On Beyond Wicked

Exploring the Uses of "Wicked Problems"

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ABSTRACT

In 1973, Horst Rittel and Melvin M. Webber added "wicked problems" to the lexicon of planning and policy-making [19]. Wicked problems are problems that can't be solved through formally or through strictly "rational" means. The term is gaining popularity and is now being invoked for all manners of issues that are not easily bounded by specific, limited perspectives, disciplines, or norms. This paper explores ways in which the concept of "wicked problems" could be useful in the development of transitional systems and other approaches for ecological-social challenges. This paper looks at a variety of questions surrounding its standing as a concept and its implications for use including: How valid is the term? Does the term help shed light on significant issues facing us today? What does its characterization imply? Does it herald a new era of cooperative and effective inquiry and action or does it signify confusion, chaos, and incoherence?

The concept of a wicked problem is best seen as a broad descriptor for a broad cluster of problems that share a family resemblance [28]. It is definitely not intended to suggest that these problems are hopeless or that there is nothing to be done about them. On the contrary, the originators of the term devised it to convey the idea that a restricted concept of "problem" was not helpful and that new ways of looking at problems were needed. Indeed, the people who are now using the term are using the concept to help understand and convey the nature of what they are doing: attempting to better understand the complexity of the problems they are working on in order to devise smarter and more dynamic interventions.

In addition to looking at the validity of the term itself, the paper focuses on characteristics of wicked problems which leads to a focus on characteristics of approaches that would be needed to help alleviate the effects of the wicked problems. I argue that regardless of the shortcomings or limitations that the concept have, it is currently serving several critical functions that other terms did not serve but are central to our collective challenges for the future. These functions are discussed throughout the paper but can be roughly summarized as follows: The expression wicked problems, through its current widespread use that transcends disciplinary and institutional boundaries, helps us understand the nature of our serious and persistent problems more thoroughly and realistically and encourages the development of new experimentation and collaboration approaches that will be necessary for us to make these problems less malign. Finally, when viewed as a whole, they help suggest what I'm calling "abstractions for action" that are particularly relevant as we focus more on wicked problems including: (1) civic intelligence; (2) loose coordination; (3) middle-range theories; (4) social (and other) mechanisms; and (5) patterns and pattern languages.

Reference Format:
Douglas Schuler. 2021. On Beyond Wicked: Exploring the Uses of "Wicked Problems". In *LIMITS '21: Workshop on Computing within Limits, June 14–15, 2021.*

1 INTRODUCTION TO WICKED PROBLEMS

Every day I receive an alert via Google Scholar that includes links to publications that mention "wicked problems." I am not maintaining a running account but I usually get between 5–15 per day. The use of the term appears to be growing, however. According to Google NGRAM (which is subject to all kinds of errors and misinterpretations, see e.g. [17]), references to "wicked problems" in books jumped about 25 times since 1980. And according to Google Scholar, over 3,000 works mentioned thus far in 2021 and over 17,000 for 2020. Even more significant, to my mind, is the diversity of the topics to which the wicked problem concept is being applied: education, climate change, public health, policing, ethnic violence, sports, financial policy, gaming, terrorism, food policy, and biodiversity to name just a few.

Before Horst Rittel and Melvin M. Webber [19] introduced the concept of "wicked problems" to the lexicon of planning and policy-making, the expression was basically unknown. And in recent years the term has now thoroughly jumped and otherwise snuck past the initial (and subsequent) disciplinary fences and is now being invoked for all manners of issues that are not easily penned in by perspective, discipline, or norms.

Wicked problems are not "solvable" as a mathematical equation or leaky roof might be. They are not mathematically or logically formalizable. Wicked problems are complex and dynamic, and addressing them will take different forms in different contexts, depending on a dynamic set of stakeholders and their values, goals, tactics, and resources, and will employ a mixture of perspectives, methods, and mechanisms. The results of attempted interventions in wicked problems are not always anticipated; unexpected consequences are likely. Generally, the goals of addressing wicked problems are unclear, unknown, and conflicting [27]. These attributes signal a variety of changes in the way we address problems as we change

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our perception from problems that are solvable that will be addressed by experts to ones that require "more effectiveness, more accountability, and more democracy" [27].

Because these characteristics describe many of the problems of interest to the LIMITS community it is useful to consider the potential promise and pitfalls of using the "wicked problem" concept in our research and action. Does the expanding use of this new term herald a new era of cooperative and effective inquiry and action or does it signify confusion, chaos, and incoherence? Can the embrace of an unruly concept be used, paradoxically enough, to help tame our unruly problems? Or does it just land us further out in the soup? Characterizing problems in a certain way only is useful if it helps point out useful paths towards addressing them. Does wicked problems do that sufficiently?

