Synthesis of Scientific and Social Facts: Evolution of a Principled Pragmatic Framework for Decision Making

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Prologue

The world is interconnected. Science, policy, and politics are interdependent. Change is the constant. And decision making under change and uncertainty is inevitable. The pace and nature of change and uncertainty has accelerated at a rate that we have never experienced before. Before the turn of the century, YouTube, Facebook, and ChatGPT did not exist; today, these technological innovations shape social dynamics, influence the nature of politics, and redefine the dynamics of decision making. There is a growing consensus that these changes are shaping and disrupting our world in an unprecedented way. A key question for us is this: how do we design a learning by doing environment to create and sustain global common good for our uncertain future using science and engineering?

As we embark on this design experiment to shape our future, we must realize that the exact nature of the challenges and opportunities in this experiment is open to multiple interpretations. There will be competing options and expected outcomes. It is important, however, to prioritize the linking of abstract ideas with concrete tasks to achieve shared goals and outcomes.

Simple Question but No Simple Answer

Consider the following: 1 + 1 = ? The answer depends on whom you ask and why. What is the nature of one? What is the meaning of plus? Are we adding two similar particles or two people? Why and how does such a simple question provoke so many different answers? The solutions presented to many of our problems often depend on who is answering the question, on behalf of whom, and for what purpose. A mathematician may assert that the answer is exactly two based on some axiomatic assumptions, an engineer may argue that it is not exactly two because of uncertainty in measurements, and a social scientist may posit that given the context of the question, the answer may have multiple interpretations (for example, are we adding two apples, an apple and an orange, or John and Jane?). Developing solutions while remaining true to the objectivity of numbers and subjectivity of narratives is a defining challenge of our time.

Narratives are persuasive but may not always be objective; numbers are often objective but may not be very persuasive. For science and engineering to provide the broadest beneficial impact on society, their findings need to be translated by integrating scientific integrity with empathy. In the twentieth century, scientists discovered, engineers created, and society benefited. During that era of inventions, science and engineering were highly regarded and their societal impacts—inventing antibiotics, making cars, and landing on the moon—were celebrated. In the 21st century, however, professionals and decision makers are tasked with satisfying technical (e.g., increase efficiency, minimize pollution, optimize cost, and so on) and societal (e.g., ensure sustainability, promote equity, enhance social justice, and so on) objectives. Satisfying these competing and often conflicting objectives creates significant tension and can lead to dilemmas. Broadly speaking, science in theory is factual and objective, whereas social impact is value-based and subjective. Unfortunately, our traditional problem-solving frames often separate the observation-based technical (what is) from the value-based sociopolitical (what ought to be) dimensions of the problem. We are faced with a duality of competing representations—numbers or narratives; quantitative or qualitative; objective or subjective—mixing science, policy, and politics and creating a dizzying set of possible options and solutions.

It's Not Either-Or; It's And

As we explore and examine the nature, origin, and implications of these competing choices as well as possible solution spaces for many engineering problems, one emergent finding is that we need to focus on making our choices scientifically defensible, societally acceptable, and politically feasible for beneficial outcomes. We need to be cognizant of the duality of representations—like numbers or narratives, particles or persons, quantitative or qualitative, objective or subjective, facts or feelings, and many other similar notions—and their implications in formulating, framing, and addressing any problem. To find feasible solutions for the many complex problems of our time, we need a different way of thinking, framing, and addressing the problem. We need to replace OR with AND. We need to explicitly recognize that science and engineering alone will not solve our most pressing complex problems, nor will policy uninformed by science and engineering be effective.

A Distinction between and Synthesis of Scientific and Social Facts

Think of the flow of water as a fact. On the one hand and in the simplest of cases, it flows downhill following the laws of gravity. On the other hand, in the American West, as the saying goes, water flows uphill toward money as water is siphoned from the Colorado River to sustain the city of Los Angeles. If, for example, we were to manage water for societal good, we need to understand the

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differences between these two types of facts: the flow of water as an object (particle with no purpose) and the flow of water uphill (defying laws of gravity) as a resource controlled by people with purpose.

