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Insolvent

How to Reorient Computing for Just Sustainability

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5

COMPUTING'S CRITICAL FRIENDS

Any use of expertise presupposes boundary judgments. . . . When the discussion turns to the basic boundary judgments on which his exercise of expertise depends, the expert is no less a layman than are the affected citizens.
—Ulrich (1983, 306)

Our position is not that of idealized neutral observers, but rather judges in our own case, with no one to properly hold us accountable.
—Gardiner (2014, xii–xiii)

Gardiner's warning rings true for tech development. Those involved in tech design are held accountable only in the most egregious cases of malpractice. In the absence of true accountability and independent oversight, existing ethics codes reinforce the idea that systems designers should be their own judges. This "makes it all too easy to slip into weak and self-serving ways of thinking," as Gardiner continues. For these and other reasons, Phil Agre's call for a "critical technical practice"—a practice that combines technical work with a critical orientation and a reflexive attitude—continues to resonate strongly with many of us (e.g., Ratto 2011; DiSalvo 2014; Britton et al. 2020). To develop an approach to systems design in computing that centers sustainability and justice, we need to gain a view of the technical rationality inherent in computing that explores its boundaries and gaps, or in other words, that doesn't end at the limits of reified frameworks of pure technical rationality. Like Agre, I am committed to developing my approach to just sustainability design in a continuous constructive engagement with computing, in computing.

This chapter argues that to support that work and balance critique with constructive design and development work, computing can call on *critical friends*.

> A critical friend is someone who is encouraging and supportive, but who also provides honest and often candid feedback that may be uncomfortable or difficult to hear. In short, a critical friend is someone who agrees to speak truthfully, but constructively, about weaknesses, problems, and emotionally charged issues. ("Critical Friend Definition" 2013)

A critical friend brings support and profound respect to the table but also enough distance to take a contrasting perspective that challenges our worldview. They ask questions that nudge us to reflect on our assumptions and beliefs. One could say that critical friends are the friends who tell us what no one else dares to—because we would not accept to hear it from just anyone. This is important: for a critical friend's advice to be valued, the recipient must listen and value constructive critique.[1]

The concept of the critical friend has been elaborated in education. After all, constructive feedback is crucial to successful learning. For the professional development of teachers, establishing relationships with peers who act as critical friends is seen as a valuable mechanism for reflective feedback (Costa and Kallick 1993; "Critical Friend" 2014; Kember et al. 1997). While education focuses on individuals or groups, it can inform our thinking about the preconditions for a successful critical friendship of communities, including the need to foster a relationship of mutual trust that allows "unguarded conversations" (Baskerville and Goldblatt 2009).

Computing's critical friends can be found in several disciplines, and some research communities in computing have long cultivated constructive relations with their critical friends.[2] For example, much of the work on critical design methods in human–computer interaction (HCI) that followed Agre's call draws from feminist science and technology studies (STS). To some degree this book does too, and the next section will briefly review key influences in intersectional feminist STS and the critical philosophy of technology. My main focus lies on *critical systems* *thinking* (CST). I consider CST a close critical friend, because CST combines the critical approach with a robust systemic perspective and grows directly out of a critical turn in operations research away from the rationalistic tradition that still dominates computer science. This is why its insights and arguments are strikingly relevant today. Its history shows parallels to the challenges that technologists face today in designing for sustainability and justice, because its proponents too grappled with the overreach of rationalist scientific reasoning and with crucial questions of expertise and legitimacy. For me, someone schooled in the rationalist paradigm, CST offered a way to restructure my understanding of computing and its role in sustainability and justice. For these reasons, I draw on the arguments of CST to grapple with the myths of computing, and I use its frameworks to populate an initial toolbox for reorienting systems design.

Below, I introduce these three critical friends: feminist STS, the critical philosophy of technology, and CST. My aim is to set in motion a conversation continued in subsequent chapters by introducing key ideas and arguments, exploring how they complement each other, and illustrating the idea of critical friendship.

FEMINIST SCIENCE AND TECHNOLOGY STUDIES

STS "investigates the institutions, practices, meanings, and outcomes of science and technology and their multiple entanglements with the worlds people inhabit, their lives, and their value", and it often aims "to open up science, technology, and society to critical assessment and interrogation" (Felt et al. 2016, 1–2). Prominent early examples include the argument that material infrastructure can embed political priorities and values (Winner 1980). Because the study of technology was not traditionally the subject of the social sciences, some STS researchers focused on emphasizing the importance of including technical objects into social analysis (Latour 1987). Others focused on the question how technologies are socially constructed (Bijker et al. 1987; 2012). The emphasis on the social construction of technology mirrors the emphasis within computing on *how computing shapes societies*. But unlike computing, STS has long maintained that societies and technologies mutually shape and constitute each other (MacKenzie and Wajcman 1999; Subramaniam et al. 2016, 407). The term *technoscience* reflects that STS views science and technology as convergent (Felt et al. 2016, 7).

Feminist STS has examined the uneven distribution of influence over technoscience and its benefits. Far from restricting itself to a focus on women's representation in technoscience and the ways in which women were affected by it, intersectional feminist STS also explored fundamental categories, beginning with gender, race, and sexuality. Drawing on such concepts as reification and the role of metaphor in structuring our understanding of the world, feminists questioned the adequacy of dominant epistemologies and ontologies (Subramaniam et al. 2016). Sandra Harding, for example, wrote that

> as a symbol system, gender difference is the most ancient, most universal, and most powerful origin of many morally valued conceptualizations of everything else in the world around us . . . gendered social life is produced through three distinct processes: it is the result of assigning dualistic gender metaphors to various perceived dichotomies that rarely have anything to do with gender differences; it is the consequence of appealing to these gender dualisms to organize social activity, of dividing necessary social activities between different groups of humans; it is a form of socially constructed individual identity only imperfectly correlated with either the "reality" or the perception of sex differences. (1986, 18–19)

