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. Virtual collaboration as we know it was designed in and for a colocated world without prioritizing diverse needs. Design is uniquely positioned to not only alleviate these ails but even make virtual teams strategically advantageous by developing solutions specifically for hybrid virtual collaboration. To do so, designers must incorporate attributes that make virtual collaboration "work". This article provides background on communication technologies before summarizing the attributes of collaboration and leadership that "work" for effective virtual collaboration. We then 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 redesign the artifact of virtual work itself for the fundamental needs of collaboration.

Keywords
team science, virtual collaboration, information and communication technologies, group performance, COVID-19, future of work, materiality, remote work, shared reality, team virtuality, virtual teams, work from home

Introduction
Since the first industrial revolution, organizations have gathered workers together in common locations. This process, called agglomeration,[1] allowed organizations to share common energy sources, tools, and goods among their employees, centralize logistics,[2] and increase worker

[1] Scott and Davis, *Organizations and Organizing: Rational, Natural, and Open System Perspectives*.
[2] Rosenberg and Birdzell Jr, *How the West Grew Rich: The Economic Transformation of the Industrial World*.

supervision and control.[3] But by the 1970s, the nature of work was evolving. Expanding use of the telephone made "telecommuting" possible, meaning people could collaborate without physically being together.[4] Tasks became "increasingly 'informated,' turning a large proportion of corporate employees at all ranks into 'knowledge workers' whose tasks are computer-mediated."[5] The need to remain competitive drove organizations to acquire the best talent wherever those workers were located, thereby guiding collaboration toward greater "virtuality".[6]

The COVID-19 pandemic conspicuously accelerated this transition, shifting 35% of US workers[7] and 80% of global corporate remote work policies[8] from primarily colocated and face-to-face (FtF) interactions to virtual and hybrid forms of collaboration within a few weeks. Nor was this sudden transition temporary. Nearly two-thirds (64%) of organizations report that "remote working is a permanent change they have made due to COVID-19," with a similar fraction (69%) reporting that at least 75% of their workforce works effectively when remote.[9] This reflects long-held self-assessments that we can still perform while collaborating virtually.[10]

Although different forms of work have their advantages,[11] the research is clear: sustained forms of virtual collaboration tend to be less effective than FtF work because of decreased trust and team cohesion; increased social isolation; and the increased importances of team selection and assessment.[12] These pitfalls manifest whether a team works remotely[13] or in hybrid arrangements,[14] which involve varying degrees of FtF and remote work. Counterintuitively, hybrid work often leaves workers feeling distant from one another and consequently comes with many of the ails of distributed teams.[15]

In all its forms − through email, chat rooms, video calls, etc. − work hereafter will involve virtuality. Yet many tools, platforms, and workplace norms were not designed in a cultural environment of primarily remote and hybrid collaboration. Designers' current and previous experiences significantly shape their sense-making processes and how they interact to socially construct a shared reality.[16] With the exception of organizations that operated fully remotely prior to 2020, ICTs were conceived of in largely colocated environments without diverse,

[3] Thompson, "Time, Work-Discipline, and Industrial Capitalism"; Scott and Davis, *Organizations and Organizing: Rational, Natural, and Open System Perspectives*.

[4] Nilles, "Telecommunications and Organizational Decentralization"; Chudoba et al., "How Virtual Are We?"

[5] Chudoba et al., "How Virtual Are We?"; citing Zuboff, *In the Age of the Smart Machine*.

[6] Chudoba et al., "How Virtual Are We?"

[7] Brynjolfsson et al., "COVID-19 and Remote Work."

[8] Eagle, "Coronavirus Flash Survey June 2020."

[9] Eagle, "Coronavirus Flash Survey October 2020."

[10] Chudoba et al., "How Virtual Are We?"

[11] Fiol and O'Connor, "Identification in Face-to-Face, Hybrid, and Pure Virtual Teams."

[12] Kirkman et al., "Five Challenges to Virtual Team Success."

[13] Olson et al., "The (Currently) Unique Advantages of Collocated Work."

[14] Gibson and Gibbs, "Unpacking the Concept of Virtuality"; Polzer et al., "Extending the Faultline Model to Geographically Dispersed Teams"; Gray, Siemsen, and Vasudeva, "Colocation Still Matters."

[15] Wilson et al., "Perceived Proximity in Virtual Work."

[16] Pauwels, De Meyer, and Van Campenhout, "Design Thinking Support"; Berger and Luckmann, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*.

primarily remote workforces in mind.[17] Even prior to the pandemic, Information & Communication Technology (ICT) adoption frequently yielded unintended or "dual" consequences.[18] To compensate, users would "appropriate new technology by adapting it to meet their needs, which may or may not match designers' goals."[19] So even as communication platforms like Slack and Microsoft Teams have grown in popularity, they create as many problems as they solve, leaving users to construct their own solutions just to make virtual collaboration tools usable.[20] Hence, knowledge workers, teams, and organizations universally find themselves with the diminished returns of virtual collaboration while expending effort to modify ICTs toward goal attainment, a productivity challenge that increasingly concerns prominent economists.[21]

Design is uniquely positioned to engage with the needs of virtual collaboration. This is not just a user interface problem; indeed, companies perpetually update their tools to improve user experiences. For years, organization scholars have called for the redesign of *work*,[22] a complex system composed of the tasks, processes, knowledge, skills, technologies, their integrations, and interdependencies therein required for an organization to accomplish the goals it sets for itself.[23] But as Buchanan notes, the problems of redesigning collaboration "are not problems of action but of reaching a new understanding of the purposes and ends,"[24] namely the needs of people. Rather than a third-order service design problem[25] centered on ICTs, we build upon prior suggestions[26] and propose reconceptualizing virtual collaboration as a fourth-order complex system design problem with an explicit objective: not just to make remote and hybrid work "as good" as colocated work, but to make virtual forms of collaboration a strategic advantage for diverse populations by designing for the underlying needs of collaborative work.

