Making Virtual Teams Work:
Redesigning Virtual Collaboration for the Future

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Abstract

The COVID-19 pandemic has shifted how many teams work, from face-to-face interactions to remote and hybrid forms of collaboration. Even at its best, though, virtual collaboration remains less effective than face-to-face collaboration, leaving millions of workers with both the temporary and permanent challenges of virtual work. Design is uniquely positioned to not only alleviate these ails but even make virtual teams strategically advantageous by developing innovative solutions specifically for hybrid virtual collaboration. To aid in that process, this article summarizes the communication technologies, individual techniques, and leadership techniques that "work" for effective virtual collaboration. Then, we highlight several outstanding concerns and possibilities as an impetus for designers and researchers to develop solutions to the challenges of sustained remote and hybrid collaboration. In doing so, we seek to motivate designers and researchers to consider social practices as designed artifacts, and therefore constituents of solutions to social systemic problems.

keywords: team science, virtual collaboration, information and communication technologies, group performance, COVID-19, team virtuality, materiality, shared reality, remote work, work from home

1   Introduction

COVID-19 has altered the world of work for employees from all walks of life. Essential workers and systemically disadvantaged populations have certainly faced the greatest, most life-threatening challenges (Godoy and Wood, 2020; Rodriguez and Alltucker, 2020), though that does not exempt non-essential personnel from undergoing changes to workplace routines. Some companies implemented staggered returns, shifted schedules, and half-empty spaces (Thomas et al., 2020). Under the impression that virtual work improved their workforce productivity while benefiting their bottom line, other businesses transitioned their workforces to long-term virtual work (Kelly, 2020; Ozimek, 2020; Schrotenboer, 2020). A few even turned to home surveillance to ensure employees stayed on task (Harwell, 2020).

While changing where and how people work remain necessary to save lives, it should not surprise us that disrupting routines substantially degrades team performance. In normal times, virtual teams risk social isolation, lower performance, higher absenteeism, and higher turnover, many of which society continues to experience for the benefit of public health (Guyot and Sawhill, 2020). During the pandemic, add the intense anxiety employees face about changing responsibilities, layoffs (Nguyen, 2020), and the necessity of protesting racial injustice (Beras, 2020; Frenkel et al., 2020; Hailu, 2020). The reader is probably acutely aware of how the pandemic has affected your individual and work routines as well, be it time saved from not commuting or time invested in coordinating your children's at-home education. The American Federal Reserve Bank continues to echo concerns about workforce productivity during the recovery (Navaroli, 2020; Schneider, 2020a,b).

Public health experts predict that society will eventually mount sufficient response to the pandemic (Woodward, 2020). But as working conditions continue to evolve, odds are that for many, some form of virtual work is permanent (Berliner, 2020). This leaves each organization, team, and individual with a challenge: Whether only a few employees are in the office at once or the whole team stays home, how can teams collaborate effectively amidst constantly shifting conditions? Is it even possible to mitigate the risks of virtual teams amidst such novel conditions?

2 How Design Can Contribute

Few problems are more "wicked" (Rittel and Webber, 1973) than global pandemics and their myriad, interconnected repercussions. Designers from all walks of life have met the call for solutions to the public health crisis, with inexpensive ventilators and expressive masks alike (Shen-Berro, 2020; Somers, 2020). But design has never limited itself to physical artifacts or public health needs. Indeed, design research and practice have sought to improve social systems for decades (Rittel and Webber, 1984; Simon, 1996). Nagai advocates that designers can be "motivated to bring about valuable social innovation" for our "future society" (in Papalambros, 2015, p.26).

"Designs are plans for intervention" (in Papalambros, 2015, p.9), and yet all too many socially-oriented designs (a) disregard collective scientific knowledge; (b) neglect validation of lasting results for teams, which are themselves social systems within larger social systems (Scott and Davis, 2007); and (c) often create, perpetuate, and amplify systemic oppression even as they attempt to solve problems (Burleson, 2020). Vermaas (2016) argues that even when experts express such designs, "the expert status of designers does not provide sufficient justification for prescribing expert design practices to non-expert designers" (p.1) because non-expert contexts and capabilities differ from those of the expert. Before disseminating the designs of experts, their practices necessarily require "support by empirical testing," to validate their claims, as evidenced by how easily untested scientific contributions can go viral amid the public's efforts to make sense of uncertainty (Cor, 2020; Niller, 2020).

Such impetuses make it more important than ever to ground designs in science toward equitable societal benefit. Ample research exists on virtual collaboration, both in terms of the virtual technologies (Rice and Leonardi, 2014) and the organizational collaboration techniques (Thompson, 2016) or social artifacts that benefit work and workers. As noted above, however, noteworthy challenges abound at the intersection of technology and collaboration. The interdisciplinary approaches of design position the discipline well to develop solutions to social systemic problems, a collaboration long called for by management scholars (Contractor, 2009).

To that end, this piece proposes a foundation for a "designerly" approach to redesigning virtual collaboration for the future, during the pandemic and beyond. Here, we use "designerly" to refer to "an explicitly organized, rational, and wholly systematic approach to design" (Cross, 2001) often found in design science. This proposal remains a "foundation" in that thoroughly-validated science cannot account for every aspect of every unique context of designers – here, referring to any participant in a social organization – particularly amidst substantial societal uncertainty. Still, designers can creatively and systematically embody the collective knowledge of science toward furthering stakeholder values in their unique contexts, as we will demonstrate through a series of examples.