Donna Haraway's argument that all knowledge is situated (1988)—or rather, that all *knowledges are* situated—opened an influential line of argument with parallels to CST: despite all claims to universality, knowledge is produced from a perspective. Because that perspective is always partial, knowledge is not, and cannot be, absolute or complete. It cannot be entirely separated from a knowing subject, as rationalist philosopher of science Karl Popper would have had it (1972). Its location and context matter, and the dominant form of knowing in technoscience is not the only form. The conclusion is not that everything therefore is equally valid, but that a critical awareness of each perspective's position, and its partiality, helps us in assessing its validity. This helps us to produce more accurate and legitimate knowledge or what Harding calls "strong objectivity":

> In societies where scientific rationality and objectivity are claimed to be highly valued by dominant groups, marginalized peoples and those who listen attentively to them will point out that from the perspective of marginal lives, the dominant accounts are less than maximally objective. Knowledge claims are always situated, and the failure by dominant groups *critically and systematically*

to interrogate their advantaged social situation and the effect of such advantages on their beliefs leaves their social situation a scientifically and epistemologically disadvantaged one for generating knowledge. Moreover, these accounts end up legitimating exploitative "practical politics" even when those who produce them have good intentions. (1992; emphasis added)

With this feminist sensitivity to the historicity and positionality of knowledge, classic studies in STS examined the mutually constitutive entanglement of technology and society through wide-ranging objects of study including household technology (Wajcman 1991) and the international disease classification system (Bowker and Star 1999). Bowker and Star's study showed how classification systems are historically shaped by social forces and interests; how marginalized perspectives are only included after significant advocacy (a prime example is the classification and later declassification of homosexuality as a disease); and they show how these technologies exert a *torque* that twists the lives of those who happen to get into its force field. Diabetics like me involuntarily collect lived experience of that torque on a daily basis. In contrast to the dominant desire to assimilate disabled bodies into the normative standard by assistive devices designed *for* disabled people by supposed experts, *crip technoscience* mobilizes feminist STS theory to advocate a nuanced politically conscious design perspective on which basis "technoscience can be a transformative tool for disability justice" (Hamraie and Fritsch 2019, 3).

Today, STS encompasses a dizzying array of perspectives, methods, theories, and approaches (Vertesi and Ribes 2019; Felt et al. 2016). Of primary interest for my argument is the intersectional feminist attention to the positionality of knowledge production, the questioning of categories, the role of the matrix of domination in technology design, and the challenging of entrenched power structures (D'Ignazio and Klein 2020). There are two reasons for this: first, these concepts speak directly to the challenges of just sustainability design, and second, they are the connection points where the arguments of STS meet the arguments of CST. These issues have been prominent in feminist HCI too (Rosner, Taylor, and Wiberg 2020). In addition, I want to introduce the critical philosophy of technology developed by Andrew Feenberg, because his democratic theory of technology suggests possible intervention points in the trajectory of technology development.

QUESTIONING TECHNOLOGICAL RATIONALITY: FEENBERG'S CRITICAL CONSTRUCTIVISM

In a series of books, philosopher Andrew Feenberg (e.g., 2002; 2017) has developed his critical theory of technology building on the work of his advisor Hebert Marcuse (1964; Feenberg 1996) and specific influences in critical theory, especially Lukács (Feenberg 2014). This theory forms an independent body of work, but it is also seen as a part of STS (Felt et al. 2016). As Feenberg writes, "Critical theory of technology agrees with STS that technology is neither value neutral nor universal while proposing an explicit theory of democratic interventions into technology" (2016, 635). A comprehensive review of this theory is beyond my ability and scope, but a few of its concepts and arguments will illustrate its central relevance for our subject.

Lukács' concept of *reification* explains "how the world can appear as a collection of facts" that seem natural and are not questioned (Feenberg 2014, 86). Technology design needs to respect facts, of course, but they alone never determine the shape of technological artifacts (Feenberg 2017). Instead, artifacts remain *underdetermined*. Different actors with differential power and influence each operate within their "margin of maneuver" (Feenberg 2002) in trying to influence the outcomes. The resulting artifacts of the present are coproduced by past values.

Feminist STS work emphasizes that each of these actors is bound to speak from their partial perspective. Power dynamics and the matrix of domination will force some perspectives to the margins. From there, their knowledges—"subjugated knowledges" in Foucault's terminology—often provide insights that go beyond the dominant perspectives, simply because *they have to*, and because their lived experience provides insights that are not available to the hegemonic view. Data feminists D'Ignazio and Klein call attention to the "privilege hazard":

> When data teams are primarily composed of people from dominant groups, those perspectives come to exert outsized influence on the decisions being made—to the exclusion of other identities and perspectives. This is not usually intentional; it comes from the ignorance of being on top. (2020, 28)

The privilege hazard is a hazard of moral corruption not unlike Gardiner's. In combination with reified rationality, it is just too easy to continue business as usual as long as that business's debts are born by others. Because the view from the top often overlooks insights from elsewhere, marginalized actors are forced to re-present their insight *as if* it came from other perspectives, just so that their expertise becomes legible *within* the dominant discourse.

Feenberg shows how marginalized perspectives are often excluded from technical standards and frameworks *by design*. For example, a standard curb, with its sudden drop to the road, cannot be handled easily by a wheelchair user. It literally manifests the priorities of values from the able-bodied top that coproduced it. Disability advocates were often motivated to organize because of their lived experience. Representatives of these marginalized perspectives organized to collectively advocate for changes, leveraged the narrow margin of maneuver available to them, and eventually achieved changes to the technical standards that afforded them some degree of accessibility. Through regulation, emerging practice and new values were embedded into a revision of standards and design guidelines. This serves as an example of how marginalized interests are expressed through *democratic interventions*, "the actions of citizens involved in conflicts over technology" (2016, 646). They take place during technology development or as "a posteriori" interventions or appropriations. In this process, expertise and knowledge have to be translated:

> the claims of experience and those of technical disciplines must be reconciled in the design process. . . . In the real world of technology, a largely unacknowledged dialogue between lay and expert is a normal feature of technical decision making and should be further developed. (Feenberg 2016, 647)