While ample research exists on both the technologies[27] and the collaboration techniques[28] that benefit virtual work and workers, noteworthy challenges abound at their intersection. To that end, this piece creates a foundation for redesigning virtual collaboration for the future by expounding attributes[29] necessary for effective virtual collaboration. First, we provide background on virtual technology implementations based on the research on ICTs. Then, we

[17] Fuglerud and Sloan, "The Link between Inclusive Design and Innovation."
[18] Majchrzak, Markus, and Wareham, "Designing for Digital Transformation: Lessons for Information Systems Research from the Study of ICT and Societal Challenges."
[19] Leonardi et al., "Multiplex Appropriation in Complex Systems Implementation," 462.
[20] Molla, "Is Slack Ruining Our Jobs — and Lives?"
[21] Bloom, "Stanford Professor on the New Remote Work Economy"; Graffeo, "Former Fed Chair Alan Greenspan Says the US Is Entering a Period of Slow Economic Growth on Lowered Productivity | Markets Insider."
[22] Sinha and Van de Ven, "Designing Work Within and Between Organizations"; Bailyn and Harrington, "Redesigning Work for Work–Family Integration."
[23] Scott and Davis, *Organizations and Organizing: Rational, Natural, and Open System Perspectives*, 21.
[24] Buchanan, "Branzi's Dilemma," 16.
[25] Buchanan, "Wicked Problems in Design Thinking"; Body and Terrey, *Design for a Better Future*.
[26] Postma, Lauche, and Stappers, "Social Theory as a Thinking Tool for Empathic Design"; Mattelmäki, Vaajakallio, and Koskinen, "What Happened to Empathic Design?"
[27] Rice and Leonardi, "Information and Communication Technologies in Organizations."
[28] Thompson, *Making the Team: A Guide for Managers*.
[29] The "design attributes" we refer to are equivalent to "ends" (Simon, *The Sciences of the Artificial*.) or "goals" in an engineering Goal-Question-Metric analysis.

review the attributes of effective collaboration, for individuals and leaders respectively, by drawing on the global teams and shared reality literatures. Finally, we explore several needs and opportunities designers should navigate 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.

Technology Implementations

Broadly, information technologies improve organizational performance.[30] More specific to virtual work are Information and Communication Technologies (ICTs), which similarly improve organizational performance.[31] 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".[32] Schaubroeck and Yu define the strengths and weaknesses of remote work in terms of *team virtuality*, "the extent and value of utilizing information and communication technologies within work teams"[33] 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.[34] The continual evolution of teams through varying degrees of remote work yields different experiences for different teams at different times.

Significant challenges remain for such technologies. Even at their best, ICTs can be 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

[30] Melville, Kraemer, and Gurbaxani, "Information Technology and Organizational Performance: An Integrative Model of IT Business Value"; Ramirez, Melville, and Lawler, "Information Technology Infrastructure, Organizational Process Redesign, and Business Value."
[31] Li, Jiang, and Klein, "The Impact of Organizational Coordination and Climate on Marketing Executives' Satisfaction with Information Systems Services"; Malhotra and Majchrzak, "Enhancing Performance of Geographically Distributed Teams through Targeted Use of Information and Communication Technologies."
[32] Hinds and Bailey, "Out of Sight, Out of Sync: Understanding Conflict in Distributed Teams."
[33] Schaubroeck and Yu, "When Does Virtuality Help or Hinder Teams? Core Team Characteristics as Contingency Factors," 636.
[34] Chudoba et al., "How Virtual Are We?"; Lu et al., "Virtuality and Team Performance"; Schaubroeck and Yu, "When Does Virtuality Help or Hinder Teams? Core Team Characteristics as Contingency Factors."

addition to substantial User Interface and User Experience designer contributions before they generate value. At their worst, ICTs create significant ethical concerns, particularly for privacy.[35]

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 influences 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.[36] Artifacts' properties, and the artificial worlds they create for users, are grounded in the designer's knowledge at the time of artifact creation which is often incongruent with the evolving needs of humans who engage with it. Consequently, conversations about "technology use" integrate designer knowledge, 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.[37] 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.[38] ICTs improve performance when teams use technologies to "facilitate situational awareness needs created by their teams' composition and task"[39] and email, teleconferencing, and videoconferencing specifically can improve intercultural communication.[40] Human behaviors can also improve technological benefits. Individuals and teams perform better when they have more experience with a technology's features[41] (The following section covers individual and team actions in more detail).

Systematic reviews of the attributes of effective ICTs are rare to date. One of the few by Rice and Leonardi 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".[42] 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

[35] Watkins Allen et al., "Workplace Surveillance and Managing Privacy Boundaries"; Smith, Dinev, and Xu, "Information Privacy Research."
[36] Rice and Leonardi, "Information and Communication Technologies in Organizations."
[37] Scott and Davis, *Organizations and Organizing: Rational, Natural, and Open System Perspectives*, 326.
[38] e.g. Steinfield, Jang, and Pfaff, "Supporting Virtual Team Collaboration."
[39] Malhotra and Majchrzak, "Enhancing Performance of Geographically Distributed Teams through Targeted Use of Information and Communication Technologies," 389.
[40] Shachaf, "Cultural Diversity and Information and Communication Technology Impacts on Global Virtual Teams."
[41] Hollingshead, Mcgrath, and O'Connor, "Group Task Performance and Communication Technology."
[42] Rice and Leonardi, "Information and Communication Technologies in Organizations," 430.

the organizational-level improves abilities to explore (or find new) and exploit (that is, utilize) knowledge and contributes to improved decision-making. 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.[43]

Outcomes of ICTs vary. Conflict can result from 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 dampen the benefits of this outcome. Finally, evidence does exist that ICTs yield generally improved performance, albeit with moderators at nearly all levels of analysis.[44]

Clearly, 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 careful design 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 attributes of effective collaboration in virtual contexts, many practices arise from clear deficiencies in the technologies and the resulting ways that people use them.

Collaborative Attributes 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,[45] or that a plethora of articles would emerge online throughout the pandemic advising people on how to keep working.[46] While readers gobble up these proposals, they were nevertheless short-term fixes to a long-term need for designs that facilitate effective virtual collaboration.

In that light, this section summarizes the validated attributes that promote effective virtual collaboration. The literature on virtual collaboration recommends fostering empathy and trust between colleagues, carefully balancing one's available time, and communicating intentionally to improve both individual performance and satisfaction. These foundational collaborative concepts should guide novel designs to promote effective virtual collaboration between diverse users.

[43] Rice and Leonardi, "Information and Communication Technologies in Organizations."
[44] Rice and Leonardi.
[45] Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"
[46] Coldewey, "How to Work during a Pandemic"; Valet, "Working From Home During The Coronavirus Pandemic."

Designing for 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.[47] Individuals find themselves more satisfied and better able to cope by being kind to themselves and reminding themselves that lower productivity is normal when working remotely.

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.[48] Individuals further improve understanding and team performance by paying extra mind to the challenges that people of historically underrepresented genders, races, ethnicities, language abilities, and other marginalized groups face in their organization.[49]

Even with such added efforts, individuals cannot assume that they understand each other. Virtual collaboration makes understanding others more difficult[50] and even the meanings of familiar language can diverge from one another without the awareness of participants.[51] 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 other's communication.[52]

Designing for Trust

Teams that trust each other perform better.[53] 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.[54] 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

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[47] Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; O'Neill et al., "Team Decision Making in Virtual and Face-to-Face Environments."