First, we summarize effective virtual technology implementations based on the research on Information and Communication Technologies. Then, we review effective virtual collaboration techniques, for individuals and leaders respectively, by drawing on the global teams, shared reality, and disaster organizing literatures. Finally, we identify several gaps necessary to bridge in order to transition from the current state of virtual work to a more optimal form of collaboration. By uniting these literatures in design, we hope to motivate research and practice toward systematically bettering virtual collaboration, and hence move society toward longer-term solutions to the shortcomings of virtual work and other social systemic problems.

3   Technology Implementations that Work

By their nature, information technologies generate sizable quantities of text, audio, video, and metadata, thereby lending themselves to topics of academic interest from healthcare to politics. Broadly, information technologies improve organizational performance (Melville et al., 2004; Ramirez et al., 2010). More specific to virtual work are Information and Communication Technologies (ICTs), which the literature similarly demonstrates can improve organizational performance (Li et al., 2003; Malhotra and Majchrzak, 2014). ICTs have significantly advanced in recent years, including the adoption of team chat, blogs, wikis, and more recently video calling, audio processing, computer vision, and natural language processing among many others.

However, one cannot simply add ICT and make a virtual team function identically to face-to-face teams. Virtual teams "operate differently and experience different outcomes than traditional teams" (Hinds and Bailey, 2003). Schaubroeck and Yu (2017) define the strengths and weaknesses of remote work in terms of *team virtuality*, which refers to "the extent and value of utilizing information and communication technologies within work teams" (p.636) where value refers to the richness of the informational content provided by ICTs such as via its synchronicity or asynchronicity. For example, integrating videoconferencing into team interactions yields lower team virtuality due to its communication synchronicity and relatively rich content, as compared to email which involves high communication asynchronicity and lower informational quality. Virtuality produces mixed results for team efficiency, performance, learning, adaptation, satisfaction, trust, and identity depending on team member skills, authority structure, and how long the team has been together (Chudoba et al., 2005; Lu et al., 2006; Schaubroeck and Yu, 2017). The continual evolution of teams through varying degrees of remote work yields different experiences for different teams at different times.

Yet, significant challenges remain for such technologies. At their best, ICTs are often ineffective at achieving their stated goals, as anyone who finds they spend too much time corresponding via email can attest. In other cases, poorly-designed technologies can make work more difficult. For example, many "smart tools" require substantial programming knowledge in addition to substantial User Interface and User Experience (UI/UX) designer contributions before they generate value. At their worst, ICTs create significant ethical concerns, particularly related to privacy (Watkins Allen et al., 2007; Smith et al., 2011).

Given the rapid growth and coincident challenges, how can we know what technologies "work"? In less vernacular terms, this question asks us to assess how use of specific technologies positively influence team outcomes.

Consider the term "technology use." Modern technology use research examines how teams accomplish outcomes with technology through understanding the interrelated contributions of the technical artifact and the social behaviors of people. This theoretical lens, known as *materiality*, asserts that while users of technologies exercise some discretion over how technologies affect their work, technologies both promote and constrain certain activities based on the properties of the designed artifact (Rice and Leonardi, 2014). Consequently, conversation about "technology use" integrates technical artifacts, social users, and their interactions therein. For better or worse, what qualifies as "good" or positive outcomes depends wholly on the specific context under scrutiny (Scott and Davis, 2007, p.326). The influence of a technology on performance depends as much on human behavior as it does on technology, hence the definition of materiality.

Still, examples do exist that demonstrate how technologies improve performance in their respective contexts (e.g. Steinfield et al., 1999). ICTs improve performance when teams use technologies to "facilitate situational awareness needs created by their teams' composition and task" (Malhotra and Majchrzak, 2014, p.389) and email, teleconferencing, and videoconferencing specifically can improve intercultural communication (Shachaf, 2008). Human behaviors can also improve technological benefits. Individuals and teams perform better when they have more experience with a technology's features (Hollingshead et al., 1993) (The following section covers individual and team actions in more detail).

Systematic reviews of ICTs appear to be relatively rare. One of the few by Rice and Leonardi (2014) summarizes how organizations adopt, use, and benefit from ICTs. Influences that increase adoption may come from "individual (e.g., innovativeness and self-efficacy), social (e.g. influence), and institutional (e.g. top management commitment) contexts" (p.430). Use of ICTs creates changes at numerous levels of analysis. At the team-level, use creates new interactions or network ties, new groups, and reduces task conflict via

greater coordination. However, tensions arise within individuals who belong to multiple groups or teams when those teams do not ubiquitously adopt tool use, or across cultures which adopt different norms of utilization. Use at the organizational-level improves abilities to explore (or find new) and exploit (that is, utilize) knowledge and contributes to improved decision-making.[1] Societal use of ICTs improves organization reputation and even executive compensation if society perceives the ICT as popular (as with tools like Slack over the past few years), though performance may degrade in the short-term even as the organization benefits from the technology long-term (Rice and Leonardi, 2014).

Outcomes of ICTs vary. Conflict can result due to disruption of organizational structures, work processes, differences in geography, culture, professionalism, and interaction frequency. Readers can likely recall instances of many of these in their own careers, such as frustration due to colleagues who either respond too quickly or too slowly to emails. ICTs may alter practices of gathering and using knowledge (i.e. knowledge management) which appears to improve performance, though significant Rice and Leonardi remain skeptical about this claim. A team or organization's network may expand from ICT use, as with many social media sites, though information overload can similarly damp the benefits of this outcome. Finally, evidence does exist that ICTs yield generally improved performance, albeit with moderators at nearly all levels of analysis (Rice and Leonardi, 2014).