In computing, this translation work is typically attributed to requirements professionals, user experience designers, systems analysts, or adjacent roles. It is recognized as a central issue for requirements engineering (see chapter 10). Feenberg sees a significant role for technology professionals in this dialogue:

> Democratic interventions must be translated by technical professionals into new regulations and designs. Struggle gives rise to new technical codes both for particular types of artifacts and even for whole technological domains. This is an essential form of activism in a rationalized society. It limits the autonomy of experts and capitalist management and forces them to redesign the worlds they create to represent a wider range of interests. (Feenberg 2014, 214)[3]

He is well aware that we cannot simply expect this to work out for everyone. Reified technical codes present the illusion of pure technical rationality, and professionals are subject to incentive structures, historically grown professional competences and constraints, and historically produced educational programs, all shaped in the context of capitalism. Their margin of maneuver is thus severely restricted, and their reasoning can be subject to a false consciousness that presents the world of their activities as a collection of facts which exclude the perspectives of those marginalized, suppressed, and hurt (D. Noble 1984; 1977; Hoffman 1989; Breslin 2018). Instead, for this process of reconciliation to be realistic and fair, *dereification* is needed to free the false consciousness and allow it to comprehend the transcendent reality beyond its operationalized concepts. To overcome reification, Feenberg argues for the development of a *dialectical rationality*:

> Dialectical rationality is what transcends the one-dimensional reified thought and supports dereification and reconstruction. . . . Now rationality is associated not only with science and experiment, but also with the practical critique coming from those subordinated to the forms of capitalism. Their situated knowledge reveals aspects of reality to which reified rationality is blind. (Feenberg 2014, 206)

In today's world of IT, with its lack of equity and diversity in the workforce and its uneven global distribution, the privilege hazard combines with the danger of moral corruption highlighted by Gardiner to make the project of reconstruction, including the restructuring of narratives, more urgent and difficult than before. For Feenberg, this continued reconstruction is activism. He believes that the continued struggle for reform is an inevitable component of social change, and that it must be incremental. Disciplinary knowledge and politics present a challenge to this process. This chapter's Feenberg epigraph suggests that no "meta-discipline" can foresee the need for integrating disciplinary knowledge, and that therefore, a different kind of knowledge is needed. Systems thinkers would readily agree and point out that this is precisely what systems thinking is all about. But depending on which systems thinker gets the word, the conclusions vary drastically.

THE SYSTEMS APPROACH AND ITS STRUGGLES

A few decades before Agre and Feenberg, West Churchman struggled with the limitations of rationalistic understanding presented by a dominant systems paradigm. Churchman had written one of the first textbooks on operations research together with Russel Ackoff. Both grew disillusioned with the narrow analytic understanding that came to dominate the communities that they themselves had helped shape. Both ultimately abandoned these fields since, in Ackoff's words, their systems approach had "degenerated into mathematical masturbation" (1977): It had lost interest in its real-world context beyond its operationalist understanding, and it was unable to recognize its own shortcomings (Kirby 2003).

Throughout his work, Churchman strived to reconcile the comprehensive aim of a systems approach with the recognition that the reductive approach represented by these forms of systems *analysis* violated the very principles of systems thinking. In his book *The Systems Approach and Its Enemies* (1979b), a strange dialectic unfolds. The main protagonist, *the planner*, comes at the world with the best of intentions and an approach we would now describe as "hard systems thinking." This approach applies scientific principles and mathematical or logical procedures to analytically address social problems. In the process, scientific propositions gain *normative content* in their context of application, because they entail value judgments, real-life implications, and side effects. The planner—conceived in the gendered language of the day as a man—is full of optimism and good will. Yet, at every step of his planning, he encounters objections brought forward by the "enemies" of the systems approach: politics, morality, religion, and aesthetics. To rationally refute the seemingly irrational objections of these enemies, he needs to sweep in additional parts of the system's environment. In response to their repeated objections, the boundaries of the system continuously expand until the entire universe seems to be inside, in a *reductio ad absurdum* reminiscent of Borges's fable of the map that expands until it fills the territory (Borges and Hurley 1999).[4]

Churchman never resolved his dilemma. Ulrich (1983) summarizes his message (substitute "design" for "planning"):

> [In "The Systems Approach and Its Enemies,"] the systems approach for the first time has become truly self-reflective with respect to the normative content of its own quest for systems rationality. In Churchman's terms, the systems approach

cannot realize its search for the comprehensive rationality of planning so long as it seeks to absorb the 'enemies' of such rationality, e. g. politics, morality, religion, and aesthetics. Rather, the systems approach can claim comprehensive rationality if it learns to reflect on its own limitations, namely, by listening to its 'enemies' and by understanding them dialectically as what they are: mirrors of its own failure to be comprehensive. (34)