[48] Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities"; Malhotra, Majchrzak, and Rosen, "Leading Virtual Teams"; Neeley, "Global Teams That Work"; Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration"; Weick, Sutcliffe, and Obstfeld, "Organizing for High Reliability: Processes of Collective Mindfulness."

[49] Neeley, "Global Teams That Work."

[50] Marlow, Lacerenza, and Salas, "Communication in Virtual Teams: A Conceptual Framework and Research Agenda."

[51] Meluso, Austin-Breneman, and Uribe, "Estimate Uncertainty: Miscommunication About Definitions of Engineering Terminology."

[52] Neeley, "Global Teams That Work."

[53] Gibbs, Sivunen, and Boyraz, "Investigating the Impacts of Team Type and Design on Virtual Team Processes"; Liao, "Leadership in Virtual Teams: A Multilevel Perspective."

[54] Liao, "Leadership in Virtual Teams: A Multilevel Perspective"; Malhotra, Majchrzak, and Rosen, "Leading Virtual Teams"; Neeley, "Global Teams That Work"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration"; Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration."

understand about each other, improve their abilities to interpret what each other say and do, and minimize misunderstandings.[55]

Nevertheless, teams go through their ups and downs. Virtual environments decrease inhibitions, so tempers flare and people overshare.[56] Managing the resulting conflicts requires individuals to help people feel equal, connected, and heard.[57] But when all else fails, individuals are often more productive working with people they have prior experience working with face-to-face.[58]

Designing for Time Management

Time is more precious than ever for working parents, especially for working mothers.[59] 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.[60] Workers become exhausted from too many video meetings (and even multitasking during those meetings)[61] which one can mitigate by keeping meetings small, in number and time.[62]

Virtual coordination often makes aligning task details more challenging, so clearly defining roles, responsibilities, and tasks helps mitigate some of the confusion in advance.[63] Routine, responsiveness, and dependability help build trust,[64] but 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.[65] That said, professional boundaries retain an important role; politely (or firmly when necessary) saying 'no' helps some employees avoid

[55] Liao, "Leadership in Virtual Teams: A Multilevel Perspective"; Malhotra, Majchrzak, and Rosen, "Leading Virtual Teams"; Marlow, Lacerenza, and Salas, "Communication in Virtual Teams: A Conceptual Framework and Research Agenda"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration."
[56] Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"
[57] Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities"; Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration."
[58] Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Schaubroeck and Yu, "When Does Virtuality Help or Hinder Teams? Core Team Characteristics as Contingency Factors."
[59] McEvers et al., "Ideas For Reopening Schools; Evidence Of Airborne Spread"; Arntz, Sarra, and Berlingieri, "Working from Home"; Wheatley, "Good to Be Home?"; Bernstein, Gallo, and Caulfield, "How Mothers WFH Are Negotiating What's Normal."
[60] Liao, "Leadership in Virtual Teams: A Multilevel Perspective."
[61] Fosslien and Duffy, "How to Combat Zoom Fatigue."
[62] Boh et al., "Expertise and Collaboration in the Geographically Dispersed Organization"; Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Schaubroeck and Yu, "When Does Virtuality Help or Hinder Teams? Core Team Characteristics as Contingency Factors."
[63] Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities"; Malhotra, Majchrzak, and Rosen, "Leading Virtual Teams"; Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration."
[64] Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration."
[65] Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities."

becoming overwhelmed.[66] Unfortunately, such firmness prevents people of any of several intersectional identities from advancing their careers as organizations often penalize them for counter-stereotypical behavior[67] leaving virtual workforces with a challenging predicament for equity.

Designing for Intentional Communication

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.[68] 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.[69]

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.[70] 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, though team success ultimately requires supportive leadership as we discuss next.

Leadership Attributes That Work

Leaders bear the responsibility of helping their team succeed, even when virtual collaboration leaves leaders struggling to maintain team productivity and morale. Fortunately, here too we

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[66] Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration."

[67] Wingfield, "The Modern Mammy and the Angry Black Man"; Wingfield, "Are Some Emotions Marked Whites Only?"; Dicicco, "Competent But Hostile"; Rosette et al., "Race Matters for Women Leaders."

[68] Gibbs, Sivunen, and Boyraz, "Investigating the Impacts of Team Type and Design on Virtual Team Processes"; Larson and DeChurch, "Leading Teams in the Digital Age: Four Perspectives on Technology and What They Mean for Leading Teams"; Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"

[69] Hinds and Bailey, "Out of Sight, Out of Sync: Understanding Conflict in Distributed Teams"; Marlow, Lacerenza, and Salas, "Communication in Virtual Teams: A Conceptual Framework and Research Agenda"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration"; Neeley, "Global Teams That Work"; Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration."

[70] Marlow, Lacerenza, and Salas, "Communication in Virtual Teams: A Conceptual Framework and Research Agenda."

understand leadership attributes that promote positive outcomes. Many of the aforementioned collaborative attributes apply to leadership as well. But as this section details, leaders also benefit their teams by creating shared reality, reducing coordination costs, fostering collective trust, and prioritizing diversity. Designs must prioritize these attributes, for and with leaders, in order to make virtual collaboration strategically advantageous.

Designing for 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*.[71] Management research shows that teams with a stronger shared reality perform better[72] because shared reality supports effective communication both within and with parties external to the team.[73] Shared reality also provides team members with a sense of stability and rhythm.[74] The 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.[75] This internal questioning creates the potential for knowledge to diverge among the team leading to miscommunication.[76]

Shared reality is the "secret sauce" of teams that enables effective teams to achieve their goals.[77] Leaders who build rhythmic patterns into team collaboration help their teams establish and reestablish shared reality.[78] By doing so, 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 each member. Should the team's schedules not align, a manager can still gather individual opinions, privately, 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 minimizes future communication demands by helping a team solidify its understanding of the preferences underlying new routines.

[71] Bechky and Chung, "Latitude or Latent Control?"
[72] Johnson, "Cross-Functional Team Performance: Inquiry, Identity and Shared Reality."
[73] Bruner, *Acts of Meaning*.
[74] Maznevski and Chudoba, "Bridging Space Over Time."
[75] Carleton, "Into the Unknown: A Review and Synthesis of Contemporary Models Involving Uncertainty."
[76] Meluso, Austin-Breneman, and Uribe, "Estimate Uncertainty: Miscommunication About Definitions of Engineering Terminology"; Weick, "The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster."
[77] Johnson, "Cross-Functional Team Performance: Inquiry, Identity and Shared Reality."
[78] Maznevski and Chudoba, "Bridging Space Over Time."

