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Digital inequalities 2.0: Legacy inequalities in the information age

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Abstract

2020 marks the 25*th* anniversary of the "digital divide." Although a quarter century has passed, legacy digital inequalities continue, and emergent digital inequalities are proliferating. Many of the initial schisms identified in 1995 are still relevant today. Twenty-five years later, foundational access inequalities continue to separate the digital haves and the digital have-nots within and across countries. In addition, even ubiquitous-access populations are riven with skill inequalities and differentiated usage. Indeed, legacy digital inequalities persist *vis-à-vis* economic class, gender, sexuality, race and ethnicity, aging, disability, healthcare, education, rural residency, networks, and global geographies. At the same time, emergent forms of inequality now appear alongside legacy inequalities such that notions of digital inequalities must be continually expanded to become more nuanced. We capture the increasingly complex and interrelated nature of digital inequalities by introducing the concept of the "digital inequality stack." The concept of the digital inequality stack encompasses access to connectivity networks, devices, and software, as well as collective access to network infrastructure. Other layers of the digital inequality stack include differentiated use and consumption, literacies and skills, production and programming, etc. When inequality exists at foundational layers of the digital inequality stack, this often translates into inequalities at higher levels. As we show across these many thematic foci, layers in the digital inequality stack may move in tandem with one another such that all layers of the digital inequality stack reinforce disadvantage.

Contents

Introducing legacy inequalities in the information age: The digital inequality stack

2020 marks the 25th anniversary of the "digital divide". This important milestone is marked in *First Monday* through a two-article series on digital inequalities in a special section bringing together scholars from across the globe whose expertise and vision have evolved with the very field itself. Despite the passing of a quarter century, legacy digital inequalities remain, while emergent digital inequalities are proliferating.

In the first article, "Digital inequalities 2.0: Legacy inequalities in the information age," we observe that many of the initial schisms identified in 1995 are still relevant today [1]. Twenty-five years later, foundational access inequalities continue to separate the digital-haves and the digital have-nots within and across countries. In addition, even in populations where access is widespread, there are distinct inequalities in terms of quality of network and device access. Further, even near ubiquitous-access populations are marked by differentiated usage and riven with skill divides. Indeed, legacy digital inequalities persist *vis-à-vis* economic class, gender, sexuality, race and ethnicity, aging, disability, healthcare, education, rural residency, networks, and global geographies — all of which are being exacerbated at the time of writing by the COVID-19 pandemic.

At the same time, emergent forms of inequality continually appear alongside legacy inequalities. In the second article in this two-part series, "Digital inequalities 3.0: Emergent inequalities in the information age," we explicitly offer an enlarged vision of digital inequalities to advocate for broadband accessibility as a human right. We examine the increasingly complex inequalities spawned by the platform economy, digital labor, automation, big data, the use of algorithms in the criminal justice system, cybersafety, civic engagement, mobility, gaming, well-being and the life course, and assistive technologies.

Across these two articles, we capture the increasingly complex and interrelated nature of digital inequalities by coining the term the "digital inequality stack." We draw our inspiration from the computing stack, which comprises multiple layers that must work together including the operating system, network, software, and user interface. We metaphorically extend the concept of the computing stack to capture the complexities of digital inequalities as they occur on many interrelated levels. When we transform the metaphor to speak to digital inequalities, we see that layers include access, skills, and usage — all of which must work in concert for optimal outcomes.

Concerning the access layer of the digital inequality stack, the concept of access must capture connectivity, device, and software access. Connectivity inequalities exist in terms of quality, duration, continuity, etc. In addition, device inequalities exist independent of connectivity. Highly resourced individuals enjoy a portfolio of multiple devices appropriate to different usage and tasks for their personal use such that they have mobile, at-will access 24/7. A third facet of access accounts for software, applications, cybersecurity, and other paid services; those with fewer resources may not have access to paid services they cannot afford from Office subscriptions to anti-virus software to name but two examples.

In addition, connectivity, device, and software access inequalities, skills and usage are also heterogeneous. From diverse domains of consumption from information seeking to shopping, differentiated use and skills continue to manifest themselves. Skill and usage inequalities also encompass prosumption activities including social media production and curation, rating systems, etc. At the production end of the spectrum, skill inequalities also exist from programming to software design to hardware engineering to AI and beyond. Skills may also impact usage and vice versa, particularly for capital-enhancing activities. Obvious examples include telework, e-learning, and telemedicine that may act to replicate both digital advantage and disadvantage.