From these varying outcomes, the mixed effects of ICTs become clear. One cannot assume that ICTs will improve outcomes for an organization nor that they will degrade them. Outcomes depend largely on the specific technology, implementation, and social use of that technology, leaving sizable impetuses for design scientific involvement.

The next sections turn from the technology implementation aspect of materiality to the social, collaborative practices. As we will see, while much is known about the most effective ways to collaborate in virtual contexts, many of the practices arise from clear deficiencies in the technologies and the resulting ways that people use them.

4 Collaborative Techniques that Work

Countless frustrations mar the experiences of virtual collaboration. Thus, it is not surprising that more-virtual teams tend to report lower levels of satisfaction than less-virtual teams (Martins et al., 2004). Responding to this clear need, a plethora of articles emerged in the first few months of the pandemic advising people on how to keep working (Coldewey, 2020; Valet, 2020).

While many of these designs may have provided some value to readers, it is difficult to assess the broader validity or "truth" of the claims of these designers because what appears "true" is often determined by an individual's cultural context, particularly in light of the pervasive availability of misinformation and disinformation (O'Connor and Weatherall, 2019). In their research on the spread of false information, O'Connor and Weatherall argue that "the reason to rely on scientific knowledge when we make decisions is not that scientists form a priesthood, uttering eternal truths from the mountaintop of rationality. Rather, it is that scientists are usually in the best position to systematically gather and evaluate whatever evidence is available" (p.44).

The scientific community can provide those who work in virtual teams with scientifically-validated practices through which workers can achieve more optimal outcomes. In that light, this section summarizes techniques that individuals can design into their routines to improve their experiences of working virtually. To improve both satisfaction and performance, the literature on virtual collaboration recommends fostering empathy and trust between colleagues, carefully balancing one's available time, and communicating intentionally as practices to improve individual virtual collaborative experiences.

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[1]Those familiar with optimization techniques may find it interesting that teams, from designers to entire organizations, utilize this same explore-and-exploit methodology and can therefore be modeled via simulated annealing (Carley and Svoboda, 1996; McComb et al., 2016).

4.1   Embrace Empathy

Virtual teams tend to be less efficient than face-to-face teams because coordinating via computer-mediated communication is more mentally and temporally demanding than coordinating face-to-face (Martins et al., 2004; O'Neill et al., 2016). Especially amidst the home-bound chaos of the pandemic, individuals find themselves more satisfied and better able to cope by being kind to themselves and reminding themselves that lower productivity is normal under such circumstances.

Likewise, being consciously understanding of the experiences of one's colleagues, whether technology troubles or toddler temper tantrums, helps individuals interpret garbled video, increase colleagues' comfort, and promote team goal attainment (Gilson et al., 2014; Malhotra et al., 2007; Neeley, 2015; Schulze and Krumm, 2016; Weick et al., 2008). Individuals further improve understanding and team performance by paying extra mind to the challenges that people of historically underrepresented genders, races, ethnicities, language abilities etc. in their organization face (Neeley, 2015).

Even with such added efforts, individuals cannot assume that they understand each other. Virtual collaboration and disasters both make understanding others more difficult (Marlow et al., 2017; Weick, 1993) and even the meanings of familiar language can diverge from one another without the awareness of participants (Meluso et al., 2020). Instead, individuals who restate in their own words the meaning of the other party, or merely asking "Do you understand what I am saying?" helps individuals verify what they understand from each others' communication (Neeley, 2015).

4.2   Build Trust

Teams that trust each other perform better (Gibbs et al., 2017; Liao, 2017). By building confidence that colleagues will do what they say, and being honest when they can't, individuals collaborate more effectively and stave off duplicated work (Liao, 2017; Malhotra et al., 2007; Neeley, 2015; Peters and Manz, 2007; Schulze and Krumm, 2016). Whether a team is meeting for the first time or they know each other well, team-building for a few minutes during each virtual meeting tends to deepen what teammates understand about each other, improve their abilities to interpret what each other say and do, and minimize misunderstandings (Liao, 2017; Malhotra et al., 2007; Marlow et al., 2017; Peters and Manz, 2007).

Nevertheless, teams go through their ups and downs. Virtual environments decrease inhibitions, so tempers flare and people overshare (Martins et al., 2004). Managing the resulting conflicts requires individuals to help people feel equal, connected, and heard (Gilson et al., 2014; Martins et al., 2004; Schulze and Krumm, 2016). But when all else fails, individuals are often more productive working with people they had experience working with face-to-face (Martins et al., 2004; Schaubroeck and Yu, 2017).

4.3   Balance Time

Time is more precious than ever for working parents, especially for working mothers according to Goldin (in McEvers et al., 2020). Spending more time on less-virtual communication mediums (such as the phone or in video meetings) saves time that individuals might otherwise spend on more-virtual mediums (like email and Slack). Less-virtual mediums help participants learn more and avoid costly misunderstandings (Liao, 2017). Yes, workers are exhausted from video meetings (Miller, 2020), so staying efficient by keeping meetings small (in numbers and time) becomes important (Boh et al., 2007; Martins et al., 2004; Schaubroeck and Yu, 2017).