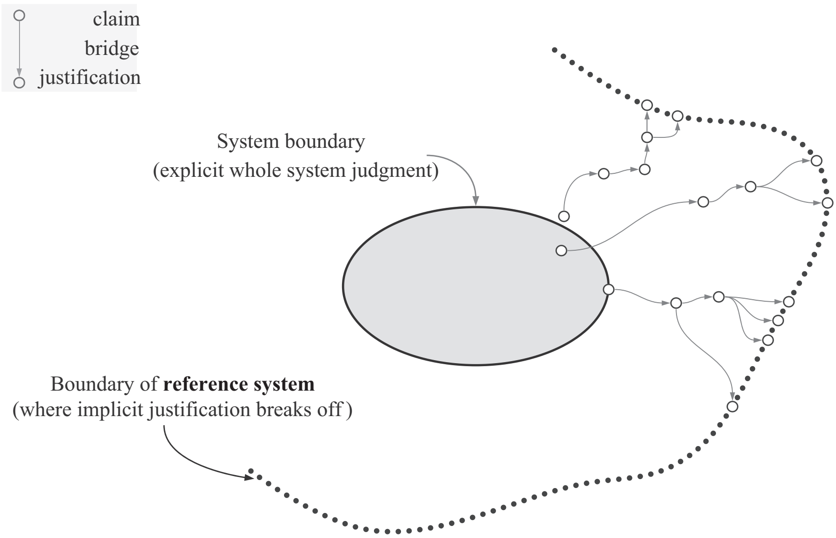
In his strange way, Churchman articulated the inability of analytic, deductive rationality to handle other forms of reasoning. For example, attempts to classify and measure all relevant values in systems design so that they can be formally represented in a model of that system's values is a prototypical example of the strategy of absorption—and it is unlikely to convince the enemies. Churchman also expressed the uncomfortable realization that rationality is founded on commitments it cannot fully explain. He did not go further than that, but his work expressed the conceptual foundation of two major turns in systems thinking. The first, in the 1970s, broke with positivist assumptions about the nature of systems as structurally present in the world and knowable. The core contribution was to acknowledge that conventional systems approaches to problem-solving fail in the social world because the central difficulty in a technological intervention is *how to define the problem* it should solve (Checkland 1981). The presence of multiple legitimately diverse perspectives demands a way to find consensus on how to frame the problem to be solved. The resulting soft systems thinking, exemplified by Checkland's soft systems methodology, is interpretive. It uses systemic concepts to organize a discourse in a problem situation, without making assumptions about how the real world is structured (Checkland 1981; 2000). This was an important step in applied systems thinking, but it did not address the issues highlighted by Feenberg, as discussed earlier, because it lacked the social theory to recognize and address issues of power dynamics and inequity among the participating stakeholders, it ignored the dangers of false consensus arising in its application, and it did not address questions of coercion.[5] In response, the second major turn resulted in critical systems thinking.[6]

THE SYSTEMS IDEA, CRITICALLY UNDERSTOOD

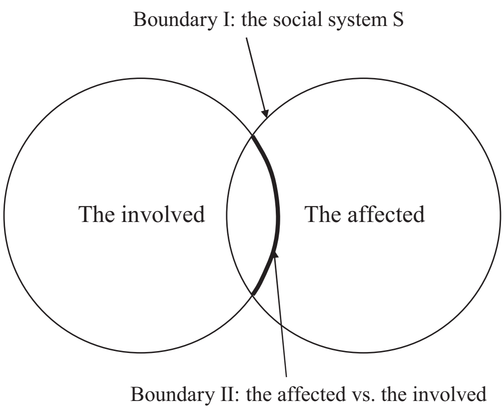
Critical systems thinking starts from the recognition that the systems idea of holistic understanding, understood critically, must begin with examining the inevitable selectivity of discursive claims *about* systems. CST emerged in the 1970s. It draws on contemporary critical social theory such as Habermas and Marcuse and later, the work of feminist scholars and writers such as Foucault (Flood 1990; M. Jackson 2019). This critical turn in systems thinking brought forth a heterogeneous set of approaches that combine a critical perspective with the intention to intervene productively in the world to create social change, much like Agres critical technical practice (1997b). It is worth retracing key steps of this difficult argument to interpret it from a contemporary perspective and resituate it in the context of systems design for the twenty-first century.

CST starts with Churchman, whose designer faces a crucial dilemma. To *rationally* evaluate even the smallest choice, the designer must justify their evaluations by reference to broader concerns. In strongly interconnected problematic situations, what they decide, explicitly or implicitly, amounts ultimately to a judgment over what is supposed to constitute *the whole system*. These "whole system judgments," or *boundary judgments*, are necessary to make any real choice. Churchman articulated the struggle and the need for a dialectic approach. His advisee Werner Ulrich continued Churchman's questioning of the rational justification of the propositions of applied science. He started with the observation that each boundary judgment—for example, whether a fact should be considered as part of the justification for a design decision or not—can be traced back to its underlying assumptions: When questioned as a claim, it should be substantiated by reference to assumptions that in turn can be questioned, and so on. At some point, the justification inevitably stops—it breaks off, as visualized in figure 5.1. The set of explicit and implicit claims at which justification breaks off is considered the *reference system*.

Ulrich was under no illusions about the homogeneity of those involved in design, or the willingness of those who are in power to open their claims to scrutiny. He distinguishes between those involved and those affected in design, as shown in figure 5.2.[7] These distinctions too are boundary judgments built on implicit reference systems: when we question who is or should be involved or affected and why, the answers will lead us to a reference system. Because the assumptions and conditions that constitute the reference system logically precede the design effort and cannot be logically or empirically justified, "the planner must trace the normative



5.1 System boundaries and reference systems.



5.2 Two basic boundary judgments (Ulrich 1983, 248).

implications of *alternative* boundary judgments . . . and make these implications transparent to those concerned" (Ulrich 1983, 244).

Ulrich looks "for the crucial sources from which the normative content of any social map or design derives" and finds them in intentionality: "*human intentionality* is the constitutive element accounting for the complex and normative nature of the object domain 'social reality'" (Ulrich 1983, 245). Intentionality sharply distinguishes the social world from the technical and the world of natural sciences. The *purposes* pursued by human actors and social groups introduce an entirely different kind of element into the object domain of design. Crucially, humans are purpose*ful*: capable of choosing their own path. In introducing purpose to the argument, Ulrich directly opposes the main proponent of rationalistic systems design, Herbert Simon.

PURPOSEFUL SYSTEMS AND THE EVACUATION OF POLITICS

The rationalistic tradition cumulating in Herbert Simon's *Sciences of the Artificial* (1996)—which lives on in computational problem solving and rationalistic systems design—stands in marked opposition to the position occupied by Churchman (Ulrich 1980; 1983, 319–325). Simon considers the ascription of purposes to social systems as a teleological fallacy, while in Churchman's view, it serves "a necessary critical purpose against hidden value assumptions." Perhaps the most interesting comparison results from the opposing views of what the "*crucial design task* to be solved" is (Ulrich 1983, 323). For Simon, it is "*problem decomposition*: how to decompose a complex system into simple systems that are easy to be controlled? Or: how to design and control complex hierarchies?" His view and focus still dominate computer science (CS) curricula today. For Churchman, the crucial task is "*problem identification*: . . . how to identify the whole system." While Simon privileges the divide-and-conquer standpoint and sees a problem of control, Churchman privileges the ethical standpoint and sees a problem of boundaries. But Churchman is not averse to relying on the powerful mechanisms developed by Simon's paradigm as long as their application can be ethically justified within a critical and reflective framework.