As we show across multiple contexts, the concept of the digital inequality stack is central to legacy and emergent forms of inequality in the digital age. The digital inequality stack's infrastructure layer necessitates collective access to network infrastructure, as well as individual access to devices. Other layers of the digital inequality stack include opportunities for literacy acquisition and skill building, all of which are implicated in differentiated use, consumption, production, etc. While foundational layers are necessary, they are insufficient to automatically enable higher layers. Therefore, as we show, it is a grave error to believe that universal access and mobility automatically or organically obviate higher level divides such as skills and literacies. On the contrary, as ubiquitous mobile computing and connectivity evolve, each new wave of "progress" simultaneously generates new avenues for the reproduction of disparities. Therefore, social inequalities are continually being amplified and reproduced in the digital realm, ever necessitating a fresh examination of the field.

From digital divides to digital inclusion

Research on the digital divide has three generally recognized topics: access, use, and outcomes. These correspond roughly to three time periods of research. The first-level digital divide refers to physical access to computers and the Internet. This was the sense in which the term "digital divide" was first used in a report published in 1995 by the National Telecommunications and Information Administration (NTIA) titled "Falling through the Net: A survey of the 'have nots' in rural and urban America." This report initiated a research stream that understood the digital divide in largely technical terms about who had and did not have access to necessary hardware (Katz and Aspden, 1997; Hoffman and Novak, 1998). Much of this work analyzed demographic predictors of Internet access.

Access alone suggests a techno-deterministic perspective where the benefits of a technology automatically follow adoption, but the Internet is complex and not easy to navigate. Simply because people who have Internet access does not mean they are all equally successful in their use of the Internet. Thus, the conceptual focus of research broadened to address the question of who makes effective use of digital technologies. This research stream is often called the "second-level divide" (Attewell, 2001), but it is also called the "participation gap" (Jenkins, *et al.*, 2006), "emerging digital differentiation" (Peter and Valkenburg, 2006) or the "usage gap". These concepts highlight inequalities in participation based on digital skills, how the Internet was used, as well as demographic predictors.

Access, skills, and use also turn out not to be sufficient to characterize Internet use; they are inputs, and what we really care about are outcomes. This is the "third-level digital divide". The research questions here include what groups of people use the Internet to improve their learning, information-seeking, productivity, and other activities that enhance their income and influence as opposed to using the Internet for entertainment or sports. The consistent answer is that people from more privileged backgrounds tend to engage in more capital-enhancing activities (Bonfadelli, 2002; Eynon, 2009).

People on the wrong side of any of the digital divides — access, use, and outcomes — can be seriously disadvantaged. The digital advantaged have regular, reliable access to digital technologies without significant opportunity costs. As we will see, these digital resources provide them with opportunities across all life spheres from jobs, to health information, products and services, and education. Also as we will see, digital resources and skills are increasingly needed to participate as a digital citizen and to protect against harmful outcomes, such as ransomware or credit card fraud. For all of these reasons, from the macro-perspective, as countries become more digital-intensive, digital resources are increasingly vital to enhance economic productivity, social inclusion, and efficient government services. In this way, digital inequality has implications for the economic, social, and political well-being of whole countries.

Economic class

Economic class remains a strong predictor of disparities throughout the digital inequality stack, including quality of hardware, software, network access, usage patterns, and skills. In 2019, even as certain populations approach ubiquitous adoption, those on the bottom rungs of the economic ladder are far more likely to be partially or wholly digitally excluded than those on higher rungs of the economic class ladder. For example, even in countries with the highest levels of Internet adoption and digital device diffusion such as the Netherlands, there is still a statistically significant income gradient in relation to access, use, and diversity of digital devices (van Deursen and van Dijk, 2019).

In the U.S., Pew data reveals striking differences are obvious between Americans earning less than $30,000 per year and those earning more than $100,000 per year. More specifically: 1) 29 percent of low-income Americans compared to three percent of high-income Americans do not own smartphones; 2) 44 percent of low-income Americans compared to six percent of high-income Americans do not have broadband service; 3) 46 percent of low-income Americans compared to six percent of high-income Americans do not have a laptop or desktop computer; 4) 64 percent of low-income Americans compared to 30 percent of high-income Americans do not own a tablet; and, 5) 18 percent of low-income Americans compared to 64 percent of high-income Americans own all of these digital devices and services (Anderson and Kumar, 2019).

Further, disparities exist in usage patterns and digital footprints associated with economic class that have strong implications for life chances. They argue that those occupying already privileged economic positions in society have higher-quality access to digital resources, use those resources more profitably and effectively, and further enhance their economic well-being. More specifically, those who are from higher economic status groups are more likely to use the Internet for work (Selwyn, 2005), for capital-enhancing activities (DiMaggio, *et al.*, 2004), for education (Robinson and Schulz, 2013), for healthcare (Khilnani, *et al.*, 2020) and to reinforce their social position in society (van Deursen and van Dijk, 2014). In sum, the economically privileged use the Internet more broadly and in more sophisticated ways for informational or service-oriented purposes than their lower income counterparts who are more likely to use digital resources for entertainment (Bonfadelli, 2002; Peter and Valkenburg, 2006).