Scientific Facts

Physics is not psychology. Psychology is not political science. Yet these three disciplines claim to be science. In what ways are they similar or different? Depending on the nature of the subject (people) or object (particle) of study and the unit of analysis, physics, psychology, and political science use scientific methods differently. The principles of observability, replicability, falsifiability, and generalizability are strongly emphasized and practiced in physics. Psychology also uses the scientific method, but it faces some unique challenges compared with physics because it studies people not particles. Consequently, the scientific method is practiced at different levels of precision with different methods across disciplines because both the subjects of the study (particle versus people) and the specific questions being addressed are different. Each discipline has its own unique challenges for applying the scientific methods. Scientific facts, as I define them here are measurable, reproducible, falsifiable, and generalizable; they are not opinions, feelings, or preferences.

Also, scientific facts are tentative and subject to revision as new observations become available. Recall that before Copernicus published his heliocentrism model in 1543, the Sun used to move around Earth. To sum, the reliability of scientific facts is not based on consensus but on its observability, replicability, falsifiability, and generalizability. A focus on such a notion of objectivity—not to confuse with complete certainty—of scientific facts serves us well when we work with well-structured problems where the dynamics are autonomous, not intentional. We can (and will) continue to improve our methods, processes, and protocols to make significant advances in addressing this class of problems we have called simple and complicated (Islam and Susskind 2013). Advancement in addressing the aforementioned class of problems, however, most likely will not translate well to address problems that are coupled with physical and societal variables, processes, actors, and institutions (Rittel and Webber 1973). What happens when water is no longer just a particle but also a resource? Now water suddenly can defy gravity because economic and political factors may force it to flow uphill. This class of problems is rooted in contexts, values, and intentions, and is dominated by social facts.

Social Facts

Social facts consist of a collective way of believing and acting toward a problem (Durkheim 1894). They exert influence that extends beyond the experiences and intentions of individuals. They operate at a collective level and shapes social dynamics. Social facts can be observed through their external manifestations, such as laws, customs, rituals, symbols, social roles, or organizational structures. They are shaped by collective beliefs, values, and norms, which may vary across different societies or contexts. Unlike scientific facts, social facts cannot be easily generalized because they often vary across different contexts, societies, cultures, or historical periods. For example, money as a social fact has value and meaning within a specific society or community. It is a widely accepted medium of exchange for goods and services. It is the shared understanding and acceptance of money's role as a medium of exchange that gives it its power and effectiveness in facilitating economic transactions.

A Synthesis of Scientific and Social Facts

Given the intricate coupling of scientific and social facts in shaping the collective decision making, a carefully crafted synthesis of the principles of scientific methods and the pragmatism of social facts is needed. In data-driven decision making, scientific facts and social facts complement each other by providing a holistic understanding of the physical and social worlds. My adherence to synthesizing the notion of social facts with scientific facts in decision making is not an attempt to define the truth but to agree on a truth that is negotiable and implementable given the capacity, constraints, and context of a problem.

How Complexity Is Shaping Professional Engineering Practice

To tackle complex (colloquially known as wicked or messy) problems, one needs to engage in the synthesis of scientific and social facts and enter the messy world of inclusive fact-value conversations. For many traditionally trained engineers, this may be an uncomfortable idea. Professional education and training tend to be centered on preparing practitioners for what Schön (1984) refers to as the high ground, i.e., the neat and orderly place where "practitioners can make effective use of research-based theory and technique" (Schön 1984). Twenty-first century engineers, on the other hand, need to be apt to practice in "the swampy lowland where situations are confusing 'messes' incapable of technical solutions" (Schön 1984). To manage complex problems of our time, we need to reframe traditional specify-design-implement to try-select-adapt approaches. Instead of searching for optimal solutions to address complex problems we need to look for an optimal space where certain solutions are actionable given the constraints the context imposes (Islam and Smith 2021).