1.1 Why Now?

Why are "wicked problems" popular today? Having an available word and a credible list of characteristics seems to help bring to light some important perspectives that we can use to help face future challenges. Many of the actions that people have taken in the face of seemingly unsurmountable problems were being taken before the expression was coined and that at some level, perhaps without suitable shared nomenclature, the difficulties (or even the impossibility) related to "solving" these issues was known or understood by many people. It seems likely the case that reality is now catching up with theory (and dominant paradigms) and perhaps the idea that the divide and conquer strategy is losing its hold as the only viable approach. People whose job it is (formally or less formally) to address challenges that we face collectively seem to be realizing that their disciplinary or institutional perspective, while still valuable and productive in many cases, is not the sole owner or arbiter of the problem / solution space and are becoming increasingly more willing to accept or embrace the necessity of productive actionable knowledge on equal footing with theory.

It also is becoming increasingly clearer that the very real possibility of large global catastrophes overtaking us if we don't make major changes in our collective behavior. Taking a sober, objective eye on the problem (perhaps viewing from an armchair or another planet) it is clear that we collectively are not making sufficient progress with climate change, biodiversity, oppression and inequality, environmental stewardship, etc and continuing along our current trajectories is, to put it mildly, unwise. Urgency may very well be the most important factor in the new realignment.

2 ISSUES WITH ORIGINAL FORMULATION

The original formulation of wicked problems contains a list of ten characteristics. Many of the characteristics demonstrate why wicked problems are immune to strictly "rational" analyses: i.e. none of the constituent elements (the problem, the solution, the goals, methods, or resources needed) can be formulated definitively. Like other original formulations especially one delineated so simply, the formulation has been criticized by many people. Some critics seem to be basically adjusting the characteristics while others seem to be opposed to the entire concept including all of the ten characteristics. To my mind, the original paper captures some very important ideas. It also proposes a term that is more-or-less adequate at a general level for describing the nature of problems before us—which, significantly are not outliers in the problem universe—that also resonates across the wide swath of people, disciplines, institutions, and perspectives that welcome such a term to help them think about problems. At the same time I believe that the formulation could be improved. The list is incomplete and somewhat misleading— and at the same time it is fetishized by some and becomes dogmatic and doctrinaire which unfortunately helps impair our ability to deal with wicked problems. Below I discuss two of the characteristics that I feel are misleading.

Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial and error, every attempt counts significantly. First it should be pointed out that they use the word "solution" (as I sometimes do) when, by definition, wicked problems do not have "solutions" (at least in the standard sense). But, semantic nitpicking notwithstanding, addressing wicked problems (as they are viewed today) should not be seen as "one shot operations" but as problems in which incremental progress should be considered and as opportunities for learning. For example, in Washington State, a Citizens Assembly on Climate [7] has just completed its initial mission: eighty Washingtonians participated in a six-week long informed deliberative process to develop climate initiatives which they would publicly present and submit to the Washington State Legislature. That project can easily be seen as a way to (or at least try to) (1) influence climate policy; (2) conduct public education; (3) uncover or develop new approaches to, or models of, democratic decision-making; (4) encourage activism or more engaged citizens; etc. But even if this case had been a failure, there would still be lessons to learn. Even with "solutions" like building bridges or subway lines, there are things that could be done before the project commences as well as lessons to be learned after subsequent success or failure regardless of the "one-shotness" of the specific instance. On the other hand, Rittel and Webber point out that incrementalism is not the answer either [19]. They are not letting us off that easily. For example, "If, however, the problem is attacked on too low a level (an increment), then success of resolution may result in making things worse, because it may become more difficult to deal with the higher problems. Marginal improvement does not guarantee overall improvement." Neither, of course, does its opposite: It is obviously not just a "simple" matter of having everybody work on every aspect of the problems at the same time and assuming that everything will work out. On the other hand, we do know that significant positive social change sometimes takes place very quickly: somehow the right conditions existed even if this was not appreciated at the time.

Every wicked problem is essentially unique. While Rittel and Webber qualify this a bit but saying "essentially unique" which means that even if two problems are similar in many ways "there always might be an additional distinguishing property that is of overriding importance," we are left with the rather hopeless feeling that there nothing to be done except to start over every time after realizing that we know nothing. The problem is here is that if "Every wicked problem is essentially unique" then, no matter which direction we take, we end up with findings that are irrelevant to other wicked problems that seem to share important similarities. If we consider world poverty as a single wicked problem then it is more likely

to be "essentially unique." If, however, we think about poverty in Seattle or poverty in Cleveland there are undoubtedly significant contextual differences. But talking about contextual differences is quite a bit different than talking about being essentially unique. The proviso against expecting something that worked in Seattle to work equally well, without modification in Cleveland is important. But, at the same time, expecting the two situations to be non-identical to the degree that there is nothing to be learned from the experiences in one place or the other is absurd. And lucky for us that that approach is absurd. If it was not we would never learn from experience; we would be perennially reinventing everything. Finally, regardless of what Rittel and Webber meant at the time they wrote that statement, they have left the impression with some people that the converse is true: If a problem is not essentially unique, it is not a wicked problem.

2.1 On Beyond Wicked

The limits to our knowledge and the limits to our actions are both tested when wrestling with wicked problems. But wicked problems as they are stated still do not sufficiently acknowledge the severity of the challenges we face. For that reason, the term "super wicked" has now been introduced to describe situations which are becoming increasingly urgent, nobody "owns" the problem, the negative implications are inadequately appreciated, and the same stakeholders contribute to both the problem and solution [12].