Economic class also influences levels of digital capital (Ragnedda, *et al.*, 2020) and the capacity to gain greater benefits from the use of the Internet (Ragnedda, 2018, 2017). The Matthew effect (Merton, 1968), the knowledge gap (Tichenor, *et al.*, 1970) and the accumulation of advantage hypothesis help explain the relationship between economic advantage and multiple layers of the digital inequality stack.

Gender

Gender represents a particularly interesting case of how disparities cut across multiple layers of the digital inequality stack. Research has shown that the diffusion of the Internet followed conventional trajectories by spreading unevenly along existing axes of social inequality, especially in its early stages (Norris, 2001; Ono and Zavodny, 2007). Gender differences in online activity were a key focal point in the first wave of digital inequality research, arising out of concerns that women may have less access to the Internet, and consequently be excluded from reaping the benefits of the information economy. Subsequent waves of research established that, at least in the U.S. and other advanced economies, the gender gap in access and use had disappeared, or had even reversed (Campos-Castillo, 2015; Ono and Zavodny, 2003).

Recent research on gender and digital inequality has evolved from simply identifying and monitoring gender gaps in Internet use, to more in-depth and nuanced studies that explore emerging themes related to digital activities. Studies of Internet addiction, for example, typically show that men are more prone to Internet addiction than are women (Kannan, *et al.*, 2019). The gender gap in cybercrime is another emerging issue. Reflecting the general trend that men are more likely to engage in offending behavior than are women, Donner (2016) finds that male undergraduate students report higher rates of digital piracy, cyber-harassment, and hacking than do their female counterparts. Other studies have examined gender differences in cyber-loafing (Baturay and Toker, 2015), Internet affairs and infidelity, the use of online versus printed newspapers (Taipale, 2013), as well as the use of online and off-line identities (Helsper, 2014).

Current research has also put the spotlight on the gender gaps that still remain in emerging countries. Significantly, for sociologists, these studies remind us that context matters: women in emerging countries have less access because of differences in social norms, expectations, and institutional arrangements. Examples include Bertrand and Fidele's (2016) study of Internet adoption in Cameroon; Gray, *et al.'s* (2017) study of Internet use in Latin American countries; and, Hoque, *et al.'s* (2017) study of e-Health adoption in Bangladesh.

The Organisation for Economic Cooperation and Development (OECD) published *Bridging the digital gender divide* (OECD, 2018) which called attention to the widening gender gap in Internet usage among the emerging countries. Between 2013 and 2017, the gender gap narrowed in developed economies, whereas it widened in less developed countries. The report outlines the vicious cycle, particularly in the emerging countries, where women are less likely to have access to the Internet and other digital technologies, which in turn lowers their likelihood of participation in labor markets and socio-economic advancement as a whole, which ultimately lowers the educational aspirations of women for the subsequent generations. The report calls for specific action plans such as integrating digital technologies to compulsory education and raising awareness about online education programs (*e.g.*, MOOCs). Finally, while gender and digital inequalities have been studied as a binary distinction between men and women, future research may reflect the evolution of more diverse gender categories.

Sexuality

Sexuality has implications for the digital inequality stack *vis-à-vis* second- and third-level digital inequalities. Whether online or off-line, sexuality concerns the expression of human desire for intimate companionship. Humans have a vast array of sexual expressions and orientations that reflect a seemingly limitless array of desires and interests beyond functional pro-creation. The Internet reconfigures accessibility and other forms of digital resource inequality (Dutton, *et al.*, 2009). This reconfiguration has implications for members of sexual minorities.

On coming out: The online world has a tendency to collapse contexts into consolidated "newsfeeds" and unitary real-name identities (Duguay, 2016). Those who come out have different friendship patterns online (McConnell, *et al.*, 2018) and different impression management strategies (Szulc and Dhoest, 2013). Through groups, forums, pages, and chat rooms, the Internet has revealed and consolidated a variety of new communities, often around paraphilias [*i.e.*, fetishes] such as "furry," "bear," "adult baby," "pup," etc. (McNair, 2013). With the heightened visibility and prevalence of paraphilias, coming out can be even more complex. For example, one might doubly come out as gay and a chubby chaser (Rosenmann and Safir, 2006). This is in addition to the challenges of coming out alongside other intersectional issues with self presentation online including but not limited to race, ethnicity, sexuality, and economic class (McConnell, *et al.*, 2018).