Designing for Coordination

Larger teams are unwieldy to manage remotely. Leaders mitigate this shortcoming by keeping teams small to reduce coordination costs when possible.[79] However, the increasing complexity of projects often means that small teams are insufficient for the parallel execution 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.[80]

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.[81] Similarly, leaders can shape the ways in which teams engage with technology. 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.[82]

Effective coordination also means efficient virtual meetings. In the previous section, we discussed the importance of incorporating social relationship building into meetings. Additionally, synchronizing understandings throughout a meeting benefits team performance. Between meetings, explicitly tracking open actions helps motivate the team toward shared goals. Virtual team leaders often achieve these goals by continually checking in with as many participants as feasible, closing with meeting minutes, storing shared actions items in a common repository, and monitoring shared understanding throughout the team between meetings to minimize corrective actions.[83]

Designing for Psychological Safety

Though individuals can foster trust in their dyadic relationships, leaders promote better team performance by establishing team psychological safety,[84] "a shared belief held by members of a team that the team is safe for interpersonal risk taking".[85] In virtual contexts, strengthening

[79] Boh et al., "Expertise and Collaboration in the Geographically Dispersed Organization"; Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Murić et al., "Collaboration Drives Individual Productivity."

[80] Hoch and Kozlowski, "Leading Virtual Teams: Hierarchical Leadership, Structural Supports, and Shared Team Leadership"; Schaubroeck and Yu, "When Does Virtuality Help or Hinder Teams? Core Team Characteristics as Contingency Factors"; Gibbs, Sivunen, and Boyraz, "Investigating the Impacts of Team Type and Design on Virtual Team Processes"; Larson and DeChurch, "Leading Teams in the Digital Age: Four Perspectives on Technology and What They Mean for Leading Teams."

[81] Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration"; Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities."

[82] Larson and DeChurch, "Leading Teams in the Digital Age: Four Perspectives on Technology and What They Mean for Leading Teams."

[83] Malhotra, Majchrzak, and Rosen, "Leading Virtual Teams."

[84] Edmondson, "Psychological Safety and Learning Behavior in Work Teams"; Baer and Frese, "Innovation Is Not Enough"; Carmeli and Gittell, "High-Quality Relationships, Psychological Safety, and Learning from Failures in Work Organizations."

[85] Edmondson, "Psychological Safety and Learning Behavior in Work Teams," 350.

internal and external relationships facilitates the trust necessary to establish psychological safety.[86] Leaders successfully increase psychological safety by setting up face-to-face meetings early, using media-rich communication channels, favoring more synchronous communication, and periodically revisiting norms of communication collectively increase which in turn maintain trust, establish norms, and improve performance.[87]

Designing for Diversity

Diverse teams can outperform more homogeneous teams, if managed effectively.[88] To benefit from this "diversity bonus",[89] leaders need to help their team members understand, appreciate, and utilize the diverse perspectives available to them.[90] Encouraging diversity training, intercultural awareness, and receptiveness advances teams toward greater understanding and therefore team benefit.[91] This kind of "learning from one another"[92] helps teams grow rather than hurting from intercultural conflict.[93]

Designing for the Needs of Collaboration

Despite the myriad ways to "make virtual work," most teams have 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. 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 solutions grounded in knowledge about "what works" for workers and the fundamental needs of work. In doing so, we can improve the lives of those working virtually, whether they choose to do so or they find themselves stuck, isolated, financially-burdened, and acting as primary caregiver.

Designers should tailor existing and new artifacts to the strengths and weaknesses of remote and hybrid collaboration, being sure to "move the scope of the task out to encompass

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[86] Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration."

[87] Liao, "Leadership in Virtual Teams: A Multilevel Perspective"; Martins, Gilson, and Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?"; Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration"; Peters and Manz, "Identifying Antecedents of Virtual Team Collaboration"; Malhotra and Majchrzak, "Enhancing Performance of Geographically Distributed Teams through Targeted Use of Information and Communication Technologies"; Marlow, Lacerenza, and Salas, "Communication in Virtual Teams: A Conceptual Framework and Research Agenda."

[88] Hong and Page, "Groups of Diverse Problem Solvers Can Outperform Groups of High-Ability Problem Solvers"; Roberson and Park, "Examining the Link Between Diversity and Firm Performance"; Klug and Bagrow, "Understanding the Group Dynamics and Success of Teams"; Gibbs, Sivunen, and Boyraz, "Investigating the Impacts of Team Type and Design on Virtual Team Processes."

[89] Page, *The Diversity Bonus*.

[90] Malhotra, Majchrzak, and Rosen, "Leading Virtual Teams."

[91] Schulze and Krumm, "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration"; Gilson et al., "Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities."

[92] Neeley, "Global Teams That Work," 10.

[93] cf. Neeley, Hinds, and Cramton, "The (Un) Hidden Turmoil of Language in Global Collaboration."

connected systems and activities; to achieve integration so that the product does not operate as a fragment in the world, but within useful and viable patterns."[94] As we have shown, these artifacts need not be technical in origin. Redesigning 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 of work we can implement to change this stance toward emotional vulnerability? Can we incorporate the attributes of effective collaboration and leadership such that working professionals can foster psychological safety; better understand the emotions and feelings of their colleagues, managers, and customers; or to express their own emotions? 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.[95]

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.[96] 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.[97] 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.[98] Can we design social and/or technical artifacts that mimic serendipity, particularly in ways that yield more equitable outcomes? Or, 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 assess complex interactions, from

[94] Golsby-Smith, "Fourth Order Design."
[95] Even the language of work could change as a result of this shift. The "workplace" is no longer a central location where white collar workers go to do work in some cases, though it remains the place of work for many service workers.
[96] Amadeo, "Google Meet Takes on Zoom with AI-Powered Noise Cancellation."
[97] 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.
[98] Gratton, "How to Increase Collaborative Productivity in a Pandemic."

predicting task or social connections that would benefit individual and team developments to building in feedback loops such that artifacts evolve in response to changing user needs?[99] 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?

But this opportunity extends beyond recreating corporeal activities, as would designing surrogate watercooler conversations. Rather than imagining an entire workplace constituted in virtual reality (nevertheless worth considering), designers will provide the greatest value by identifying the underlying fundamental objectives of work and thinking broadly about how to achieve those objectives. Many people miss the opportunity to build relationships with colleagues and find fundamental value in the depths and breadths of human connection afforded by work. As we've shown, incorporating such individual and collective values will continue to prove necessary for solutions to stand the test of time.