But things can always get worse. I would like to propose two additional levels which seem to be unstated or understated in the above characterizations. Unfortunately they do not appear to be rare. Super wicked problems become *ultra super wicked problems* when there is active well-resourced opposition, both intellectual and material, to addressing the problems (as we see with climate change denial), and the failure to address the problems is lethal on a grand scale. (And what if the people responsible for addressing the problem are not only not addressing the problem but are actively exacerbating it. Jair Bolsonaro, the president of Brazil, for example, besides being an opponent of native people, is encouraging the destruction of the Brazilian rain forest, the "lungs" of our planet [6].)

Finally, ultra super wicked problems become *hyper, ultra super wicked problems* when multiple ultra super wicked problems are occurring at the same time simultaneously and in more places and with unknown, presumably negative tipping points and accelerating feedback loops. For example, global land subsidence (e.g. [9]), agricultural soil loss [25], and global biodiversity erosion [5] are all wicked problems that have impact on each other. Helbing [8] depicts these dramatically with his work on networked, interconnected risks. (Also to be fair, this is at least alluded to with one of Rittel and Webber's ten characteristics: "Every wicked problem can be considered to be a symptom of another problem." [19])

3 POTENTIALS AND PITFALLS OF USING THE CONCEPT

At this point the *de facto* "meaning" of wicked problems is being (socially) constructed by researchers and practitioners and the *de jure* meaning, although important, is less relevant. (Rittel and Webber ended their landmark paper with this sentence: "We are inclined to think that these theoretic dilemmas may be the most wicked conditions that confront us." [19]) In any case, thinking about potential advantages and disadvantages of using the concept remains useful.

The following is not a comprehensive review of how people are currently using wicked problems as a concept, how they will use it in the future, and what critics of the concept have to say about that. In general, however, it goes without saying that any discussion of the potential should focus on benefits derived from its use to all its stakeholder communities (intellectual, scientific, policy-making, activist, citizens, etc.) as time goes on while discussion of pitfalls should focus on any harms it may cause and, if possible, how to avoid or mitigate them.

3.1 The Potential

First and foremost, the wicked problem concept helps alert us to some of the realities of the world, as unwelcome as they may be. The world is full of problems that will never be completely "solved," but, if left unheeded, may ultimately punish the whole of life on earth. This function as a wake-up call may turn out to be invaluable. The very act of labeling something as a "problem" (i.e. problematizing it) is a critical step in that it demands if not a "solution" at least a reduction in the damage it can wreak. And we see from the arenas in which the concept is being applied that these problems are ubiquitous; no one will be unaffected, directly or indirectly.

Characterizing problems as "wicked problems" tends to extend the conception of the problem in many directions. For one thing, demonstrating that a problem is a wicked problem entails describing the problem in a richer way. This means viewing a variety of causes and effects, indicators, etc. that exist at different scales and timeframes, are not entirely predictable, and are perpetrated and experienced by many actors in many different ways.

The concept helps diagnostically by providing a focus on what's going wrong and a license to expand the approaches used to address the problems. Looking through a wicked problem lens seems to inspire a variety of interesting multi-sectoral and mixed-method approaches. Presumably many, if not most or all, of the approaches were already being used but perhaps not as often (and when they were they were often seen as less fundable, lesser status among researchers, than other approaches).

One upshot of the new popularity is that multifaceted approaches to addressing problems becomes more legitimate and more people will be encouraged to use them. As the perceptions of problems are pushed out to involve other stakeholders (since we know that, for example, policy-makers can not simply throw switches to solve problems by themselves), wicked problems can also serve as invitations, generally implicit, for other people to get on board. It helps signal and motivate possible collaborations.

Opening the discussion on a given wicked problem may expose constraints and habits of people operating under one set of norms, constraints, and assumptions that can block progress. Using the concept could possibly also help highlight disciplinary truisms that turn out not be true, or to be only true under certain controlled circumstances. Remember the presumptions that policy-makers would necessarily listen to the scientific community, or, even, that human beings were rational, or that capitalism paved the way towards democracy? Or, on the other hand(s), concepts from diverse

communities who have very little direct interchange or intermingling canons, could receive more attention as they are applied in more diverse fields. Perhaps the onslaught of fake news, Qanon, dangerous Covid-19 "advice" and elements of an "infodemic" has more in common with health pandemics than one might expect. Certainly the two influence each other: "... the virus [COVID-19] emerged in an information ecosystem that helps misinformation and lies spread faster than scientific evidence, weakening our ability to respond to new threats" [11].

Working on "wicked problems" seems to be increasingly seen as a legitimate focus for researchers, academics, policy-makers, and advocacy, activist, and citizen groups. This focus may also have the interesting side-effect of diminishing the searching for and endorsing for a single, "rational", solution and, indeed, a "solution" at all. This change of perspective invokes the prospect of failure as a good thing since it "could promote a more positive attitude towards the inevitability of failure and the opportunity it provides to support learning and inspire resilience" [13].