The digital world can make sexual minorities vulnerable in terms of forced disclosure and privacy, as well as the risks of bullying. This is true of online dating. Reconfiguring access means people and sexual objects are more findable and yet more vulnerable to the gaze of others, potentially disempowering individuals in terms of public stigma such as “slut shaming” and complicating relationship formation and dissolution (Gershon, 2010; Hogan, 2018). For gay men, the mobile app Grindr was a paradigm shift in findability (Blackwell, *et al.*, 2015) potentially narrowing the opportunity for finding relationships in the physical world while providing less satisfying digital alternatives.

Whereas disconnecting from commercial platforms can be seen as a way out in some cases, complete isolation from these platforms is hardly a feasible solution given the depth and extension to which women establish and maintain connections through them. Indeed, responsibility in and for the worldings in play on the Web requires the cultivation of response-abilities, instead of evasion when facing violent attacks. This means embedding infrastructural meanings and materials into our engagement with technology (*e.g.*, autonomous servers, hashtags), to infect technological processes and practices, compose and assemble shared stories from a feminist perspective — a kind of situated worlding. The examples we have discussed indicate the multiple ways through which women can get involved in online progressive politics: while some aim at recoding the unequal and misogynist infrastructure of the Web, some navigate and appropriate the space provided by commercial platforms.

Further, the shift to the digital creates hidden inequalities given the prevalence of dating sites and social media content data that reproduces or even exaggerates traditional sexual norms. Researchers have shown the existence of desire hierarchies on online dating sites (Bruch and Newman, 2018), while others have begun documenting the emergence of (often misogynistic) sexual grievance cultures such as the men’s rights movement (LaViolette and Hogan, 2019). Internet infidelity also emerges as it is easy to slide across boundaries online that would be otherwise clearly demarcated in off-line interaction (Norton, *et al.*, 2018) with sites such as AshleyMadison.com.

The fact that digital images can be easily created and manipulated, for example, through pornography and deep fake, make some demographic groups more vulnerable than others. But regulating access to pornography has proven difficult despite strong motivation from the challenges Internet porn creates or exacerbates. Stigma around nudity/sexuality coupled with easy access has led to concerns with “revenge porn” (Bates, 2017), “human flesh search”/facial recognition (Chao and Tao, 2012), and more recently “deep fakes”. These put sexual minorities and women at additional risk, particularly as women are more likely than men to be victims (Bates, 2017). Reports of child pornography are exploding while unwanted or unexpected exposure to pornography among pubescent/pre-pubescent children remains alarmingly high (Livingstone, *et al.*, 2018). Finally, compulsive pornography use is facilitated by the Internet and overuse of pornography is associated with lower relationship satisfaction (Morgan, 2011) although meta-analyses suggest these findings might be overstated.

Race and ethnicity

With respect to inequalities related to race and ethnicity, the digital inequality stack plays out differently across global contexts. Digital inequalities often augment racial and ethnic disparities that intersect with other forms of inequality (Fuchs and Horak, 2008) as in the case of multicultural societies that are characterized by the existence of ethnic and racial groups that hold different positions in the stratification system.

The study of digital inequality investigates how different ethnic and racial groups access and use new technology and how their differing digital engagements lead to the amplification or reduction of social disadvantages (Chen, 2013). For example, it is well documented that because of health-related social inequalities, minorities are more likely to access online health information but less likely to use e-health services (Mesch, *et al.*, 2012; Mesch, 2016; Mitchell, *et al.*, 2019), a service that is essential during the ongoing COVID-19 pandemic (Khilnani, *et al.*, 2020). As this indicates, digital resources may both reinforce existing racial inequalities or provide new avenues through which some inequalities may be mitigated. Reflecting this tension, research on digital inequalities has relied on two central contrasting perspectives in relation to race and ethnicity: the stratification hypothesis and the diversification hypothesis.

The stratification hypothesis holds that the process of ICT adoption, use, and skills, replicates existing social inequalities, and online networks replicate off-line social network structures. Early research showed that Internet use among ethnic and racial minorities was typically lower among racial minority groups than for majority groups. Disadvantaged minorities in the U.S. have smaller social networks and greater network homophily, representing a barrier for access to social capital (DiMaggio and Garip, 2012; DiPrete, *et al.*, 2011). According to the stratification hypothesis, as with gender, these early studies indicated that digital inequalities related to race and ethnicity followed the trajectories of off-line marginalization.