> The problem of [Simon's approach] is clear: it simply avoids the moral and political question of how a better whole will result from incremental improvement of small and separate subsystems; it leaves that question to the market as a surrogate planner—and to the interest groups that control it. . . . The crucial task then is not one of providing analytic tools such as social indicators, simulation models, etc., but rather dialectic tools to help the planner reflect . . . and enter into reasonable discourse with the affected . . . no systems approach for handling real-world complexity can be rational unless it makes room for the (self-) critical reflection of *free citizens*; for these alone know what social reality is and what it ought to be like. The systems approach may yet have a great future, if only it begins to understand that the "enemies" are really its allies. (Ulrich 1983, 325)

In other words, the rationalistic approach exemplified by Simon evacuates values and politics from the design discourse and leaves behind a depoliticized *science of design*. The resulting analytic tools are powerful but one-dimensional.[8] Other systems approaches, such as cybernetics, similarly evacuate intentionality.[9]

The project of critical systems thinking is not concerned with denying the validity or effectiveness of the analytic tools of "one-dimensional" hard systems approaches, but with undoing the evacuation of politics. The aim is to support the integration of analytic tools into a critical approach in which their application can become legitimate and appropriate under clearly defined conditions.[10] In systems design for sustainability and justice, too, the central challenge is not one of providing more exact analytic tools to measure sustainability and justice, but to address the need for dialectical forms of reasoning in which conflicting worldviews, including on those analytic tools, can be reconciled (see chapter 8). It is difficult to overstate the importance of this project in today's social reality of systems design, presented as unpolitical (Costanza-Chock 2020, 120–123; Dourish 2010), in which the legacy of Simon's approach still enjoys a hegemonic position (Rosner 2018).

To reestablish purpose in systems design, Ulrich relies on a principled argument: Just as causality is an important idea in the physical sciences, intentionality matters for understanding the "facts" of the social world, and it is in fact no less empirical in content, no less observable, than causality. He draws on Habermas's (1972) argument that human interests and purposes are always constitutive factors of knowledge. There is a useful distinction to be made among *technical interests* in prediction and control in the domain Habermas labels "work," *practical interests* of mutual understanding in communication in the domain Habermas labels "interaction," and *emancipatory interests* in autonomy and freedom (Habermas 1972).

In design, technical interests intersect with practical interests and emancipatory interests when stakeholders seek consensus on what to do about a situation. Habermas's concept of the *ideal speech situation* captures the idea of a situation in which participants can freely arrive at a consensus that can be regarded as genuine because it arises from a fair and equal process. The concept serves primarily as a hypothetical comparison point to help observers distinguish true from false consensus: that is, consensus emerging from unfair discourse. But it is a bit more than that: in Habermas's view of rationality, the possibility of the ideal speech situation has to be at least presupposed in principle in any act of communication. For him, any communication assumes four validity claims: that what is said is comprehensible, true, right, and sincere. "Thus we can ask a speaker 'What do you mean?' 'Is what you say true?' 'Are you entitled to say that?' and 'Do you really mean it?'" (Outhwaite 1994, 40).[11] These questions apply to any claim made about systems and, therefore, any boundary judgment.

Against this background of interests in a situation where claims are made about systems, the designers need to identify what the perceived social reality *means*:

> Defining "purpose" as a mapping dimension analogous to "space" and "time" is thus *not* to "introduce" value judgments into social mapping but rather to include in our basis of experience the value judgments that are always already there, as constituent elements of both social reality and our maps of it. (Ulrich 1983, 243)

Ackoff had made an important distinction between purposive and purposeful systems. Organs such as the human heart are purposive systems—the heart's main purpose is fixed: to regulate blood circulation. It will respond to external conditions such as exercise or sleep by adapting its goals: pumping more or less blood. In contrast, a purpose*ful* system "can change its goals under constant conditions; it selects ends as well as means and thus displays *will*. Human beings are the most familiar example of such systems." (Ackoff 1971, 666).[12] This distinction becomes especially relevant when we consider organizations and sociotechnical systems. After all, "power is the ability of an individual or a group to impose its purpose on others" (Galbraith 1975, 88). For example, an individual person is a purposeful system whose elements are purposive—the heart does not choose its purpose. In contrast, organizations are not only purposeful systems but their elements too are purposeful systems. This crucially distinguishes organizations from organisms (Ackoff 1971, 669). Despite its dry conceptual basis, Ackoff's deceptively simple distinction has serious ethical consequences: it becomes unethical to treat a purposeful system as if it was merely purposive—to treat it as if it was unable to select ends, to treat it as a means to preselected ends. That is why the algorithmic control of humans, such as the control of workers in places like Amazon warehouses, is so repulsive to many of us.