Problems Arising in Complex Systems Are Best Addressed with a Problem-Driven Approach to Interdisciplinary Collaboration

Interdisciplinary approaches to collaboration are widely praised and promoted; however, these recommendations seldom come with explicit prescriptions about the modes of collaboration. A theory-driven method of collaboration, for example, is effective for well-structured problems that can be adequately described by natural laws. Biologists and chemists, for example, have collaborated to create powerful general theories of molecular biology. However, theory-driven approaches tend to fail in providing actionable results when natural and human systems are coupled and where scientific and social facts cannot be easily separated. Instead of seeking a generalized theory to bridge disparate disciplines to address this class of problems, interdisciplinary teams need to seek and work with shared frameworks (e.g., Islam and Susskind 2013; Islam and Smith 2021). Shared frameworks can reduce the friction of working across disciplinary barriers because they create an actionable space for synthesis (e.g., Poteete et al. 2010; Verdini 2017). Addressing these problems will require more than just diverse expertise; they demand inclusive stakeholder engagement in fact-value deliberation, joint fact-finding, collective decision making, and adaptive management (Islam and Susskind 2013).

Engineers tend to be specialized, and their training does not prepare them well for working in value-laden environments, where knowledge is expected to be coproduced. To work effectively in these spaces will require drawing upon four domains of knowledge: episteme (formal knowledge), phronesis (practical wisdom), techne (practiced technique), and praxis (thoughtful practice). Effectively

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using these domains of knowledge to promote sustainable and equitable outcomes will require attention to both principles and pragmatism.

A Principled Pragmatic Framework

A principled pragmatic framework (PPF) suggests the conception, design, implementation, and evaluation of interventions with concrete tasks and activities. A key element of a PPF is fallibilism—the idea that one cannot be sure of anything, and that any intervention needs to be tentative and subject to revision based on changing circumstances. A PPF is not based on some dogmatic principles or prior belief. Instead, it is a framework to motivate affected parties to engage in a conversation to develop shared beliefs for action (think of social facts). It will guide the exploration and cocreation of set of concrete tasks that are motivated by scientific facts and are consistent with the capacity and constraints imposed by a given context. Such a framing of and acting with PPF offers a way to imagine and explore different future courses of actions. I emphasize four key distinguishing features of PPFs. First, a PPF is a negotiated process to decide on desired outcomes with agreed upon indicators. Second, it operationalizes the notion of fallibilism by continuously looking for emergent patterns and remaining agile to adapt as situation changes. Third, it explicitly recognizes that the future realities created by chosen interventions might produce unanticipated and sometimes undesirable outcomes. Fourth, it must have a process to show why and how the PPF is likely to achieve better outcomes than competing frameworks.

Epilogue

I have purposefully chosen epilogue rather than the more commonly used concluding remarks section. Because my purpose in writing this forum article is to open a new way to examine, explain and address complex problems, one that draws upon the notion of emergent patterns and contingent nature of interventions. A key premise is to address coupled natural and human system problems using complexity thinking by synthesizing scientific and social facts for collective decision making. My purpose here is not to provide a definitive prescription but to distill insights gained from many years of effort working with problems when neither the certainty of scientific solution nor the consensus of what intervention to implement exists: what we need is a PPF. A careful synthesis and application of two types of facts will be guided by principled pragmatism, where the principles constitute value considerations (which shape understanding and create social facts), and pragmatism constitutes the factual considerations (explanation based on scientific facts in each action context). The proposed PPF seeks to move away from the dichotomy of being either pragmatic or normative and focus on their interaction.

In methodological terms, this means respecting both the need to (slowly) cultivate understandings (i.e., to identify shared values, acknowledge social facts, agree on acceptable risks, and pinpoint areas of irreconcilable disagreement) and the importance of (quickly) arriving at actionable experiments to test and revise possible explanations (i.e., identify physical system constraints, establish scientific facts, and elucidate so-called knowable unknowns through active engagement of stakeholders and joint fact-finding). In practical terms, this involves a focus on the most effective means of generating scientifically defensible ideas and transforming them into actionable agenda (Smith et al. 2021). As we continue to explore this uncharted territory of synthesizing scientific and social facts for effective decision making, I hope you will engage with the arguments discussed here and welcome your critiques and refinements as we build a path to achieve equitable, beneficial, and sustainable societal outcomes to the complex challenges we face.

Data Availability Statement

No data, models, or code were generated or used during this study.

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