By contrast, the diversification hypothesis holds that ethnic and racial groups can expand their social networks and social capital through access to online networks. Consistent with this perspective, studies in the U.S. found that African Americans reported a significantly higher number of weak ties, while White Americans had a significantly higher number of strong ties. Work on Brazil among “Afro-Brasileiros” in low-SES neighborhoods also shows how digital resources can be employed to cross social boundaries and forge beneficial ties (Nemer, 2015). Minorities’ efforts are directed to access information and resources through weak ties, consistent with the social diversification hypothesis (Mesch, 2018). These theoretical perspectives are not incompatible. While the stratification hypothesis is better suited to the study of social inequality in access, the social diversification hypothesis is more suited for the study of the outcomes of access and use.

Minorities may use ICT to reduce network homophily and increase the number of weak ties to others. Thus, social media may constitute a promising ICT-based mechanism for the reduction of inequalities by creating weak ties which translate into real changes in social capital. Another example is the utilization of social media for content creation in the U.S. where African Americans report more online content creation than comparable European Americans. These preliminary results call for moving a step forward and investigating the extent to which activities such as content creation and the use of social media could potentially enhance the social capital of minority users.

Aging

Like other segments of the population, older adults also exhibit disparities associated with access, usage, and skills. In addition to these facets of the digital inequality stack, they are more likely to encounter challenges with technostress and technology maintenance. Although the proportion of older adults who are digitally active is increasing, individuals aged 65 and older are a heterogeneous demographic group, with significant differences in ICT use, exposure, and impacts. Compared to younger age groups, individuals aged 65 and older are still less likely to use the Internet, smartphones, and social media (Anderson and Kumar, 2019; Anderson and Perrin, 2017). Individuals aged 80 and older are even less likely to use ICTs than are those aged 65–79.

For those who are able to go online and use ICTs, this provides them opportunities to overcome spatial and social barriers, connect with social ties through e-mail, online communities, social media, and messaging, and access information for health, travel, entertainment, and other activities (Cotten, 2001; Cotten and Gupta, 2004; Hale, *et al.*, 2018; Hale, *et al.*, 2014). Staying engaged with social ties, participating in community events, and having access to informational and emotional resources are all critical to successful aging for older adults.

However, cost, cognitive ability, digital skills, and availability of technical support all factor into whether older adults (1) use ICTs; (2) continue to use ICTs over time; and, (3) acquire benefits of ICT use, particularly for individuals aged 80 and older (Cotten, *et al.*, 2017; van Deursen and Helsper, 2015). Declining health and limitations in activities of daily living may also result in older adults who use ICTs not being able to maintain ICT use over time (Cotten, *et al.*, 2017; Berkowsky, *et al.*, 2015).

Maintenance of ICTs is particularly important for ensuring that older adults have continuous, quality access to digital resources and garner benefits from them (Cotten, forthcoming). When a device ceases to function as it should, ICT maintenance is difficult for many older adults and especially older adults of lower socioeconomic status. Low-SES older adults may lack either the financial means to pay the professionals, such as the Geek Squad, or the social ties to enlist help (Francis, *et al.*, 2018).

Finally, some older adults also experience technostress due to challenges associated with rapidly changing ICTs (Nimrod, 2018; Tarafdar, *et al.*, 2007). Significant challenges for older adults include managing passwords, maintaining online safety, and understanding changing ICT interfaces (Cotten, Forthcoming; Cotten, *et al.*, 2017; Jiang, *et al.*, 2016). In sum, disparities in digital resources impact all layers of the digital inequality stack, especially for older adults who are also at risk for loss of digital autonomy and accompanying diminished well-being.

Disability

An understudied component of the digital inequality stack is disability. One of the most significant worldwide challenges for equality in the digital age is disability. One billion people, or 15 percent of the world's population are disabled. Those with disabilities, "Persons with disabilities are more likely to experience adverse socioeconomic outcomes than persons without disabilities, such as less education, poorer health outcomes, lower levels of employment, and higher poverty rates" (World Bank, 2020).

In terms of Internet (non-) use by various demographic groups in the U.S., the disability digital divide, as this aspect of digital inequality is known, is one of the largest and the most intractable. In 2017, the latest year for which data are available, the gap between non-disabled and disabled Internet users was 20.7 points. The disability digital divide has narrowed the least over time, when compared to other digital inequalities along demographic lines (U.S. Census Bureau, 2001–2017). Finally, disability intersects with other types of disadvantages in exacerbating digital inequality (Kretchmer and Drabowicz, 2018).

Recent research reveals the importance of the disaggregation of the disability digital divide by types of disability; how various demographic and socio-economic factors impact divergent groups differently; and the lack of relevance of the presence of home Internet service technologies on Internet use by those with most types of disabilities (Kretchmer and Drabowicz, 2018). Other research focuses on issues of assistive technologies, Web accessibility, usability, interoperability, and legal aspects (*e.g.*, Blanck, 2014; Jaeger, 2011).