There is always something interesting in my daily briefing (via Google Alerts) on "wicked problems." While it is possible, even likely, that the wide variety of papers bear some strong resemblance to each other it seems productive at this point to mark what the differences are, particularly those that are looking at the "same" problem. But at least some of what is interesting may be found in the sum of the parts. Through that accumulating and evolving corpus of articles we can begin to at least obtain knowledge of what areas of inquiry and design scholars believe deserve this designation. It is that set of studies that can begin to inform us into what areas are being looked at and with what tools. The articles represent a steady stream of briefings from observers around the world. And by virtue of drawing upon a variety of perspectives and techniques each of these papers evinces a map or network of ideas and perspectives that draws a map of possible collaborators.

3.2 The Pitfalls

The possible problems with using the wicked problem concept are related to how it might affect the way that problems are thought about and about how they are acted upon — and by whom? The implications that we discuss here hinge on what the various stakeholder groups actually do with the concept and these uses will depend on a variety of factors which are not necessarily predictable. As a not particularly outlandish hypothetical, it is not inconceivable to imagine rightwing populists decrying the concept because of the word "wicked" and government agencies could be banned from even using the word.

3.2.1 Theory. Could the use of the concept limit or otherwise denigrate other approaches from being further developed? Could it cut off more fruitful ways of thinking? Scholars in the public policy field (for example [26]) have pointed out that dividing problems into two categories, *tame* and *wicked*, is itself problematic since the distinction is so broad that it says very little. I would also add that the dividing line between the two is not always clear, making the characterization even more open to interpretation, which may turn out to be a feature, not a bug. The choice seems to have been made to use the concept for the broad concept that it is. Other complementary perspectives, concepts, and theories that are currently in use (and will be developed in the future) that provide more in-depth analytical support can and should still be used. In other words, employing "wicked problems" as a concept does not preclude using other concepts as well. It also appears that researchers and others who are focusing on "wicked" may be tacitly ignoring ostensibly "tame" problems. This, to me, suggests that the majority of our problems are not tame and certainly those are the ones we can afford to worry less about.

Critics have said that the term has been stretched too far or that "equivalent definitions" for wicked problems including Ill-structured, unstructured, ill-defined, ambiguous, contested, messy, fuzzy, and complex already exist [26]. While none of the competitors may overtake "wicked problems" as the preferred concept, reviewing those "equivalent definitions" would likely yield insight for continuing wicked problem work. Moreover, "Critics have commented that the wicked problem idea is too totalizing, unhelpfully resisting analysis and promoting an impossible idea of 'success' [26]. Interestingly, the idea of "success" is highlighted as a feature of policy-making, which on the face of it, seems quite reasonable. But what does it mean? Turnbull and Hoppe [26] state that for policy-makers have "far less autonomy in crafting questions and answers" and they cite [3] who says that "a problem definition ought to be seen as a realistic opportunity to improve a current problematic situation, according to the standards or feelings of a majority of active and passive stakeholders." In other words, policy-makers are hired to bring about "success" and they need to define their problems in such a way that they can do something about it, This seems reasonable at first glance and accountability is important but it implicitly suggests that untamable problems get ignored. And must policy-makers and planners guarantee success in exchange for their employment? And if they refrain from promising success who would hire them?

Critics have also suggested that the adoption of wicked problems means a "retreat from science" and abandoning various useful analytic approaches. I would argue that the conceptualization of wicked problems does not signal a "retreat from science" although it does suggest a "retreat" from addressing problems solely from a "scientific" approach. While a belief in science-based, "non-political" solution may be justified at some points in historic and future location and time, it seems positively naive in the era of science denial, authoritarianism, and industrial strength conspiracy mongering.

All of this is to say that looking at messy, unstructured, etc. problems as wicked does indeed open up the concept in many ways to public and interdisciplinary use and scrutiny. It in no way should denigrate or disregard the role of the professional. But it aims to not artificially bottle up the problems we face via departmental or disciplinary or professional balkanization.

3.2.2 Practice. Could the use of the wicked problem concept limit or otherwise prevent other more effective practices from being explored? A group that adopted a severe wicked problem perspective could decide to ignore all of the findings of those that came before. Or, in the future, due to the allure of the concept, an insurgent group that claimed to know all about wicked problems could successfully secure all the funding, thus abandoning the ones who are toiling within the vineyards of traditional perspectives. Or might it be possible, on the other hand, that using the term actually encourage

people to engage in harmful practices? As with other words, terms, and concepts in the "real world" people *do things* with them. The concept of wicked problems is obviously not immune.

One possible problem could arise if people were to take the concept too literally by believing that because wicked problems are so thorny, so resistant to humankind's attempts, that it is simply folly to try to address them. This point of view has been invoked recently to justify Trump's hands off approach to the pandemic (What could he do anyway?!) or not addressing climate change (humans cannot do anything to alter the climate). Wicked problems could actually scare people off because of its inherently limiting features? Too daunting to even try? Would the crushing weight of a world full of wicked problems bring in exhaustion and despair? People could also take the idea that wicked problems are not completely solvable via analysis or science and that, therefore, anything goes and any old theory is as valid as anything else, even findings established by scientific consensus.