BOUNDARY JUDGMENTS AND REFERENCE SYSTEMS

It is the designers' responsibility "to secure the transparency of the boundary judgments" and "to trace their possible normative consequences" (Ulrich 1983, 227). In opposition to Simon's paradigm, Ulrich proposes a critical interpretation of the role of the systems concept. To develop meaningful questions about boundary judgments and reference systems, he lists typical examples of boundary judgments that locate a systems design effort in the space of intentions, reproduced here in abridged form:

1. What should be considered as a *problem?* That is, what or who ought to belong to the section of social reality that is to be studied?
2. What *purpose* should the study serve? That is, who ought to belong to the group of those who are to benefit from the project?
3. What ought to be the totality of conditions that define the client's *standard of success*?
4. What should be the *time horizon* with respect to the "relevant" conditions in the future? For instance, should the *future generations* be included within the problem-relevant client system? Is intergenerational transfer of costs or risks acceptable? Are irreversible consequences acceptable?
5. What should be the *time horizon* with respect to the "relevant" conditions in the *past*? (Should the past generations—e.g., their goals and dreams, the traditions we inherited from them—belong to the problem-relevant system?)
6. Who might be *affected* by the project (by a change in the social system in question) although he does not belong . . . to those who are involved and benefit from the planning effort? Under what conditions can we assume it is legitimate that some people are affected although they cannot belong to the client system? How do we draw the boundary between the affected and the unaffected in the case of long-term risks such as radiation or cancer? (Who among the affected ought to be involved in the project?)
7. Who should *plan* and who ought to belong to the *decision-making body?* (Who ought to belong to the "experts" and "decision-makers"?). (Ulrich 1983, 228)

Each of these questions represents a boundary judgment. I hardly need to elaborate the striking relevance of these judgments to sustainability and justice. Some of these judgments directly map onto the central practices of systems design represented by requirements (see chapter 10). They are the departure points that motivate the development and justification of critical systems heuristics (CSH). The questioning of the explicit boundary judgments and their justifications can to some degree make the reference system visible. And it is here, at this frontier, that the selectivity inherent in all worldviews becomes visible.

CRITICAL SYSTEMS HEURISTICS

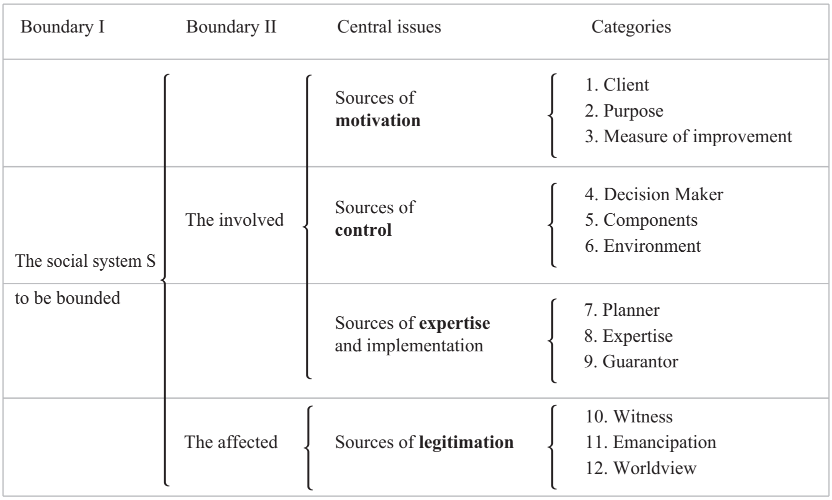
Based on the distinction between the involved and the affected, Ulrich distinguishes between three classes of involvement according to their sources of influence. The client represents *sources of motivation* (purposes, values, interests), the decision-maker represents *sources of control* (resources, authority), and the planner represents *sources of expertise* (knowledge, skills). The group of those affected but not involved is more difficult to delineate—its members qualify not by virtue of influencing the design, but by virtue of being affected. Because of the vast array of potential effects and their dispersion in time and space, this group can be simply too large. Ulrich covers the array of dispersion later addressed by Gardiner, including references to socio-ecological destruction, and emphasizes that the group includes "individuals to whom the planner cannot turn for hearing their concerns, be it because they are unborn, too young, or handicapped by other reasons." (Ulrich 1983, 252) The crucial question of legitimacy is how a design "discourse can be rational *even though not everyone affected can become involved."* (Ulrich 1983, 252). The key category is that of the *witness*:

> The essence of their role, it seems to me, is that of a *witness*: by virtue of their own affectedness, they can bear witness to the way in which all those who cannot voice their concerns may be affected—their feelings, their suffering, their moral and political consciousness, their ways of expressing dissent, their ways of *living* the social reality in question, their vision of their own future . . . the planner cannot adequately trace the normative content of alternative boundary judgments . . . without referring to *some* actors playing the role of a witness.

The four categories (motivation, control, expertise, and legitimation) are crossed with three basic questions that ask for (1) the social roles of the involved and the affected, (2) role-specific concerns, and (3) key problems in determining the necessary boundary judgments. The resulting twelve heuristic categories, and the questions they translate into, are not a checklist but a starting point for continued investigation and reflection. After all, "a well understood systems approach begins and ends with the questions we ask, not with the answers we give" (Ulrich and Reynolds 2010, 290). The term *heuristics* remains crucial: this approach is not a universalist critical theory but a humble yet powerful and effective dialectic device. The risk of deception is central, so in using the categories, a constant vigilance and humility is important.

1. Sources of motivation unfold into the client, the purpose of planning (design), and the *measure of improvement*. There is never a perfect measure of improvement, but "some such measure is implied in every social design, and . . . the existence of such a measure is a heuristic necessity" (Ulrich 1983, 255). In other words, this category is the "value basis" of design (Ulrich 1993).
2. Sources of control unfold into the decision maker, the components under the control of the decision maker, and the *decision environment* that provides the conditions outside of the decision maker's control. They constitute the "basis of power" (Ulrich 1993).
3. Sources of expertise unfold into the planner (or designer), their expertise, and the *guarantor* of expertise. The guarantor term refers not to people but to the conditions that assure us that the expertise to be applied is valid and applicable. It is important because expertise can be deceptive: "How can the planner even know that the experts' skills, experience, or tools are not a source of deception?" The category compels the designers to examine the guarantors of expertise. That is the context of the chapter's epigraph: "no amount of expertise . . . is ever sufficient for the expert to justify all the judgments on which his recommendations depend. When the discussion turns to the basic boundary judgments on which his exercise of expertise depends, the expert is no less a layman than are the affected" (Ulrich 1983, 306). In other words, this category captures the "basis of knowledge" (Ulrich 1993).
4. Sources of legitimation unfold into the witness, their ability to emancipate themselves from the rationality of those involved, and the *worldview* underpinning the planning effort. The crux lies in the possibility of fundamentally conflicting worldviews—different visions and ideals of what life should be like. In Ulrich's words, "The essential point is that the affected must be given the chance of emancipating themselves from being treated merely as means for the purposes of others" (Ulrich 1983, 257).