To drive such efforts, designers and researchers should engage in interdisciplinary collaborations to further develop theory. Contractor notes that the web and cyberinfrastructure create "unprecedented potential for the development of 'design-assisted theory construction' to advance our understanding of communication technologies and social behavior" due to their data-generation capabilities.[100] To date, the unique contexts of workplaces leave many studies to utilize case studies and correlation to distill meaning from practice, or hypothesize about practice through student experiments. Collaborating with scholars of organizational communication, social networks, computer science, information, management, sociology, and more would create *shared* theoretical understandings of complex systems that could feed back into designs, thereby producing more meaningful solutions to the unwieldy sociotechnical challenges of virtual collaboration.

Countless other possibilities remain. In reading this piece, 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, creating significant obstacles if we seek to make virtual collaboration into a strategic advantage. To achieve *that* goal, new designs for hybrid collaboration must, on average, achieve the same or greater performance and satisfaction for workers and organizations as FtF work. Such a tall order

[99] cf. Simon, *The Sciences of the Artificial*, chap. 6,"Social Planning: Designing the Evolving Artifact"; Senge, *The Fifth Discipline*.
[100] Contractor, "The Emergence of Multidimensional Networks," 745.

practically necessitates that designs be adaptive and responsive to the needs of diverse stakeholders,[101] up to and including new and adaptive organizational forms.[102]

The flexibility to design the ways and means of hybrid and remote collaboration offer great potential not afforded to FtF work. By implementing these attributes, virtual organizations could conceivably become more balanced, psychologically safe, and diverse than even FtF organizations. Let this prospect motivate us to help people by developing artifacts that solve the complex systemic design challenge that is virtual work.

Conclusion

The COVID-19 pandemic accelerated the transition of work from face-to-face to virtual forms of collaboration. This left society with widespread challenges because work as we know it was designed for a colocated rather than distributed or hybrid form. Fortunately, the abilities of design to engage with fourth-order, complex system design problems leave the discipline uniquely positioned to respond. This article proposes that we redesign "work" -- both its technical and social elements -- for a future of remote and hybrid collaboration in ways that make virtual collaboration itself a strategic advantage for diverse populations by designing for the underlying needs of collaborative work. Building upon this context, designers and researchers should develop new ways of working that make the flexibility of hybrid work more beneficial than our colocated past.

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References

Amadeo, Ron. "Google Meet Takes on Zoom with AI-Powered Noise Cancellation." *Ars Technica*, June 9, 2020. https://arstechnica.com/gadgets/2020/06/google-meet-takes-on-zoom-with-ai-powered-noise-cancellation/.

Arntz, Melanie, Ben Yahmed Sarra, and Francesco Berlingieri. "Working from Home: Heterogeneous Effects on Hours Worked and Wages." SSRN Scholarly Paper. Rochester, NY: Social Science Research Network, 2019. https://doi.org/10.2139/ssrn.3383408.

Baer, Markus, and Michael Frese. "Innovation Is Not Enough: Climates for Initiative and Psychological Safety, Process Innovations, and Firm Performance." *Journal of Organizational Behavior* 24, no. 1 (2003): 45–68. https://doi.org/10.1002/job.179.

Bailyn, Lotte, and Mona Harrington. "Redesigning Work for Work–Family Integration." *Community, Work & Family* 7, no. 2 (August 1, 2004): 197–208. https://doi.org/10.1080/1366880042000245470.

[101] Redström, "Towards User Design?"; Mathieu et al., "Team Effectiveness 1997-2007."

[102] Zammuto et al., "Information Technology and the Changing Fabric of Organization"; Frey, Krafft, and Keegan, "This Place Does What It Was Built For."

Bechky, Beth A., and Daisy E. Chung. “Latitude or Latent Control? How Occupational Embeddedness and Control Shape Emergent Coordination.” *Administrative Science Quarterly* 63, no. 3 (September 1, 2018): 607–36. https://doi.org/10.1177/0001839217726545.

Berger, Peter L, and Thomas Luckmann. *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*. Penguin Uk, 1991.

Bernstein, Amy, Amy Gallo, and Emily Caulfield. “How Mothers WFH Are Negotiating What’s Normal.” *Harvard Business Review*, October 12, 2020. https://hbr.org/podcast/2020/10/how-mothers-wfh-are-negotiating-whats-normal.

Bloom, Nicholas. “Stanford Professor on the New Remote Work Economy: A ‘productivity Disaster’ and ‘Ticking Time Bomb for Inequality.’” *CNBC*, October 7, 2020, sec. Make It - Work. https://www.cnbc.com/2020/10/07/stanford-professor-not-optimistic-about-work-from-home-economy-ticking-time-bomb-for-inequality.html.

Body, John, and Nina Terrey. *Design for a Better Future: A Guide to Designing in Complex Systems*. Milton, UNITED KINGDOM: Taylor & Francis Group, 2019. http://ebookcentral.proquest.com/lib/uvm/detail.action?docID=5744589.

Boh, Wai Fong, Yuqing Ren, Sara Kiesler, and Robert Bussjaeger. “Expertise and Collaboration in the Geographically Dispersed Organization.” *Organization Science* 18, no. 4 (March 2007): 595–612.

Bruner, Jerome Seymour. *Acts of Meaning*. Vol. 3. Harvard university press, 1990.

Brynjolfsson, Erik, John J. Horton, Adam Ozimek, Daniel Rock, Garima Sharma, and Hong-Yi TuYe. “COVID-19 and Remote Work: An Early Look at US Data.” National Bureau of Economic Research, June 15, 2020. https://doi.org/10.3386/w27344.

Buchanan, Richard. “Branzi’s Dilemma: Design in Contemporary Culture.” *Design Issues* 14, no. 1 (1998): 3–20. https://doi.org/10.2307/1511825.

———. “Wicked Problems in Design Thinking.” *Design Issues* 8, no. 2 (1992): 5–21. https://doi.org/10.2307/1511637.

Carleton, R Nicholas. “Into the Unknown: A Review and Synthesis of Contemporary Models Involving Uncertainty.” *Journal of Anxiety Disorders* 39 (2016): 30–43.

Carmeli, Abraham, and Jody Hoffer Gittell. “High-Quality Relationships, Psychological Safety, and Learning from Failures in Work Organizations.” *Journal of Organizational Behavior* 30, no. 6 (2009): 709–29. https://doi.org/10.1002/job.565.

Chudoba, Katherine M., Eleanor Wynn, Mei Lu, and Mary B. Watson‐Manheim. “How Virtual Are We? Measuring Virtuality and Understanding Its Impact in a Global Organization.” *Information Systems Journal* 15, no. 4 (2005): 279–306. https://doi.org/10.1111/j.1365-2575.2005.00200.x.