Healthcare

At first glance, it might appear that healthcare is less implicated in the digital inequality stack. The number and use of digital health technologies (DHTs) has expanded rapidly and are key components in strategies to improving healthcare and empowering people to achieve healthier lives (Kvedar, *et al.*, 2014). Also termed "eHealth", DHT encompasses hardware and wearable devices, software, methods of data transmission and storage, and related technologies. The pace of DHT diffusion has increased dramatically in recent years. For example, mobile health apps have increased in number from 66,700 in 2013 to 318,600 in 2017 (Aitken, *et al.*, 2017) and electronic health records (EHRs) are now in use in 84 percent of U.S. acute care hospitals in 2015, up from nine percent in 2008 (Henry, *et al.*, 2016).

However, there is a growing realization that DHT benefits are not equally distributed, but vary by social factors (Fang, *et al.*, 2019), thus indicating an important new layer in the digital inequality stack. In fact, new medical technologies do little to narrow social health disparities, as more advantaged populations (*i.e.*, socio-economic status) are better positioned to take advantage of these new technologies (Phelan, *et al.*, 2010). For this reason, although DHTs have the potential to improve care, their unequal use is creating new structural barriers to accessing health-related resources (Pérez-Stable, *et al.*, 2019).

Therefore, recent DHT research has focused on how to overcome digital inequalities to ensure care equity and narrow gaps in social disparities in health (Fang, *et al.*, 2019; Pérez-Stable, *et al.*, 2019). Latulippe, *et al.* (2017) suggests a broader conceptualization of universal access, starting with physical access but also in creating DHT that meets the needs and preferences, skills, literacy level, and culture of future DHT users — particularly people from disadvantaged populations. Sociologists can make a significant contribution to the design of new, equitable DHTs via digital inequality research to understand how differences in access, use, skills, beliefs, and motivations of future DHT users vary by social factors. As with other layers of the digital inequality stack, the unequal ways that people use digital technology results in unequal benefits that derive from technology use, and subsequently, the reproduction of social inequalities (DiMaggio, *et al.*, 2004) and potentially persistent social disparities in health (Fang, *et al.*, 2019).

To narrow social disparities in health requires a different approach equalizing usage benefits by addressing all layers of the digital stack: access, use, skills, and orientations. A non-exhaustive list of promising strategies includes: (1) continuing research to understand barriers to access and use, especially as new DHTs are introduced and new digital inequalities emerge; (2) user-centered design; (3) health and numeracy literacy; (4) understanding the role of culture; (5) patient-provider communication and interaction; and, (6) community-based, participatory research methods (Fang, *et al.*, 2019; Latulippe, *et al.*, 2017).

Education

As we have seen with many other legacy inequalities, educational disparities are implicated in every layer of the digital inequality stack. Scholars have begun to unpack the importance of access to digital resources and skill building in educational settings, as well as linkages to career training; both of which are vital for achievement. Students with insufficient access to digital resources are less likely to earn higher grades and benefit from skill-building opportunities in low-SES schools (Robinson, *et al.*, 2018). Research also draws important connections between variations in access to digital resources and learning opportunities with emotional impacts and well-being (Huang, *et al.*, 2015) that enhance students' desire to learn digital skills.

This being said, the overuse of digital technologies can be just as damaging to students' academic success as is insufficient access to digital resources (Gulek and Demirtas, 2005; Judge, 2005; Lei and Zhao, 2007). Further, academic performance as measured by grade point average implicates differentiated use of digital technologies (Cingel and Hargittai, 2018; Judge, *et al.*, 2006; Junco and Cotten, 2012). Capital-enhancing activities are positively correlated with higher achievement, whereas elevated levels of social or leisure activities impede academic outcomes (Jackson, *et al.*, 2008; Junco and Cotten, 2011).

Studies also indicate the importance of digital inequalities that impact career trajectories (Robinson, 2012). As the information economy transforms the numerous occupations, employers increasingly demand digital skills and literacies (Drabowicz, 2014). For many low-income students, school is the primary place where digital skills are acquired. Even in egalitarian countries such as Finland with excellent educational institutions, more than two thirds of Finnish adults with vocational education and training are at-risk or weak performers as regards digital skills (Hämäläinen, *et al.*, 2015).

In turn, OECD research conducted in Germany on teenagers establishes that the old inequalities in the distribution of objectified cultural capital (Bourdieu, 1986) are being reproduced among teenagers with respect to new digital inequalities. More specifically, this research finds that even among students that can be classified as frequent digital users those living in a home with fewer traditional media sources tend to use digital technologies for leisure activities whereas those living in a home with plentiful traditional media sources tend to use digital technologies for academic activities (Drabowicz, 2017).