Figure 5.3 summarizes the conceptual relationship between the two types of boundary judgments, the categories of being involved and affected, and the heuristic categories. The resulting matrix of categories is summarized in table 5.1. This set of categories should be instantiated with attention to the context of design, so the exact terminology and focus can



5.3 The basic categories of CSH (adapted from Ulrich 1983, 258).

Table 5.1 CSH categories adapted from Ulrich and Reynolds (2010), Reynolds (2007), Ulrich (1993)

Sources of influence	**Social Roles (Stakeholders)**	**Specific Concerns (Stakes)**	**Key Problems (Issues)**
Motivation (the value basis)	Beneficiary ("client")	Purpose	Measure of Improvement
Control (the power basis)	Decision Maker	Resources	Decision Environment
Knowledge	Expert	Expertise	Guarantor
Legitimation	Witness	Emancipation	Worldview

vary accordingly (McCord and Becker 2019; Duboc, McCord, et al. 2020; Ulrich and Reynolds 2010; Wing 2015; Ulrich 1998). For each category, the key question can be asked in two modalities: an empirical "what is the case" and an ideal "what ought to be the case." The system of categories can be used in at least three ways:

1. *Reflectively*, those involved in a design effort can use it to understand how their own worldview is positioned—how their knowledge is situated in the world.

2. *Critically*, in constructive engagement, a critical friend can help the designers understand the boundaries of their system of assumptions and how it invokes selectivity.
3. *Polemically*, those affected but not involved can expose the lack of legitimacy of undemocratic interventions in situations where the designers (those involved but not affected) are unwilling to engage. They can do this by dialectically demonstrating to others what some of the designers' assumptions are and, importantly, that the designers are unable or unwilling to admit or justify them.

Ulrich's work marks a milestone for CST. It has found a wide range of applications in planning and design, in the evaluation of sustainable development projects (Reynolds 2007; Ulrich and Reynolds 2010) and healthcare policies and, more recently, in understanding the politics of stakeholder involvement in systems design (Wing 2015; McCord and Becker 2019; Duboc, McCord, et al. 2020). This will be of closer interest in chapter 10.[13]

CRITICAL TECHNICAL PRACTICES IN CST

Because CST proponents sought a balance between reflective critique and real-world interventions, they developed systemic frameworks for participatory Action Research (Flood 2010) and management (Flood and Jackson 1991a; M. Jackson 2019) as well as community-oriented methodologies broadly situated in the domain of social work (Midgley 1997; 2000). What unites these approaches is that they emphasize a careful evaluation of partial perspectives as the crucial step that must be secured for technical approaches to be legitimated in their application. CST methodologies such as total systems intervention (Flood and Jackson 1991a), systemic intervention (Midgley 2000) or critical systems practice (M. Jackson 2019) do not reject rationalistic approaches altogether or substitute critical reflection for technical modeling, simulation, or prediction. They do not abandon technical work but instead consciously design processes by which technical approaches are evaluated for applicability and legitimacy, and then embed technical work *within* the critical and reflective frame of CST if and when it is appropriate. In a sense, CST researchers developed what Agre strived for in their respective disciplines. And these disciplines are much closer than they may appear: both operations research and artificial intelligence originated in the same place, time, conditions, theories, and even people as computer science.

CST practice addresses a wide range of situations and domains, from internal organizational questions in management (Flood and Jackson 1991b) to public healthcare (Midgley 2006), sustainable development (Reynolds 2007), or community planning (Midgley, Munlo, and Brown 1998). More recently, CST has been brought in dialogue with ecofeminism (Stephens 2013; Stephens, Taket, and Gagliano 2019). These CST approaches all share a three-fold commitment (Midgley 1996):

1. to *critical reflection*, as illustrated by critical systems heuristics and further developed into the theory and practice of boundary critique by Midgley (Midgley 2000; Midgley, Munlo, and Brown 1998);
2. to the *emancipation* of marginalized perspectives, for instance through attention to the mechanisms by which situated knowledges and the concerns of those affected are marginalized (Midgley 1992); and
3. to *methodological pluralism*, including heterogeneous understandings that Gregory describes as "discordant pluralism" (Gregory 1996a).

SHARED THEMES

We are finally ready to return to Feenberg's question: "Who is likely to first notice the limitations of the engineers' useful but narrow conception of reality?" (Feenberg 2014, 213). It appears that there *is*, indeed, someone ready to notice these limitations. There is a meta-discipline "able to predict the need to integrate multiple forms of disciplinary knowledge." Critical systems thinking emerged to do almost precisely what Feenberg calls for. It provides a dialectical rationality that begins with the recognition of positionality and partiality that feminist STS also calls for. In terms of Feenberg's perspective, with CST, one-dimensional rationality gets embedded in a multidimensional reasoning frame. Ulrich's reference system, and the way Midgley developed his ideas about first- and second-order boundary critique, essentially conceptualize in systemic terms *how knowledge claims are situated* and how they are mobilized in design. Ulrich's heuristics allow the demonstration that a given scientific or engineering method cannot justify its own assumptions, and that the legitimacy of experts does not rest on their knowledge alone. Only those affected can justify the normative implications of design.

The critical idea and the systemic idea need each other (see also Midgley 1996, 18; Flood 1990, 177). A perspective that is critical but not systemic will be ineffective or mistaken: either the boundaries of the argument remain vague and implicit (which severely limits the degree to which the inquiry can be critical), or they are subject to continual expansion. At the same time, perspectives that are systemic but not critical will be harmful and unethical. The critical turn in systems thinking illustrates how to extricate ourselves from instrumental thinking and create a critical technical practice. In the following, with no claims for comprehensiveness, I trace some commonalities and differences between the positions of CST and STS on issues that are central to the myths of systems design, before suggesting preliminary conclusions.