Virtual coordination often makes aligning task details more challenging, so clearly defining roles, responsibilities, and tasks helps mitigate some of the confusion in advance (Gilson et al., 2014; Malhotra et al., 2007; Martins et al., 2004; Peters and Manz, 2007). In normal times, routine, responsiveness, and dependability help build trust (Schulze and Krumm, 2016). Since many virtual employees do not have the time to be responsive, building in short, scheduled check-ins can compensate for the inability to stop by someone else's office (Gilson et al., 2014). That said, professional boundaries retain an important role; politely (or firmly when necessary) saying 'no' helps some employees avoid becoming overwhelmed (Schulze and Krumm, 2016). Unfortunately, such firmness prevents people of any of several intersectional identities from advancing careers as

organizations often penalize them for counter-stereotypical behavior (Wingfield, 2007, 2010; Dicicco, 2012; Rosette et al., 2016) leaving society with a challenging predicament for equity.

4.4   Communicate Intentionally

As we've discussed, different mediums of communication involve varying degrees of virtuality and therefore information content. Intentionally thinking about the benefits and detriments of a communication medium before using it at least improves employee awareness of repercussions, and at best increases shared understanding and communicative efficiency (Gibbs et al., 2017; Larson and DeChurch, 2020; Martins et al., 2004). How likely are the parties to understand one another? How long will sharing and clarifying take? Can participants find a time that works for everyone? Unique individual contexts and objectives mean no universal "best" medium exists, so employees need to use their best judgment for the needs and constraints at hand (Hinds and Bailey, 2003; Marlow et al., 2017; Neeley, 2015; Peters and Manz, 2007; Schulze and Krumm, 2016).

And finally, as counterintuitive as it may seem, individuals benefit from incorporating non-verbal cues. It may seem unprofessional to send emojis. However, workers display subtle emotional cues in face-to-face interactions at work that text-based exchanges lose, meaning colleagues become more likely to infer emotions through an email – even from their own emotional state – unless the sender makes their feelings explicit (Marlow et al., 2017). Whether on Slack or responding to a virtual presentation, gesticulating or using emojis to express themselves can help interlocutors differentiate between a joke shared and offense taken.

Each person's context is unique which yields varying effectiveness for individuals. Nevertheless, the research demonstrates that designing these objectives into collaborative interactions increases the likelihood of both individuals and teams achieving their goals.

5   Leadership Techniques that Work

Leaders may find themselves struggling to maintain productivity, as do many individuals. But they bear the further responsibility of helping their team succeed despite constant change and uncertainty. As science can facilitate individuals with designs for success, it can do so for teams and those who lead them as well. Many of the individual techniques apply to leaders. In addition, leaders can construct a "new team normal" for their team via shared reality, help their team reduce coordination costs, increase collective trust, and appreciate the value of team diversity.

5.1   Reestablish Shared Reality

Teams develop routines – like stopping by colleagues' offices with a question, weekly update meetings, and happy hours – from their collective preferences for working together. These routines and preferences are how we coordinate to get work done and represent the team's *shared reality* (Bechky and Chung, 2018). Management research shows that teams with a stronger shared reality perform better (Johnson, 2020) because shared reality supports effective communication both within and with parties external to the team (Bruner, 1990). Shared reality also provides team members with a sense of stability and rhythm (Maznevski and Chudoba, 2000). The ongoing disruptions of COVID-19 aside, even routine team reorganization, team member additions, or task reprioritizing can create internal, invisible questioning within a team as they make sense of their new reality (Carleton, 2016). This internal questioning creates the potential for knowledge to diverge among the team leading to miscommunication (Meluso et al., 2020; Weick, 1993).

Insightful leaders benefit their teams by redesigning team interactions in rhythmic patterns (Maznevski and Chudoba, 2000) that reestablish shared reality. Shared reality is the "secret sauce" of teams that enables effective teams to achieve their goals (Johnson, 2020). Leaders stave off team dysfunction and establish a "new team normal" that works for everyone by holding explicit conversations about decisions that affect team functioning. Through this process, the team collectively grows to understand its options, how the team defines what is important to the decision, and how that decision affects everyone. Should the team's schedules not align, a manager can still gather individual opinions, privately or via a poll on Slack, to

make an informed decision even if the whole team doesn't simultaneously share a room. Thus, creating a shared reality is an upfront investment in discussion that, by helping a team solidify its understanding of the underlying preferences undergirding new routines, will minimize future communication demands.

5.2 Reduce Coordination Costs

Even though expanding the size of a team can improve its idea generation abilities (Martins et al., 2004), larger teams become unwieldly to manage remotely. Leaders mitigate this shortcoming by keeping teams small to reduce coordination costs when possible (Boh et al., 2007; Martins et al., 2004; Murić et al., 2019). However, the increasing complexity of projects often means that small teams are insufficient for the parallel completion of tasks necessary to complete a project on time. In larger virtual teams, sharing leadership responsibilities among team members improves performance by decreasing delays introduced by managerial inputs and oversight, especially in highly-skilled teams (Hoch and Kozlowski, 2014; Schaubroeck and Yu, 2017; Gibbs et al., 2017; Larson and DeChurch, 2020).

Regardless of team size, virtual leadership often promotes coordination via openly established norms. Clearly delineating expertise, roles, responsibilities, goals, and tasks helps reduce the likelihood of redundancies and conflicts (Martins et al., 2004; Peters and Manz, 2007; Gilson et al., 2014). Similarly, leaders can shape the ways in which teams engage with technology. As discussed previously, despite the discomforts many users experience from excessive videoconferencing, lower team virtuality corresponds to improved performance. Establishing norms of low-virtuality technology use fosters shared cognition, affection, processes, and boundaries (Larson and DeChurch, 2020).