Coldewey, Devin. “How to Work during a Pandemic.” *TechCrunch* (blog), March 1, 2020. https://social.techcrunch.com/2020/03/01/how-to-work-during-a-pandemic/.

Contractor, Noshir. “The Emergence of Multidimensional Networks.” *Journal of Computer-Mediated Communication* 14, no. 3 (2009): 743–47. https://doi.org/10.1111/j.1083-6101.2009.01465.x.

Dicicco, Elaine Claire. “Competent But Hostile: Intersecting Race/Gender Stereotypes And The Perception Of Women’s Anger In The Workplace.” Pennsylvania State University, 2012. https://etda.libraries.psu.edu/catalog/17672.

Eagle, Liam. “Coronavirus Flash Survey June 2020.” S&P Global Market Intelligence, June

2020. https://pages.marketintelligence.spglobal.com/451-on-COVID19-Request.html?utm_source=spgisite.

———. “Coronavirus Flash Survey October 2020.” S&P Global Market Intelligence, October 2020. https://pages.marketintelligence.spglobal.com/rs/565-BDO-100/images/VotE_DigitalPulse-CoronavirusFlashSurveyOct2020-Advisory-FINAL.pdf.

Edmondson, Amy. “Psychological Safety and Learning Behavior in Work Teams.” *Administrative Science Quarterly* 44, no. 2 (June 1, 1999): 350–83. https://doi.org/10.2307/2666999.

Fiol, C. Marlene, and Edward J. O’Connor. “Identification in Face-to-Face, Hybrid, and Pure Virtual Teams: Untangling the Contradictions.” *Organization Science* 16, no. 1 (February 1, 2005): 19–32. https://doi.org/10.1287/orsc.1040.0101.

Fosslien, Liz, and Mollie West Duffy. “How to Combat Zoom Fatigue.” *Harvard Business Review*, April 29, 2020. https://hbr.org/2020/04/how-to-combat-zoom-fatigue.

Frey, Seth, P. M. Krafft, and Brian C. Keegan. “‘This Place Does What It Was Built For’: Designing Digital Institutions for Participatory Change.” *Proceedings of the ACM on Human-Computer Interaction* 3, no. CSCW (November 7, 2019): 32:1–32:31. https://doi.org/10.1145/3359134.

Fuglerud, Kristin Skeide, and David Sloan. “The Link between Inclusive Design and Innovation: Some Key Elements.” In *Human-Computer Interaction. Human-Centred Design Approaches, Methods, Tools, and Environments*, edited by Masaaki Kurosu, 41–50. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer, 2013. https://doi.org/10.1007/978-3-642-39232-0_5.

Gibbs, Jennifer L, Anu Sivunen, and Maggie Boyraz. “Investigating the Impacts of Team Type and Design on Virtual Team Processes.” *Human Resource Management Review* 27, no. 4 (2017): 590–603. https://doi.org/10.1016/j.hrmr.2016.12.006.

Gibson, Cristina B., and Jennifer L. Gibbs. “Unpacking the Concept of Virtuality: The Effects of Geographic Dispersion, Electronic Dependence, Dynamic Structure, and National Diversity on Team Innovation.” *Administrative Science Quarterly* 51, no. 3 (September 1, 2006): 451–95. https://doi.org/10.2189/asqu.51.3.451.

Gilson, Lucy L, M Travis Maynard, Nicole C Jones Young, Matti Vartiainen, and Marko Hakonen. “Virtual Teams Research: 10 Years, 10 Themes, and 10 Opportunities.” *Journal of Management* 41, no. 5 (November 2014): 1313–37. https://doi.org/10.1177/0149206314559946.

Golsby-Smith, Tony. “Fourth Order Design: A Practical Perspective.” *Design Issues* 12, no. 1 (1996): 5–25. https://doi.org/10.2307/1511742.

Graffeo, Emily. “Former Fed Chair Alan Greenspan Says the US Is Entering a Period of Slow Economic Growth on Lowered Productivity | Markets Insider.” *Business Insider*, October 21, 2020, sec. Markets. https://www.businessinsider.com/economic-outlook-alan-greenspan-fed-slow-growth-productivity-entitlements-aging-2020-10.

Gratton, Lynda. “How to Increase Collaborative Productivity in a Pandemic.” *MIT Sloan Management Review*, June 8, 2020. https://sloanreview.mit.edu/article/how-to-increase-collaborative-productivity-in-a-pandemic/.

Gray, John V., Enno Siemsen, and Gurneeta Vasudeva. “Colocation Still Matters: Conformance Quality and the Interdependence of R&D and Manufacturing in the Pharmaceutical Industry.” *Management Science* 61, no. 11 (May 18, 2015): 2760–81. https://doi.org/10.1287/mnsc.2014.2104.

Hinds, Pamela J, and Diane E Bailey. “Out of Sight, Out of Sync: Understanding Conflict in Distributed Teams.” *Organization Science* 14, no. 6 (March 2003): 615–32.

Hoch, Julia E, and Steve W J Kozlowski. “Leading Virtual Teams: Hierarchical Leadership, Structural Supports, and Shared Team Leadership.” *Journal of Applied Psychology* 99, no. 3 (May 2014): 390–403. https://doi.org/10.1037/a0030264.

Hollingshead, Andrea B., Joseph E. Mcgrath, and Kathleen M. O’Connor. “Group Task Performance and Communication Technology: A Longitudinal Study of Computer-Mediated Versus Face-to-Face Work Groups.” *Small Group Research* 24, no. 3 (August 1, 1993): 307–33. https://doi.org/10.1177/1046496493243003.

Hong, Lu, and Scott E Page. “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, no. 46 (November 2004): 16385 LP – 16389. https://doi.org/10.1073/pnas.0403723101.

Johnson, Susan. “Cross-Functional Team Performance: Inquiry, Identity and Shared Reality.” Case Western Reserve University, 2020.

Kirkman, Bradley L., Benson Rosen, Cristina B. Gibson, Paul E. Tesluk, and Simon O. McPherson. “Five Challenges to Virtual Team Success: Lessons from Sabre, Inc.” *Academy of Management Perspectives* 16, no. 3 (August 1, 2002): 67–79. https://doi.org/10.5465/ame.2002.8540322.

Klug, Michael, and James P Bagrow. “Understanding the Group Dynamics and Success of Teams.” *Royal Society Open Science* 3, no. 4 (2016): 160007.

Larson, Lindsay, and Leslie A DeChurch. “Leading Teams in the Digital Age: Four Perspectives on Technology and What They Mean for Leading Teams.” *The Leadership Quarterly* 31, no. 1 (2020): 101377–101377. https://doi.org/10.1016/j.leaqua.2019.101377.