But, even if the best practices are followed and people enter in good faith (not always a reliable assumption), satisfactory public problem solving is not guaranteed. Could these practices sometimes lead to less desirable outcomes than those derived using other approaches? Probably. Or take longer to reach desirable ones? Almost certainly. It could open up longer (and more contentious) dialogues resulting in no progress or bring the wrong people into the conversation. Wicked problem scholars [27] point out that the approaches to wicked problems will require "more effectiveness, more accountability, and more democracy" and this combination is not always achievable.

3.3 Summary

Not thinking about certain problems as wicked problems is a greater risk than thinking about certain problems as wicked problems. And considering the idea of wicked problems is potentially invaluable. Unfortunately, the major problems of the world may be as immune to one approach as the other. My (modest) suggestion to the critics of the wicked problem concept is to help people allow people to use the designation but "inform their discretion" as necessary.

While it also seems true that some "wicked problems" (or at least aspects of them) can be addressed in the standard, normative, trust the government, style, this approach is often unwarranted. The conceptualization of wicked problems seems to be necessary (to my mind at least) but (and here I agree with critics), it is not sufficient. Characterizing problems as "wicked" does not directly determine how they ought to be addressed although it does reveal some critical implications that shed light on which directions we need to head in.

4 IMPLICATIONS

The relatively newish arrival of the concept of wicked problems (in all its guises), by itself, is no panacea. One of the critical lessons to learn from looking at the characteristics of wicked problems is what types of things are necessary for addressing them. Although the concept of wicked problems by itself is primarily descriptive, rather than diagnostic or prescriptive, it contains critical implications. The focus of this section is to identify implications of the concept and actions that are needed that include both research and action motivated by the desire to address wicked problems. Acknowledging the importance of identifying what were up against (whether we use the term wicked problems or not) is a critical step, as is acknowledging the ubiquity of problems that could be deemed wicked. I also argue that while the idea of a wicked problem is critical — and daunting / frightening enough already — it doesn't actually reflect the severity and urgency of the problems facing us.

4.1 New Consciousness

The hardest pill to swallow may be that our core beliefs, often unacknowledged, are not as rock solid as we thought they were. Rittel and Webber [19] made this bold point quite directly:

> A deep-running current of optimism in American thought seems to have been propelling these diverse searches for direction-finding instruments. But at the same time, the Americans' traditional faith in a guaranteed Progress is being eroded by the same waves that are wearing down old beliefs in the social order's inherent goodness and in history's intrinsic benevolence. Candide is dead. His place is being occupied by a new conception of future history that, rejecting historicism, is searching for ways of exploiting the intellectual and inventive capabilities of men. (p. 157)

The reference to "men" notwithstanding, the acknowledgement of wicked problems brings with it a strong (though often tacit) message that neither gods, bureaucrats, authoritarian rulers, the market ("free" or otherwise), the inevitability of progress, faith, luck, or accident will prevail to rescue us from ourselves at the 11th hour and that people, you and me, will need to step up and be a part of the process if we are to make any progress.

The ubiquity of wicked problems, of ancient and contemporary origins, casts the rational, unseen academic view that things will work out in doubt. It also casts a shadow on the idea that scholars toiling in their own particular vineyards will necessarily inform the work performed by others in time for it to be acted upon. And it also casts doubt on the very idea of a "solution." Wouldn't it be nice if all "problems" had solutions? Or, if we define problems in such a way that problems that defy solutions are not exactly "problems" but something else. And that that type of non-problem inconveniently does not have a name and, so, as Giovanni Sartori stated, "what is not named remains unnoticed or, in any event, impervious to cognitive development" and we will never know what hit us. (Conversely the idea of a "solution" suffers from the same problem. It is linguistically inconvenient to use phrases such as "making progress on a problem" every time you're talking about methods or actions that are intended to help "solve" problems when you know in your heart (and head) that there is no "solution.")

At the same time, our disdain for solutionism should not lead us to reject positive, plausible, and test-worthy proposals that come our way. And we also do not to avoid something just because it is distressing or can not be described formally. The new consciousness not only includes the idea that many cherished assumptions are unwarranted but also that we are a very creative species and sometimes, even, capable of rising to the occasion.

4.2 Polycentricity

This implication and the following one are the most relevant ones for developing transition computing systems. No one person, agency, or institution has the sole responsibility for addressing wicked problems. Nor does one person, agency, or institution have the ability to address any entire wicked problem, such as climate change. There is no central omniscient control. An academic or cultural critic might chose to address how we might change our way of thinking, but not how we measure emissions. A government official might work with other governments to agree on targets for emissions, but not on how to motivate people in business or communities to think about their sphere more holistically. And the educational effort to support these efforts must be vast and diverse. And the people creating the systems to help support this work must be heterogenous and distributed around the world. And the computer systems they create must also reflect and support the burgeoning need for collaboration and sharing.