Effective coordination also means running efficient virtual meetings. Above we mentioned the importance of starting meetings with social relationship building. Virtual team leaders benefit their teams' performance by additionally synchronizing understandings throughout, continually checking in with as many participants as feasible, and closing with meeting minutes and actions shared in a common repository. Between meetings, explicitly tracking open actions helps motivate the team toward shared goals. Equally important is monitoring shared understanding throughout the team between meetings to minimize corrective actions (Malhotra et al., 2007).

5.3 Create Psychological Safety

Though individuals can foster trust in their dyadic relationships, leaders promote better team performance by establishing team psychological safety (Edmondson, 1999; Baer and Frese, 2003; Carmeli and Gittell, 2009), "a shared belief held by members of a team that the team is safe for interpersonal risk taking" (Edmondson, 1999, p.350). In virtual contexts, strengthening internal and external relationships helps facilitate the trust necessary to establish psychological safety (Gilson et al., 2014; Peters and Manz, 2007). Setting up face-to-face meetings early, using media-rich communication channels, favoring more synchronous communication, and periodically revisiting norms of communication collectively increase and maintain trust, establish norms, and thus improve performance (Liao, 2017; Martins et al., 2004; Schulze and Krumm, 2016; Peters and Manz, 2007; Malhotra et al., 2007; Marlow et al., 2017).

5.4 Promote Diversity

Diverse teams can outperform more homogeneous teams, if managed effectively (Hong and Page, 2004; Roberson and Park, 2007; Klug and Bagrow, 2016; Gibbs et al., 2017). To benefit from this "diversity bonus" (Page, 2019), leaders need to help their team members understand, appreciate, and utilize the diverse perspectives available to them (Malhotra et al., 2007). Encouraging diversity training, intercultural awareness, and receptiveness advances teams toward greater understanding and therefore benefit for the team (Schulze and Krumm, 2016; Gilson et al., 2014). This kind of "learning from one another" (Neeley, 2015, p.10) helps teams grow from, rather than hurting from, intercultural conflict (cf. Neeley et al., 2012).

6 What Still Doesn't Work

Despite the myriad ways to "make virtual work," most teams have now experienced the shortcomings of virtual collaboration. While some workers benefit from remote working conditions, the research is clear about the long-term challenges of virtual collaboration. And yet, the forced adoption of new virtual routines creates the opportunity to provide workers with new solutions to these difficulties. As designers and researchers, this provides us with an impetus to develop both solutions grounded in science and to further knowledge about "what works." In doing so, we can improve the lives of those working from home, whether they choose to do so or they find themselves stuck, isolated, financially-burdened, and acting as primary caregiver.

Virtual collaboration artifacts can and should provide innovative mechanisms tailored to the strengths and weaknesses of remote collaboration. When possible, designs should be motivated by science as our review seeks to facilitate. However, these artifacts need not be technical in origin. As we have shown, redesigning one's own time or interactions with teammates can improve performance and satisfaction. Contributions often arise from psychology, though knowledge from sociology, anthropology, social work, education, and even espionage similarly could yield benefits.

Exemplary of this, one of the greatest challenges of virtual collaboration is the difficulty of conveying emotion, and indeed people's reluctance to do so. Are there normative designs we can implement to change this stance toward emotional vulnerability? What techniques can working professionals draw from these domains to better understand the emotions and feelings of their colleagues, managers, and customers? Or to express their own in ways that provide them with psychological safety? Emotion provides us with valuable information about the relationship between "workplace" activities, individual values, and collective values, so designing ways to enable more authentic emotional expression in virtual contexts should be a priority.[2]

That said, materiality posits that technologies incentivize behaviors while making others more challenging, thereby prompting improvements to the technologies as well. For example, video communication involves numerous forms of "noise" that make establishing shared understanding between participants more difficult. Are there ways to use computer vision, audio processing, and natural language processing to overcome these difficulties? Videoconferencing software has already begun to address background noise in real time (Amadeo, 2020). Live speech synthesis may provide transcription, but may also help overcome garbling of audio and video signals due to the significantly lower bandwidth requirements of transmitting text.[3] These technologies may even identify visual or auditory cues that many people lose when transitioning from face-to-face to virtual collaboration. Acknowledging the cultural, contextual, and ethical challenges of this question, could computer vision identify the emotions of attendees to a presentation to assess engagement, even if anonymously? While such questions come laden with concerns, what ought designers aspire to be if not considerate of the values of a multitude of stakeholders and equitable outcomes?

Another concern of many business executives is innovation, or the lack thereof due to insufficient serendipity (Gratton, 2020). Can we design social and/or technical artifacts that mimic serendipity, particularly in ways that yield more equitable outcomes? Rather than just recreating "watercooler conversations," note that virtual work amplifies the amount of data we have on workplace interactions. Can we use that information to predict task or social connections that would benefit individual and team developments alike? Fully digital interaction enables complete recordkeeping of interactions. With another nod to ethical concerns, written language in collaboration tools could reveal anything from work patterns to employee concerns. Managers can examine workflows (and bottlenecks) using visual tools due to the abundance of data. Analyzing social networks could help predict links as social networking sites do, but now within organizations at work. Could something as simple as rewarding employees for using LinkedIn at work help, especially if they meet someone recommended by its link-prediction algorithms?