Finally, of critical importance, the occupational trajectories of digital workers are influenced by early educational experiences. While low-income youth have the most to gain by entering lucrative STEM professions, they are often the least likely to pursue STEM fields in college. STEM intent is positively associated with school-based and extracurricular enrichment activities as early as primary school (Moller, *et al.*, 2015) and continues through early adolescence (Mahoney, 2010). Recent research probes the potential for digital resources in schools to slow the leakage from the STEM pipeline (Robinson, 2020) and builds upon scholars pioneering the use of gaming and VR experiences to bring low-income students into STEM careers (Ball, *et al.*, 2018, 2017; Ball, *et al.*, 2019).

Rural and urban inequalities

Rural-urban digital inequalities exist in both emerging and developed nations as another component of the digital inequality stack. For example, rural Internet users in the U.S. not only lack high-speed Internet infrastructure but also have lower adoption levels of Internet devices compared to urban users. The Oxford Internet Survey also suggests geographical inequality in Internet use in the U.K.

Meanwhile, due to the uneven distribution of ICT infrastructure, the rural-urban digital gap in emerging countries is wider than that of developed countries. In 2017, the Internet penetration rate in rural India was over 20 percent, which was almost 45 percent lower than that of urban India. The Internet penetration rate in rural China was just under 38 percent, which was over 36 percent lower than that of urban China.

Studies have shown that in addition to the rural-urban residence, the adoption of Internet services is also associated with other demographic factors such as age, education, and gender. As the Internet becomes the dominant source of everyday information-seeking for jobs, education, and business, structural constraints such as residence, education, and age have posed challenges for the digitally disadvantaged groups in rural areas.

To meet the challenges posed by inadequate infrastructure, leap-frogging mobile technologies have become widely used among rural populations. Oreglia (2015) studied the adoption and use of ICTs in rural and urban China and the role of migrant workers in giving mobile phones as gifts to their families in the village. She found that in rural China, ICTs are mainly used for leisure and maintaining social connections, not for information seeking about markets and farming techniques (Oreglia, 2013). Yu's (2010) study on information poverty also suggested that rural residents in China rarely use the Internet as a source of information.

Turning to potential solutions to rural digital inequalities, empirical studies have shown the effectiveness of interventions. Better quality Internet access and the provision of computer classes in rural areas mitigated rural-urban digital disparities in Taiwan. A macro-level study in China found that the introduction of mobile technologies halted the widening of gaps among Chinese provinces. Yet technology must be accompanied by skill-building opportunities. Local Chinese governments have played essential roles in providing training sessions for civil servants and setting up information centers that serve local farmers' agricultural needs. Thus, narrowing the rural-urban digital inequalities necessitates investment in infrastructure, the enhancement of digital skills, and improvement of information services.

Networked individualism

The digital inequality stack also has implications for network engagement and participation. Those who are unable to fully participate in digital networks are less likely to be networked individuals or individuals participating in multiple networks, each getting only their partial attention and commitment. Often, these are diverse networks of kin, friends, neighbors, and workmates (or schoolmates). Each may have only some connection with each other, and individuals have the freedom and the chore of maneuvering among them to find companionship, supportive resources, and information.

The concept of networked individualism describes people with partial membership in multiple, diversified networks who rely less on permanent membership in settled groups. Although most people in developed countries have local ties, the majority of their ties are not local (Fischer, 1982; Mok, *et al.*, 2010). In these multiple, partial, often far-flung networks, people in different role relations provide specialized social support: for example, neighbors tend to exchange small services such as childminding while parents often provide financial aid. Networked individuals reach out in complex multiple networks — what Burt (2001) called "bridging capital" — that have relatively high contact with dissimilar others and diversified situations and ideas. Yet, not all ties are interacted with equally, as some partial networks are stronger, more diverse, and more densely knit than others (Quan-Haase, *et al.*, 2018).

How has the turn to networked individualism come about? Although some form of networked individualism has been present for centuries, residents of the global north now live in network societies where formally organized institutions are less powerful than before (Castells, 1996). As women left home to do paid work, households became less like castles, and fluid work relationships superseded traditional jobs in large bureaucratic organizations. Moreover, the proliferation of instant mobile connectivity devices such as mobile phones and laptop computers have emphasized the individual rather than the household or the kinship unit as the hub for connectivity via the personally logged on Internet (Rainie and Wellman, 2012).

Such developments have afforded opportunities for those with digital resources to maintain ties over substantial distances and to rekindle them when they go fallow. They give resourced individuals more ability to reach into multiple social circles. Yet, to do so, individuals must network actively on their own rather than rest in the comfort of all-encompassing groups (Hampton and Wellman, 2018).