Leonardi, Paul M., Diane E. Bailey, Eduardo H. Diniz, Dan Sholler, and Bonnie Nardi. “Multiplex Appropriation in Complex Systems Implementation: The Case of Brazil’s Correspondent Banking System.” *MIS Quarterly* 40, no. 2 (June 2016): 461–74.

Li, Eldon Y., James J. Jiang, and Gary Klein. “The Impact of Organizational Coordination and Climate on Marketing Executives’ Satisfaction with Information Systems Services.” *Journal of the Association for Information Systems* 4, no. 1 (May 1, 2003). https://doi.org/10.17705/1jais.00031.

Liao, Chenwei. “Leadership in Virtual Teams: A Multilevel Perspective.” *Human Resource Management Review* 27, no. 4 (2017): 648–59. https://doi.org/10.1016/j.hrmr.2016.12.010.

Lu, Mei, Mary Beth Watson-Manheim, Katherine M. Chudoba, and Eleanor Wynn. “Virtuality and Team Performance: Understanding the Impact of Variety of Practices.” *Journal of Global Information Technology Management* 9, no. 1 (January 1, 2006): 4–23. https://doi.org/10.1080/1097198X.2006.10856412.

Majchrzak, Ann, M Lynne Markus, and Jonathan Wareham. “Designing for Digital Transformation: Lessons for Information Systems Research from the Study of ICT and Societal Challenges.” *MIS Quarterly* 40, no. 2 (2016): 267–77.

Malhotra, Arvind, and Ann Majchrzak. “Enhancing Performance of Geographically Distributed

Teams through Targeted Use of Information and Communication Technologies." *Human Relations* 67, no. 4 (April 1, 2014): 389–411. https://doi.org/10.1177/0018726713495284.
Malhotra, Arvind, Ann Majchrzak, and Benson Rosen. "Leading Virtual Teams." *Academy of Management Perspectives* 21, no. 1 (2007): 60–70.
Marlow, Shannon L, Christina N Lacerenza, and Eduardo Salas. "Communication in Virtual Teams: A Conceptual Framework and Research Agenda." *Human Resource Management Review* 27, no. 4 (2017): 575–89. https://doi.org/10.1016/j.hrmr.2016.12.005.
Martins, Luis L, Lucy L Gilson, and M Travis Maynard. "Virtual Teams: What Do We Know and Where Do We Go From Here?" *Journal of Management* 30, no. 6 (December 2004): 805–35. https://doi.org/10.1016/j.jm.2004.05.002.
Mathieu, John, M. Travis Maynard, Tammy Rapp, and Lucy Gilson. "Team Effectiveness 1997-2007: A Review of Recent Advancements and a Glimpse Into the Future." *Journal of Management* 34, no. 3 (June 1, 2008): 410–76. https://doi.org/10.1177/0149206308316061.
Mattelmäki, Tuuli, Kirsikka Vaajakallio, and Ilpo Koskinen. "What Happened to Empathic Design?" *Design Issues* 30, no. 1 (December 19, 2013): 67–77. https://doi.org/10.1162/DESI_a_00249.
Maznevski, Martha L., and Katherine M. Chudoba. "Bridging Space Over Time: Global Virtual Team Dynamics and Effectiveness." *Organization Science* 11, no. 5 (October 1, 2000): 473–92. https://doi.org/10.1287/orsc.11.5.473.15200.
McEvers, Kelly, Ailsa Chang, Mary Louise Kelly, and Danielle Kurtzleben. "Ideas For Reopening Schools; Evidence Of Airborne Spread." *Consider This from NPR*, July 7, 2020. https://www.npr.org/2020/07/07/888159170/ideas-for-reopening-schools-evidence-of-airborne-spread.
Meluso, John, Jesse Austin-Breneman, and Jose Uribe. "Estimate Uncertainty: Miscommunication About Definitions of Engineering Terminology." *Journal of Mechanical Design* 142, no. 7 (February 2020). https://doi.org/10.1115/1.4045671.
Melville, Nigel, Kenneth Kraemer, and Vijay Gurbaxani. "Information Technology and Organizational Performance: An Integrative Model of IT Business Value." *MIS Quarterly* 28, no. 2 (2004): 283–322.
Molla, Rani. "Is Slack Ruining Our Jobs — and Lives?" *Vox*, May 1, 2019, sec. Recode. https://www.vox.com/recode/2019/5/1/18511575/productivity-slack-google-microsoft-facebook.
Murić, Goran, Andres Abeliuk, Kristina Lerman, and Emilio Ferrara. "Collaboration Drives Individual Productivity." *Proceedings of the ACM on Human-Computer Interaction* 3, no. CSCW (November 7, 2019): 74:1–74:24. https://doi.org/10.1145/3359176.
Neeley, Tsedal. "Global Teams That Work." *Harvard Business Review* 93, no. 10 (2015): 74–81.
Neeley, Tsedal B, Pamela J Hinds, and Catherine D Cramton. "The (Un) Hidden Turmoil of Language in Global Collaboration." *Organizational Dynamics* 41, no. 3 (2012): 236–44.
Nilles, J. "Telecommunications and Organizational Decentralization." *IEEE Transactions on Communications* 23, no. 10 (October 1975): 1142–47. https://doi.org/10.1109/TCOM.1975.1092687.
Olson, Judith S, Stephanie Teasley, Lisa Covi, and Gary Olson. "The (Currently) Unique Advantages of Collocated Work." *Distributed Work*, 2002, 113–35.

O'Neill, Thomas A, Samantha E Hancock, Katarina Zivkov, Nicole L Larson, and Stephanie J Law. "Team Decision Making in Virtual and Face-to-Face Environments." *Group Decision and Negotiation* 25, no. 5 (2016): 995–1020. https://doi.org/10.1007/s10726-015-9465-3.

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

Pauwels, Pieter, Ronald De Meyer, and Jan Van Campenhout. "Design Thinking Support: Information Systems Versus Reasoning." *Design Issues* 29, no. 2 (2013): 42–59.

Peters, Linda M., and Charles C. Manz. "Identifying Antecedents of Virtual Team Collaboration." *Team Performance Management: An International Journal* 13, no. 3/4 (January 2007): 117–29. https://doi.org/10.1108/13527590710759865.

Polzer, Jeffrey T., C. Brad Crisp, Sirkka L. Jarvenpaa, and Jerry W. Kim. "Extending the Faultline Model to Geographically Dispersed Teams: How Colocated Subgroups Can Impair Group Functioning." *Academy of Management Journal* 49, no. 4 (August 1, 2006): 679–92. https://doi.org/10.5465/amj.2006.22083024.