Of value to researchers, design can contribute to interdisciplinary efforts to develop theory. In 2009, Contractor observed that the web and cyberinfrastructure would create "unprecedented potential for the development of 'design-assisted theory construction' to advance our understanding of communication technologies

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[2]Even the language of work could change as a result of this shift. The "workplace" is no longer a central location that white collar workers go to do work in some cases, though it remains the place of work for many service workers.

[3]This is to say nothing of long underprioritized accessibility accommodations which often address latent needs of more than just the key stakeholders, or the needs of many who cannot access the internet despite its increasing necessity.

and social behavior" (p.745). Let us collaborate with scholars of organizational communication, social networks, computer science, information, management, sociology, and more to build shared theoretical understandings of these wicked problems. To date, the unique contexts of workplaces leave many studies to utilize case studies, observation, and correlation to distill meaning from practice, or hypothesize about practice through student experiments. Can we utilize techniques like agent-based modeling, network theory, and natural language processing to explore the underlying mechanisms that re-create the outcomes unique teams experience? Doing so would afford the greater research community opportunities to design more meaningful solutions to the hairy sociotechnical challenges of virtual collaboration.

Countless other possibilities remain. In reading the reviews of ICTs and collaborative practices that work, the reader may have recalled experiences of their own which went surprisingly poorly, or surprisingly well. While those who work from home have grown accustomed to some of the challenges, others continue to plague us. Let us not sit idly by and instead take this time as motivation to begin developing methods of solving social systemic problems.

7   Conclusion

During the opening months of the COVID-19 pandemic, workers transitioned from face-to-face to virtual interaction. Companies later announced that many of those transitions would be permanent, leaving society with widespread challenges of virtual work. Fortunately, the interdisciplinary, scientific, and solution-orientated postures of design leave the discipline uniquely positioned to respond to such social systemic problems.

This article proposes a "designerly" approach to redesigning virtual collaboration for the future of work. We achieve this by summarizing the scientific knowledge on successful Information and Communication Technologies followed by virtual collaboration techniques. We then highlight several prominent challenges of virtual work to motivate the discipline to develop solutions and further knowledge. Finally, we contextualize this approach as thinking about both technical and social creations as designed artifacts, thereby motivating the discipline to integrate each into solutions to social systemic problems.

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References

(2020). Coronavirus: Trump says he is taking unproven drug hydroxychloroquine. *BBC News.*

Amadeo, R. (2020). Google Meet takes on Zoom with AI-powered noise cancellation. *Ars Technica.*

Baer, M. and Frese, M. (2003). Innovation is not enough: Climates for initiative and psychological safety, process innovations, and firm performance. *Journal of Organizational Behavior*, 24(1):45–68. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/job.179.

Bechky, B. A. and Chung, D. E. (2018). Latitude or Latent Control? How Occupational Embeddedness and Control Shape Emergent Coordination. *Administrative Science Quarterly*, 63(3):607–636.

Beras, E. (2020). Employees looks at companies' actions, not just statements. *Marketplace.*

Berliner, U. (2020). Get A Comfortable Chair: Permanent Work From Home Is Coming. *NPR.org.*

Boh, W. F., Ren, Y., Kiesler, S., and Bussjaeger, R. (2007). Expertise and Collaboration in the Geographically Dispersed Organization. *Organization Science*, 18(4):595–612.

Bruner, J. S. (1990). *Acts of Meaning*, volume 3. Harvard university press.

Burleson, G. (2020). Racism in America, manifested in engineering design: A pledge to take responsibility and action.

Carleton, R. N. (2016). Into the unknown: A review and synthesis of contemporary models involving uncertainty. *Journal of anxiety disorders*, 39:30–43.

Carley, K. M. and Svoboda, D. M. (1996). Modeling organizational adaptation as a simulated annealing process. *Sociological Methods and Research*, 25(1):138–168.

Carmeli, A. and Gittell, J. H. (2009). High-quality relationships, psychological safety, and learning from failures in work organizations. *Journal of Organizational Behavior*, 30(6):709–729. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/job.565.

Chudoba, K. M., Wynn, E., Lu, M., and Watson-Manheim, M. B. (2005). How virtual are we? Measuring virtuality and understanding its impact in a global organization. *Information Systems Journal*, 15(4):279–306. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2575.2005.00200.x.

Coldewey, D. (2020). How to work during a pandemic.

Contractor, N. (2009). The Emergence of Multidimensional Networks. *Journal of Computer-Mediated Communication*, 14(3):743–747. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1083-6101.2009.01465.x.

Cross, N. (2001). Designerly ways of knowing: Design discipline versus design science. *Design Issues*, 17(3):49–55.

Dicicco, E. C. (2012). *Competent But Hostile: Intersecting Race/Gender Stereotypes And The Perception Of Women's Anger In The Workplace*. PhD thesis, Pennsylvania State University.

Edmondson, A. (1999). Psychological Safety and Learning Behavior in Work Teams. *Administrative Science Quarterly*, 44(2):350–383.

Frenkel, S., Isaac, M., Kang, C., and Dance, G. J. X. (2020). Facebook Employees Stage Virtual Walkout to Protest Trump Posts. *The New York Times*.

Gibbs, J. L., Sivunen, A., and Boyraz, M. (2017). Investigating the impacts of team type and design on virtual team processes. *Human Resource Management Review*, 27(4):590–603.

Gilson, L. L., Maynard, M. T., Jones Young, N. C., Vartiainen, M., and Hakonen, M. (2014). Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities. *Journal of Management*, 41(5):1313–1337.

Godoy, M. and Wood, D. (2020). What Do Coronavirus Racial Disparities Look Like State By State? *National Public Radio*.