Today, feminist data scientists and their allies find themselves in a dilemma similar to the critical systems thinkers: They don't want to abandon data science, because it can be useful; and while categories are problematic and loaded, data must be categorized to be usable data. They need to find ways to work with categorization while constantly challenging it, just like the critical systems thinkers needed to find ways to think systemically while grappling with the inevitable selectivity of their claims. Just as data feminism is not ready to abandon the nutritious grounds of data science with all its powerful tools, CST decided not to abandon the powerful tools of systems thinking but relocate them onto a ground on which they can be put to ethical use. The tension between critical and generative perspectives identified by Bardzell (2010) in the context of feminist HCI can be resolved by critically systemic thought, because it allows a critical approach to become generative, and a generative approach to become critical.

Sandra Harding critiques science in ways strikingly parallel to CST, rejects value-neutrality just as CST did, and addresses the importance of purpose (1986, 46). Ackoff's distinction between the purposive and the purposeful adds an additional lever to the argument. Critical systems heuristics, with its focus on selectivity, may be able to complement rationalistic computational reasoning very effectively, helping those involved in computing practice to pursue Harding's call to "critically and systematically . . . interrogate their advantaged social situation and the effect of such advantages on their beliefs" (Harding 1992). The nature of CSH helps it in building the necessary rapport that a critical friend needs to be heard by those schooled in rationalist thought (see chapter 10).

The design justice framework as discussed by Costanza-Chock (2020) starts from a Venn diagram with striking similarities to Ulrich's. It splits those affected into *those who benefit* and *those who are harmed*. There are often overlaps—for example, most users of social media are arguably in both groups—but it leads to similar consequences. In a move with parallels to Midgley's approach to systemic intervention, design justice emphasizes the importance of shifting participation in design to empower those affected and ideally involve all those who are affected. Ulrich and Gardiner remind us that in sustainability and justice, this ideal will always remain unfulfilled. CSH therefore raises the complementary question: How can those who are involved but not affected minimize and reflect on the inevitable omission of some who are affected, and how can they develop an approach to design that is legitimate even though not everyone affected can participate fully?

This is not to say CST has all the answers. Its focus lies on discursive claims, boundary judgments, methodological questions, and legitimate justification. Intersectional feminist thought in STS offers substantive, empirical, and material attention to the matrix of domination and nuanced studies of gender, race, class, ability, and other dimensions. This attention is not sufficiently developed in CST. "Data feminism insists that the most complete knowledge comes from synthesizing multiple perspectives, with priority given to local, Indigenous, and experiential ways of knowing" (D'Ignazio and Klein 2020, 18).

CST has explicitly referenced the work of feminists and STS researchers. So, is CST feminist? When Churchman speaks of seeing the world through the eyes of another and emphasizes the partial nature of all perspectives, he prefigures themes that emerge later in Harding and Haraway. When Midgley writes about boundary critique, he addresses the positionality of situated knowledges. And Ackoff writes about the role of values in objectivity in ways similar to Harding:

> Objectivity is not the absence of value judgments in purposeful behavior . . . because such behavior cannot be value free. Rather, objectivity is the social product of an open interaction of a wide variety of individual subjective judgments.

> There is no concept as value-loaded as objectivity, and no activity more value-full than science. Objectivity is obtained only when all possible values have been taken into account, not when none have been. (Ackoff 1977)

In some sense, CST is perhaps feminist in process and sometimes in form but rarely in content. The attention of CST writers is still guided by categories that are gendered and racialized and that are not always appreciated or recognized as such. CST has also not addressed decolonial thought at any length, even though the "discordant pluralism" (Gregory 1996a) of CST is ready for the pluriverse that Escobar (2018) argues for—ready for "a world in which many worlds fit." And CST and feminist STS certainly agree that the myths of systems design are just that, myths.

These complementary arguments suggest that there is a fertile ground to explore in their interactions. Feminist STS has been vibrant and active over the past decades. Its attention to structural power relations and inequity provides rich accounts of the larger social forces shaping technology that add much to CST. On the other hand, CST offers a way to systemically interrogate how knowledge claims are situated and mobilized in design, and how different types of knowledges are elevated into a "sacred" or demoted to a "profane" status (Midgley 1992). As a result, critically systemic approaches to participation in design offer rigorous conceptual frameworks that could afford additional depth to design justice. Second, there are more subtle epistemological, historical, strategic, practical, and pedagogical lessons to be learned from the critical turn in systems thinking and its direct confrontation of the mode of reasoning that underpins computing.

CONCLUSIONS: AT LAST, A CRITICAL TURN IN COMPUTING?

From design justice and data feminism to algorithmic justice, refusal and resistance, there is no doubt that critically oriented computing research is surging.[14] In their practice, these scholars, activists, and tech workers draw heavily on the conversations discussed above. Large-scale algorithmic harms have placed these concerns finally at a more visible space on the table of public attention. "It Is Time for More Critical CS Education" as well, as Amy Ko and her students write (Ko et al. 2020). Their argument speaks to the need to reorient the perspectives in computing, and computer science education is a central vector for this necessary social change. I concur and agree that education is a central vehicle by which these social changes should be enacted. But as a leverage point for social change, education is foundational, slow, backloaded, and resistant. While change is being introduced, prior commitments and rationalistic worldviews continue to percolate through research and practice. A critical turn in computing is important for education, but it has already begun in tech workers' collective organizing practices, in public protest about harmful technologies such as racist algorithms, in researchers' turn to intersectional approaches to algorithmic justice and fairness, and in research on sustainability and justice. More and more, these approaches do not stop at critiquing from outside, but engage in constructive generative work from inside. That is the critical turn that is already happening. It is time to recognize and amplify it. Systems design for the twenty-first century finally needs to overcome the limitations of the rationalistic worldview that computer science has grown up in. Computing's critical friends are ready to help with the dialogue of restructuring. Their arguments suggest concrete ways to rethink and reshape the narrative of systems design in computing. The following chapters will explore how.

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