Postma, Carolien, Kristina Lauche, and Pieter Jan Stappers. "Social Theory as a Thinking Tool for Empathic Design." *Design Issues* 28, no. 1 (December 28, 2011): 30–49. https://doi.org/10.1162/DESI_a_00122.

Ramirez, Ronald, Nigel Melville, and Edward Lawler. "Information Technology Infrastructure, Organizational Process Redesign, and Business Value: An Empirical Analysis." *Decision Support Systems* 49, no. 4 (November 1, 2010): 417–29. https://doi.org/10.1016/j.dss.2010.05.003.

Redström, Johan. "Towards User Design? On the Shift from Object to User as the Subject of Design." *Design Studies* 27, no. 2 (March 1, 2006): 123–39. https://doi.org/10.1016/j.destud.2005.06.001.

Rice, Ronald E, and Paul M Leonardi. "Information and Communication Technologies in Organizations." *The SAGE Handbook of Organizational Communication: Advances in Theory, Research, and Methods*, 2014, 425–48.

Roberson, Quinetta M., and Hyeon Jeong Park. "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*, October 2007. http://journals.sagepub.com/doi/10.1177/1059601106291124.

Rosenberg, Nathan, and L. E Birdzell Jr. *How the West Grew Rich: The Economic Transformation of the Industrial World*. Basic books, 2008.

Rosette, Ashleigh Shelby, Christy Zhou Koval, Anyi Ma, and Robert Livingston. "Race Matters for Women Leaders: Intersectional Effects on Agentic Deficiencies and Penalties." *The Leadership Quarterly*, Special Issue: Gender and Leadership, 27, no. 3 (June 1, 2016): 429–45. https://doi.org/10.1016/j.leaqua.2016.01.008.

Schaubroeck, John M, and Andrew Yu. "When Does Virtuality Help or Hinder Teams? Core Team Characteristics as Contingency Factors." *Human Resource Management Review* 27, no. 4 (2017): 635–47. https://doi.org/10.1016/j.hrmr.2016.12.009.

Schulze, Julian, and Stefan Krumm. "The 'Virtual Team Player': A Review and Initial Model of Knowledge, Skills, Abilities, and Other Characteristics for Virtual Collaboration." *Organizational Psychology Review* 7, no. 1 (November 2016): 66–95. https://doi.org/10.1177/2041386616675522.

Scott, W Richard, and Gerald F Davis. *Organizations and Organizing: Rational, Natural, and*

Open System Perspectives. 1st ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.
Senge, Peter M. *The Fifth Discipline: The Art & Practice of the Learning Organization*. New York, UNITED STATES: Crown/Archetype, 2010. https://ebookcentral-proquest-com.proxy.lib.umich.edu/lib/umichigan/detail.action?docID=5336528.
Shachaf, Pnina. "Cultural Diversity and Information and Communication Technology Impacts on Global Virtual Teams: An Exploratory Study." *Information & Management* 45, no. 2 (March 1, 2008): 131–42. https://doi.org/10.1016/j.im.2007.12.003.
Simon, Herbert A. *The Sciences of the Artificial*. MIT Press, 1996.
Sinha, Kingshuk K., and Andrew H. Van de Ven. "Designing Work Within and Between Organizations." *Organization Science* 16, no. 4 (August 1, 2005): 389–408. https://doi.org/10.1287/orsc.1050.0130.
Smith, H. Jeff, Tamara Dinev, and Heng Xu. "Information Privacy Research: An Interdisciplinary Review." *MIS Quarterly* 35, no. 4 (December 1, 2011): 989–1016.
Steinfield, Charles, Chyng-Yang Jang, and Ben Pfaff. "Supporting Virtual Team Collaboration: The TeamSCOPE System." In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work*, 81–90. GROUP '99. Phoenix, Arizona, USA: Association for Computing Machinery, 1999. https://doi.org/10.1145/320297.320306.
Thompson, E. P. "Time, Work-Discipline, and Industrial Capitalism." *Past & Present*, no. 38 (1967): 56–97.
Thompson, Leigh L. *Making the Team: A Guide for Managers*. Sixth Edit. New York, NY: Pearson Education, 2016.
Valet, Vicky. "Working From Home During The Coronavirus Pandemic: What You Need To Know." *Forbes*, March 12, 2020, sec. Leadership. https://www.forbes.com/sites/vickyvalet/2020/03/12/working-from-home-during-the-coronavirus-pandemic-what-you-need-to-know/.
Watkins Allen, Myria, Stephanie J. Coopman, Joy L. Hart, and Kasey L. Walker. "Workplace Surveillance and Managing Privacy Boundaries." *Management Communication Quarterly* 21, no. 2 (November 1, 2007): 172–200. https://doi.org/10.1177/0893318907306033.
Weick, Karl E. "The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster." *Administrative Science Quarterly* 38, no. 4 (1993): 628–52. https://doi.org/10.2307/2393339.
Weick, Karl E, Kathleen M Sutcliffe, and David Obstfeld. "Organizing for High Reliability: Processes of Collective Mindfulness." *Crisis Management* 3, no. 1 (2008): 81–123.
Wheatley, Dan. "Good to Be Home? Time-Use and Satisfaction Levels among Home-Based Teleworkers." *New Technology, Work and Employment* 27, no. 3 (2012): 224–41. https://doi.org/10.1111/j.1468-005X.2012.00289.x.
Wilson, Jeanne M., Michael Boyer O'Leary, Anca Metiu, and Quintus R. Jett. "Perceived Proximity in Virtual Work: Explaining the Paradox of Far-but-Close." *Organization Studies* 29, no. 7 (July 1, 2008): 979–1002. https://doi.org/10.1177/0170840607083105.
Wingfield, Adia Harvey. "Are Some Emotions Marked Whites Only? Racialized Feeling Rules in Professional Workplaces." *Social Problems* 57, no. 2 (May 1, 2010): 251–68. https://doi.org/10.1525/sp.2010.57.2.251.
———. "The Modern Mammy and the Angry Black Man: African American Professionals' Experiences with Gendered Racism in the Workplace." *Race, Gender & Class* 14, no. 1/2

(2007): 196–212.
Zammuto, Raymond F., Terri L. Griffith, Ann Majchrzak, Deborah J. Dougherty, and Samer Faraj. “Information Technology and the Changing Fabric of Organization.” *Organization Science* 18, no. 5 (October 1, 2007): 749–62. https://doi.org/10.1287/orsc.1070.0307.
Zuboff, Shoshana. *In the Age of the Smart Machine: The Future of Work and Power*. Oxford: Heinemann Professional, 1988.