Gratton, L. (2020). How to Increase Collaborative Productivity in a Pandemic. *MIT Sloan Management Review*.

Guyot, K. and Sawhill, I. V. (2020). Telecommuting will likely continue long after the pandemic.

Hailu, R. (2020). Health care workers say protesting racial injustice should be part of the job. *STAT*.

Harwell, D. (2020). Managers turn to surveillance software, always-on webcams to ensure employees are (really) working from home. *Washington Post*.

Hinds, P. J. and Bailey, D. E. (2003). Out of Sight, Out of Sync: Understanding Conflict in Distributed Teams. *Organization Science*, 14(6):615–632.

Hoch, J. E. and Kozlowski, S. W. J. (2014). Leading virtual teams: Hierarchical leadership, structural supports, and shared team leadership. *Journal of Applied Psychology*, 99(3):390–403.

Hollingshead, A. B., Mcgrath, J. E., and O'Connor, K. M. (1993). Group Task Performance and Communication Technology: A Longitudinal Study of Computer-Mediated Versus Face-to-Face Work Groups. *Small Group Research*, 24(3):307–333.

Hong, L. and Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proceedings of the National Academy of Sciences of the United States of America*, 101(46):16385 LP–16389.

Johnson, S. (2020). *Cross-Functional Team Performance: Inquiry, Identity and Shared Reality*. PhD thesis, Case Western Reserve University.

Kelly, J. (2020). Twitter CEO Jack Dorsey Tells Employees They Can Work From Home 'Forever'—Before You Celebrate, There's A Catch. *Forbes*.

Klug, M. and Bagrow, J. P. (2016). Understanding the group dynamics and success of teams. *Royal Society open science*, 3(4):160007.

Larson, L. and DeChurch, L. A. (2020). Leading teams in the digital age: Four perspectives on technology and what they mean for leading teams. *The Leadership Quarterly*, 31(1):101377–101377.

Li, E. Y., Jiang, J. J., and Klein, G. (2003). The Impact of Organizational Coordination and Climate on Marketing Executives' Satisfaction with Information Systems Services. *Journal of the Association for Information Systems*, 4(1).

Liao, C. (2017). Leadership in virtual teams: A multilevel perspective. *Human Resource Management Review*, 27(4):648–659.

Lu, M., Watson-Manheim, M. B., Chudoba, K. M., and Wynn, E. (2006). Virtuality and Team Performance: Understanding the Impact of Variety of Practices. *Journal of Global Information Technology Management*, 9(1):4–23. _eprint: https://doi.org/10.1080/1097198X.2006.10856412.

Malhotra, A. and Majchrzak, A. (2014). Enhancing performance of geographically distributed teams through targeted use of information and communication technologies. *Human Relations*, 67(4):389–411.

Malhotra, A., Majchrzak, A., and Rosen, B. (2007). Leading Virtual Teams. *Academy of Management Perspectives*, 21(1):60–70.

Marlow, S. L., Lacerenza, C. N., and Salas, E. (2017). Communication in virtual teams: A conceptual framework and research agenda. *Human Resource Management Review*, 27(4):575–589.

Martins, L. L., Gilson, L. L., and Maynard, M. T. (2004). Virtual Teams: What Do We Know and Where Do We Go From Here? *Journal of Management*, 30(6):805–835.

Maznevski, M. L. and Chudoba, K. M. (2000). Bridging Space Over Time: Global Virtual Team Dynamics and Effectiveness. *Organization Science*, 11(5):473–492.

McComb, C., Cagan, J., and Kotovsky, K. (2016). Drawing Inspiration From Human Design Teams For Better Search And Optimization: The Heterogeneous Simulated Annealing Teams Algorithm. *Submitted to the Journal of Mechanical Design*, 138(4):1–6.

McEvers, K., Chang, A., Kelly, M. L., and Kurtzleben, D. (2020). Ideas For Reopening Schools; Evidence Of Airborne Spread. *Consider This from NPR*.

Meluso, J., Austin-Breneman, J., and Uribe, J. (2020). Estimate Uncertainty: Miscommunication About Definitions of Engineering Terminology. *Journal of Mechanical Design*, 142(7).

Melville, N., Kraemer, K., and Gurbaxani, V. (2004). Information technology and organizational performance: An integrative model of IT business value. *MIS quarterly*, 28(2):283–322.

Miller, R. W. (2020). What's 'Zoom fatigue'? Here's why video calls can be so exhausting. *USA TODAY*.

Murić, G., Abeliuk, A., Lerman, K., and Ferrara, E. (2019). Collaboration Drives Individual Productivity. *Proceedings of the ACM on Human-Computer Interaction*, 3(CSCW):74:1–74:24.

Navaroli, G. (2020). Working moms are struggling to engage at work — and it will cost the economy $341B. *NBC News*.

Neeley, T. (2015). Global teams that work. *Harvard Business Review*, 93(10):74–81.

Neeley, T. B., Hinds, P. J., and Cramton, C. D. (2012). The (un) hidden turmoil of language in global collaboration. *Organizational Dynamics*, 41(3):236–244.

Nguyen, J. (2020). How COVID-19 has affected Americans' paychecks and working hours. *Marketplace*.

Niller, E. (2020). Are Running or Cycling Actually Risks for Spreading Covid-19? *Wired*.

O'Connor, C. and Weatherall, J. O. (2019). *The Misinformation Age : How False Beliefs Spread*. Yale University Press, New Haven.