Polycentricity [16], in which there are many centers of knowledge, engagement, environmental abuse, economic control, etc. has always been the norm but the complex, deeply interconnected, and volatile situation today is unprecedented. While the nature that the polycentric socio-technological complexes that we need assumes is not known in advance, it is fair to say that we know they are both necessity and unavoidable. Coming to terms with this and trying to support the requisite networks of people and institutions is critical. In our exploration of what to do in the face of ubiquitous wicked problems the burgeoning corpus of writings on wicked problems may help us think about our strengths and weaknesses of the myriad approaches. For example many of the ways of helping to address wicked problem issues is through citizen input. But which ways are more likely to be successful? Who refuses to participate and how do they register their disapproval?

Looking at networks of how the problems are propagated or detoured is likely to help us develop focal areas that, while not changing the status of a problem from wicked to tame, can nevertheless help make a problem less wicked and viable action plans, although not immune from change, are more easily devised.

4.3 Institutionalization and Re-Institutionalization

Because our wicked problems are unfolding rapidly and our intellectual and material habits are so ingrained and ubiquitous we are in the position of needing to change the tires on a moving car – maybe the engine and transmission too. Wicked problems demand the involvement of more people including those who have been on the receiving end of humankind's perennial unthinking and unjust practices for whom participation is the most difficult to conceive. It also suggests the need for considering how best to support more support between communities, and how to engage and educate in a meaningful way an ever expanding diversity of people.

Computing systems that support both reinstitutionalization and polycentricity are crucial to any substantial addressing of wicked problems in the near-term. Unfortunately they are unlikely to be created by the computer industry as we know it [2]. While a whole new civic infrastructure, one that supports people in democratic problem-solving, seems unlikely to simply "emerge," we have no choice but to envision and build systems that perform at least some of these functions—including tackling wicked problem collaboratively. How then to proceed? Governments, educational institutions, foundations, and billionaires may help but they will need encouraging. In our 2020 LIMITS paper [24] we envisioned an open research and action community network of 2030 that was inclusive and diverse, that would be focused on wicked problems like climate change. One conclusion from that paper was that it would require a sufficiently large community (of communities) that worked together with varying degrees of direct and indirect coordination using a repertoire of patterns and pattern languages and tools.

4.4 Resistance is Inevitable and Will be Harsh

Sadly, resistance to addressing wicked problems is more likely than not. (Any list of current national leaders makes this point quite definitively.) Following Rittel and Webber's declaration that, "Candide is dead," *we do not live in the best of all possible worlds*. Having said that, however, does not mean that troglodytism is our destiny. While the nature of these problems means that we have to expand the work, it also could very mean expanded risks and resistance. Wicked problems, especially including the proposed amendments acknowledging increased wickedness, mean that there is "intelligent" (or at least wily) and well-resourced active civic ignorance out there as well as the uninformed, unthinking civic ignorance that is inert, if not benign. Resisting the resistance will be key. Grasping at "easy answers" often coming from leaders who seem to "know it all", fascism, science denial, and demonization of people are all powerful and compelling (to some) elements of civic ignorance. And, finally, much of the form that resisting resistance will take will be in avoiding it and changing the conditions that spawn and sustain it.

5 ABSTRACTIONS FOR ACTION

And while the debates will continue to rage over definitions, scope, ownership, and nomenclature, the fact remains that we need to be addressing challenges that many people deem to be wicked. Balancing consideration of the situation and acting in relation to the situation is one life-sustaining hallmark of intelligence. What types of additional approaches become more important with the realization of wicked problems? What abstractions, theories-in-the-small (if you will), are called for that may be useful in helping us think more effectively and equitably together?

To achieve any degree of success in addressing any type of problem, the approach taken should mimic or reflect to some degree the complex of entangled processes, resources, resultants, and mechanisms of the problem. In general terms the approach should help to avoid or temper the forces and actions that perpetuate the problem and it should help reduce or mitigate the negative effects of the action. For those reasons, the more we know about the characteristics of the problem the better our chances at designing and implementing suitable approaches.

The characteristics of "wicked problems" though interesting in their own right, are more valuable when they are used to consider current and possible future approaches to help address them. I

would argue that surfacing work on wicked problems and the variety of approaches will be useful in others. This period must be one of creative and informed experimentation and engagement.

Within a framework of global communication there is the very difficult problem of ensuring that the right people, groups, and institutional body are getting the information they need at the right time. The barriers to this are of course legion, but this is a core issue that must be addressed if we are to build adaptive and flexible approaches to addressing wicked problems. This may in practice mean getting slightly less useless information to almost the right people approximately when they might need it.

Building on what people are currently doing and through the implicit requirements of the wicked problems five main abstractions are briefly presented below, namely (1) civic intelligence (and ignorance); (2) loose coordination; (3) middle-range theories; (4) mechanisms; and (5) patterns and pattern languages. They are discussed separately (mostly) and individually they can help provide benefit, but to my mind, they can help work together as a unit. Each of these are further from "high theory" and closer to action. They are also capable of local customization based on contextual differences. In general they are also more accessible and are more likely to be used by broader groups of people, especially if an effort is made to make them less academic. Note that this is not patronizing or disparaging of people without academic training and background but simply acknowledging that different people have different points of reference and use different vocabularies.

