harvey. (1995). The convergence of technology and creativity in the corporate environment. *IEEE Transactions on Professional Communication*, *38*(1*)*, 20-23.

Markel, Mike, & Selber, Stuart. (2019). *Practical strategies for technical communication* (3rd ed.). Bedford/St. Martin's.

Mirel, Barbara. (1992). Analyzing audiences for software manuals: A survey of instructional needs for 'real world tasks'. *Technical Communication Quarterly, 1*(1), 15–35.

Mumford, R. Enid. (1987). Socio-technical systems design: Evolving theory and practice. In Gro Bjerknes, Pelle Ehn, & Morten Kyng (Eds.), *Computers and democracy (*pp. 59-77). Avebury; Aldershot.

Norman, Donald A. (2002). *The design of everyday things*. Basic Books.

Orasanu, Judith, & Connolly, Terry. (1993). The reinvention of decision making. In Gary Klein, Judith Orasanu, Roberta Calderwood, & Caroline Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 3-20). Ablex.

Redish, Janice. (2007). Expanding usability testing to evaluate complex systems. *Journal of Usability Studies 2*(3), 102–111.

Robertson, George, Mackinlay, Jock, & Card, Stuart. (1993). Information visualization: Using 3D interactive animation. *Communications of the ACM*, *36*(4), 57-71.

Spool, Jared. (2014). Service design: Pushing us beyond the familiar. *Center Centre – UIE*.https://articles.uie.com/service_design/

Terveen, Loren, Selfridge, Peter, & Long, M. David. (1995). Living design memory: Framework, implementation, lessons learned. *Human-Computer Interaction, 10*(1), 1-37.

Trist, Eruc. (1981). The evolution of socio-technical systems—A conceptual framework and an action research program. In Andrew Van de Ven & William Joyce (Eds.), *Perspectives on organisational design and behaviour.* (pp. 19–75) Wiley Interscience.

Vicente, Kim. (1999). *Cognitive work analysis.* Erlbaum.

Wickman, Chad. (2014). Wicked problems in technical communication. *Journal of Technical Writing and Communication*, *44*(1), 23-42.

Wikipedia. (n.d.) *Sociotechncial system*. Retrieved January 28, 2019 from https://en.wikipedia.org/wiki/Sociotechnical_system

Woods, David D. & Roth, Emilie. (1988). Cognitive engineering: Human problem solving with tools. *Human Factors* 30(4), 415–430.