O'Neill, T. A., Hancock, S. E., Zivkov, K., Larson, N. L., and Law, S. J. (2016). Team Decision Making in Virtual and Face-to-Face Environments. *Group Decision and Negotiation*, 25(5):995–1020.

Ozimek, A. (2020). The Future of Remote Work. Technical report, Upwork.

Page, S. E. (2019). *The Diversity Bonus: How Great Teams Pay Off in the Knowledge Economy*. Princeton University Press.

Papalambros, P. Y. (2015). Design Science: Why, What and How. *Design Science*, 1:e1–e1.

Peters, L. M. and Manz, C. C. (2007). Identifying antecedents of virtual team collaboration. *Team Performance Management: An International Journal*, 13(3/4):117–129.

Ramirez, R., Melville, N., and Lawler, E. (2010). Information technology infrastructure, organizational process redesign, and business value: An empirical analysis. *Decision Support Systems*, 49(4):417–429.

Rice, R. E. and Leonardi, P. M. (2014). Information and communication technologies in organizations. *The SAGE handbook of organizational communication: advances in theory, research, and methods*, pages 425–448.

Rittel, H. W. J. and Webber, M. M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences*, 4(2):155–169.

Rittel, H. W. J. and Webber, M. M. (1984). Planning Problems are Wicked Problems. *Developments in Design Methodology*, NA(NA):134–144.

Roberson, Q. M. and Park, H. J. (2007). Examining the Link Between Diversity and Firm Performance: The Effects of Diversity Reputation and Leader Racial Diversity - Quinetta M. Roberson, Hyeon Jeong Park, 2007. *Group & Organization Management*.

Rodriguez, A. and Alltucker, K. (2020). Thousands of health care workers sickened by COVID-19 and 27 dead, CDC report says. *USA TODAY*.

Rosette, A. S., Koval, C. Z., Ma, A., and Livingston, R. (2016). Race matters for women leaders: Intersectional effects on agentic deficiencies and penalties. *The Leadership Quarterly*, 27(3):429–445.

Schaubroeck, J. M. and Yu, A. (2017). When does virtuality help or hinder teams? Core team characteristics as contingency factors. *Human Resource Management Review*, 27(4):635–647.

Schneider, H. (2020a). Fed's Barkin: Help may be needed to prop up labor force, productivity in recovery. *Reuters*.

Schneider, H. (2020b). With 'Main Street' in view, Fed weighs risks of job, productivity shocks. *Reuters*.

Schrotenboer, B. (2020). Working at home had a positive effect on productivity during the pandemic, survey says. *USA TODAY*.

Schulze, J. and Krumm, S. (2016). The "virtual team player": A review and initial model of knowledge, skills, abilities, and other characteristics for virtual collaboration. *Organizational Psychology Review*, 7(1):66–95.

Scott, W. R. and Davis, G. F. (2007). *Organizations and Organizing: Rational, Natural, and Open System Perspectives*. Number Upper Saddle River, N.J. :. Pearson Prentice Hall, Upper Saddle River, N.J., 1st ed. edition.

Shachaf, P. (2008). Cultural diversity and information and communication technology impacts on global virtual teams: An exploratory study. *Information & Management*, 45(2):131–142.

Shen-Berro, J. (2020). Latino designers turn masks to protect against COVID-19 into cultural expression. *NBC News*.

Simon, H. A. (1996). Social Planning: Designing the Evolving Artifact. In *The Sciences of the Artificial*, pages 139–167. MITP.

Smith, H. J., Dinev, T., and Xu, H. (2011). Information privacy research: An interdisciplinary review. *MIS Quarterly*, 35(4):989–1016.

Somers, J. (2020). The Engineers Taking on the Ventilator Shortage. *The New Yorker*.

Steinfield, C., Jang, C.-Y., and Pfaff, B. (1999). Supporting virtual team collaboration: The TeamSCOPE system. In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work*, GROUP '99, pages 81–90, Phoenix, Arizona, USA. Association for Computing Machinery.

Thomas, D., Morris, S., and Edgecliffe-Johnson, A. (2020). The end of the office? Coronavirus may change work forever. *Financial Times*.

Thompson, L. L. (2016). *Making the Team: A Guide for Managers*. Pearson Education, New York, NY, sixth edit edition.

Valet, V. (2020). Working From Home During The Coronavirus Pandemic: What You Need To Know. *Forbes*.

Vermaas, P. (2016). A logical critique of the expert position in design research: Beyond expert justification of design methods and towards empirical validation. *Design Science*, 2.

Watkins Allen, M., Coopman, S. J., Hart, J. L., and Walker, K. L. (2007). Workplace Surveillance and Managing Privacy Boundaries. *Management Communication Quarterly*, 21(2):172–200.

Weick, K. E. (1993). The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster. *Administrative Science Quarterly*, 38(4):628–652.

Weick, K. E., Sutcliffe, K. M., and Obstfeld, D. (2008). Organizing for high reliability: Processes of collective mindfulness. *Crisis management*, 3(1):81–123.

Wingfield, A. H. (2007). The Modern Mammy and the Angry Black Man: African American Professionals' Experiences with Gendered Racism in the Workplace. *Race, Gender & Class*, 14(1/2):196–212.

Wingfield, A. H. (2010). Are Some Emotions Marked Whites Only? Racialized Feeling Rules in Professional Workplaces. *Social Problems*, 57(2):251–268.

Woodward, A. (2020). The COVID-19 pandemic could last for 2 years, according to US experts.