5.1 Civic Intelligence

Civic intelligence is the capacity of individuals and groups to address shared problems equitably and effectively, and as such, it helps shape the actions that we take. Based on my experience teaching at The Evergreen State College and my research, civic intelligence exists at all levels, at least in latent form, and that individuals seem to resonate with the idea particularly in acknowledging that they are part of a greater nexus and that they are actually *capable* of meaningful participation.

Civic intelligence can be improved but it takes work and generally takes time. I hesitate to say that cultivating civic intelligence is a wicked problem but there is no specific one way that it can be cultivated through education, discussion, and meaningful action, nor, obviously, is there a "best way."

Civic intelligence can also be degraded and intuitively it seems easier to degrade it than to improve it. Lyndon Johnson noted that "any fool can burn a barn down." At any rate a society with low civic intelligence, that neglects the education of its citizens, believes, at least implicitly in predestination, demonizes science and learning, eschews public life and collective problem-solving, or believes that hatred and violence is warranted against others, will have a rougher time trying to cultivate or utilize its civic intelligence.

If the civic intelligence is low in a city, region, country, etc. one might think that it has nowhere to go but up. Unfortunately there seems to be no lowest possible depth and low civic intelligence seems to produce more of the same. But we can also be surprised. A flower can sprout in the middle of an alley. Sometimes there is a strong outpouring of civic intelligence that seems to come from nowhere sparked by an egregious action in Belarus, Myanmar, or Ferguson, Missouri or via slower steady oppression from voter suppression, inadequate educational opportunities or access to jobs, healthy food and water, and social services.

5.2 Loose Coordination

As we have seen embracing the idea of wicked problems, while necessary for any intellectual and material progress, greatly expands our conceptions of problems in general—mostly by increasing our appreciation of them. It also increases the number of people who need to be working on them and the number of tools that must be mastered. Loose, flexible, and timely coordination of people and knowledge becomes ever more critical. With an infinitude of possible connections, limits to our ability to do much on our own, the necessity of communication, and the unlikely prospects of optimum connections between people and between information they need, the need to identify and development of effective strategies for improving networked communication is acute.

"Loose coordination" is vital to any success given the extent of the problems we face and the people who will be needed to work on these. To address climate change, for example, governments will play vital roles in any progress that is made. But they will not make it on their own. At the very least they will need strong encouragement from scientists, activists, and other citizens to work effectively in this area. And it goes far beyond that: all sorts of people from regions near and far will need to "cooperate" with each other, but they will rarely communicate directly with the vast numbers of people who share their views and aspirations. There are just too many people for that. But they must still coordinate in some way (or many ways) if they are to contribute effectively. If, for example, it looks like one direction that many groups are heading in to reach some goal needs to be scaled back and efforts redeployed, how might that reorientation take place? The following list of ways that people "work together" without necessarily communicating directly suggests a wide range of loose coordination possibilities. Note that in many cases, such as shared aspirations or norms, these can be "shared" absolutely. In other cases, however, coordinating means not doing something that some other group or groups are already doing. In other words, "sharing" can mean adapting according to a more holistic view than simply participating in an existing plan.

Some "Shareables" for Coordinating and Supporting Mutual Work:

- shared themes or challenge (or problem) focus (not necessarily determined via specific grant programs);
- shared methodology, best practices, rubrics, patterns and pattern languages;
- shared aspirations, commitments, goals (prioritized or not), indicators, manifestos;
- shared norms, values, codes of ethics;
- shared taxonomy, data, vocabulary, dictionaries, models, formalisms, ontologies;
- shared intellectual, moral, ethical, reliable, creative spokespeople
- shared community or project members;
- shared projects, research or other task agendas;
- shared milestones (task beginnings and endings), schedules, and plans;

- shared awareness, vigilance and monitoring of topics and information sources;
- shared informational and communicative venues (structured and unstructured; virtual, in-person, and hybrid);
- shared tools, systems, APIs, online repositories, services, portals, test-beds; and
- shared knowledge of community needs, interests, skills, and roles

5.3 Middle-range Theories

Middle-range theory, developed by Robert Merton [14], is an approach to sociological theorizing that is intended to integrate theory and empirical research. It begins with observable phenomena and integrates that with theorizing that is less general and universal (sometimes known as "grand theory"). Hence a middle range theory can be applicable in one context and not in another. According to Kaidesoja [10] "The reason why the notion of middle-range theory continues to draw sociologists' attention seems to be that it promises to integrate different types of research activities, such as theoretical and empirical analysis, micro- and macro-analysis, and basic and applied research. In addition, middle-range theories are often said to create connections between different research fields." The focus on context, empirical evidence, and potential integration makes this approach applicable to understanding and addressing wicked problems. Kaidesoja [10] also argues even then, that "we should reject Merton's static and single-function definition and develop an account of middle-range theories that is consistently dynamic and does justice also to their other functions in sociological research, such as providing concepts for identifying and describing social phenomena to be explained, formulating explanatory questions about them, explaining these phenomena and consolidating theories developed in different research fields."

5.4 Social (and other) Mechanisms

The idea of social (and other, e.g. natural and technological) mechanisms and mechanism-based explanations of social phenomena are also efforts to see what is actually happening—and how it actually happens rather than trying to impose a theoretical approach from on high. Generally this means "explaining" an event by citing a previous event as the cause and provide or suggest the causal mechanism behind it." Kaidesoja also asserts that "causal mechanisms are neither intervening variables nor pieces of theories [10].

The use of mechanisms is used by diverse communities both formally (e.g. by researchers) and informally (e.g. by activists) and for various purposes. Ridley et al. [18] relied on mechanisms to demonstrate the causal links between poverty and depression and anxiety disorders, showing that lower income people are generally 1.5 to 3 more likely to suffer from those disorders. Lyons-White et al. [13] describes the use of mechanisms in tackling the wicked conservation problem of tropical deforestation and looking forward suggest that social mechanisms are also "intertwined with other mechanisms (and various contingent occurrences) whose concatenations generated the observed outcome."

Because context varies and our understanding of the situation changes these chains of social mechanisms also must be reconfigurable. For that reason Lyons-White et al. [13] propose a framework that "emphasizes the need for mechanism mixes to be perpetually reconfigured to sustain progress towards desired conservation outcomes." They believe that these abstractions can provide a versatile strategy at least in their field: "... armed with mechanism mixes and prepared to reconfigure them, conservation professionals can sustain progress towards elusive conservation goals in the long term" [13].

5.5 Patterns & Pattern Languages

Patterns and pattern languages were introduced by Christopher Alexander and his colleagues in their book, A Pattern Language, in which they introduced 253 "patterns" that could be used in the construction of towns, buildings, and other built spaces that were "alive and whole" [1]. Each of the patterns in the book "... describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over without ever using it the same way twice." A pattern language is a collection of patterns that form a unified whole that are used together to work within one design or problem area. In their book, they stated that the pattern language they present is one possible pattern language and, indeed, the work has motivated a large number of efforts including many pattern languages for tech projects and in more socially oriented projects around themes such as refugee resettlement [15] and communication for social change [20].

Patterns and pattern languages may be particularly suitable for addressing wicked problems. Rittel and Webber, for example, state that "There are no classes of wicked problems in the sense that principles of solution can be developed to fit all members of a class." Patterns and pattern languages help address this because the inherent abstraction of a pattern does not make that claim. Patterns are designed for incremental / adaptable use. They are repeatable, but malleable for particular circumstances. Patterns can be used for description, explanation, reflection, design, and action. Ideally they can be used to help communities evolve answers together in collaborative transition computing systems. Patterns also work well with other approaches; the metaphor and structure are flexible and not overly restrictive.

Patterns by their nature are general and are not the property of any particular discipline. They can be shared by multiple communities working on a wicked problem including those without credentials. The *Carbon Audit* pattern, for example, which has been proposed for a Green New Deal pattern language [22, 23] can be used in developing complex monitoring devices and it can be used by people conducting house-by-house surveys. By providing a common collaborative language or lingua franca [4] pattern languages can be used to help provide loose coordination.

In another potentially strong connection between the abstractions discussed in this section, the original patterns (from [1]) which were all presented using the same format included a graphic, "which shows the solution in the form of a diagram, with labels to indicate the main components." Although to my knowledge this approach has not been formalized across the pattern community—or even within the original book, a graphic treatment could be developed integrating the mechanisms approach and the pattern "forces" and, thus, also serve as an approach to loose coordination.

The problems that are acknowledged and the approaches that are being taken to ameliorate them in the growing and evolving wicked problem corpus that Google keeps feeding me is actually providing the rudiments of a pattern language for wicked problems in latent and inchoate form. Some of the patterns from the *Liberating Voices* pattern language, such as *Open Action* and *Research Network*, *Voices of the Unheard*, and *Power of Story* are appropriate for wicked problem work while others need to be formulated, such as *Dynamic Middle Range Theory* (suggested by [26]) and *Mechanism Mix* (suggested by [13]).

6 CONCLUSIONS

Wicked problems are everywhere and if the indicators are to be believed the wicked problems are getting the better of us. The increasing interest in wicked problems may be a good sign. Acknowledging wicked problems and developing the transition computing systems to support the collaboration is an immense challenge for the LIMITS community and all others interested in sustainability and just human systems. It is clearly not only a technical challenge, it is a wicked problem in its own right. (And one where active resistance should be expected.)

In an earlier paper for LIMITS [21] I discussed ways in which "limitations" can actually encourage and cultivate the type of empowerment that is needed in today's world. An important aspect of this is realizing which limits are actual limits and which ones are ones that either don't exist or that exist but can be transcended with human will and intelligence. Acknowledging limits does not mean surrender or denial of efficacy. I see it as more of a call to arms. (And a call for brains.) Acknowledging limits does not mean denial of imagination or creativity or innovation. It is more of a demand for more of it.

Scientists have found it necessary to be more politically engaged and more socially active in general. The main reasons are that at best their findings are being ignored, and at worst they are being actively attacked. Scientists—and tech workers too—are also citizens and have an obligation to work in that sphere as well.

Necessity is the mother of invention. The wicked problems are taunting us with indefatigable vigor and cunning. In theory we have the ability to turn the tide. We know that the limits to our collective collaborative ability extends far beyond where it is might appear to be now.

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