Not all residents of developed countries are networked individuals. Many continue to be members of traditional, encompassing groups in which they are embedded in a densely knit, relatively homogenous network of kin, neighbors, close friends, and social organizations. Members of such bounded networks gain in certainty of connectedness and collective efficacy while lack the information and resources coming from diverse sources. Moreover, despite the benefits of digital connectivity, still others continue to have only a limited number of neighborhood and kinship ties.

Global digital inequality

Numerous barriers to full inclusion exist at all layers of the digital inequality stack: affordability of devices and network services, inadequate infrastructure and institutions, digital literacy and skills gaps, and lack of supportive social networks. All of these challenges are magnified when combined with other inequalities. Therefore, we view the digital inequality stack from a global perspective, always acknowledging endemic inequalities within countries, as well as similarities and differences within regions.

Digital inequalities and divides between nations and regions of the world have long been of keen interest to scholars (Chen and Wellman, 2004). It is recognized that, in emerging countries, certain segments of the population are at the forefront of technology development and use equaling their elite counterparts in developed countries. Therefore, examining digital inequalities both within and across nations is important to shed light on how to understand global digital inequality and its consequences from micro and macro perspectives.

Probing the current state of global digital inequalities today, we see that legacy inequalities remain with us. Statistics from 2018 show that North America and Europe have the highest levels of Internet penetration, with 95 percent and 85 percent, respectively, which is in stark contrast to the 36 percent and 49 percent reported for Africa and Asia, respectively.

However, where traditional computing devices (laptops and desktops) are less widespread, mobile devices are surging. In these cases, technological leapfrogging via mobile devices has been a key factor in increasing rapid connectivity with the potential to create enhanced opportunities for connectivity, community, and economic gain (Ling and Horst, 2011). For example, while as much as three-quarters of the population in sub-Saharan Africa has a SIM connection, only a third of cell phone users can afford a smartphone (Radcliffe, 2018).

Researchers are seeking solutions to the low levels of Internet and smartphone penetration that undermine efforts to improve citizens' quality of life and increase participation in the global economy (Ragnedda and Muschert, 2013; Boas, *et al.*, 2005). Key initiatives include ICT4D (Information and Communication Technology for Development), One Laptop per Child, and the UN 2030 Agenda. National communication solutions must include improvement of literacy levels, professional education, multi-stakeholder cooperation, appropriate and flexible regulation, and user-friendly access to governmental and institutional information. Finally, the unequal allocation of digital production and consumption must be one of the main foci of future digital inequality research. For example, given the rise in digitized labor, much of which is located in lower rungs of the economic value chain and is outsourced by developed to less developed regions, we may see digitization as an additional means to exploit cheaper labor. These and other social problems created by digital technologies are the new face of global digital inequality.

Digital inequalities and the COVID-19 pandemic

Finally, at time of writing, many legacy digital inequalities are being exacerbated by the COVID-19 pandemic in new ways (Robinson, *et al.*, 2020). In particular, digital inequalities related to healthcare, education, economic disadvantage are even more pronounced. Regarding healthcare, Khilnani, *et al*. (2020) argue that "because the digitally disadvantaged are less likely to use eHealth services, they bear greater risks during the pandemic in order to meet ongoing medical care needs." Differentiated disadvantage also marks the experience of digitally disadvantaged students who cannot take advantage of remote learning via the Internet and who are at greater risk of falling behind their digitally resourced peers. In both the case of eHealth and eEducation, we see how economic advantage and digital advantage compound one another in light of the COVID-19 pandemic. While difficult for all, the digitally under-resourced are at greater risk and bear greater burdens than those who can mitigate the effects of the pandemic with digital resources.

2.0: Implications of legacy digital inequalities

Although 25 years have passed since the digital divide was first recognized, digital inequalities have become more multifaceted. As we have seen across these many thematic foci, the digital inequality stack encompasses access to connectivity networks, devices, and software, as well as collective access to network infrastructure. Other layers of the digital inequality stack include differentiated use and consumption, literacies and skills, production and programming, etc. Further, layers in the digital inequality stack are interconnected such that a deficiency in one layer may precipitate deficiencies in other layers. When inequality exists at foundational layers of the digital inequality stack (access to networks, devices, software), this translates into inequalities at higher levels including skill building and use for capital-enhancing activities.

When digital inequalities begin early in life, they impact educational and professional trajectories because all layers of the stack must work together to produce optimal outcomes. Digitally disadvantaged individuals cannot afford multiple personal devices or plentiful subscription software at home or for work. They are less likely to have been exposed to digital skills training at school or on the job. As skills may be implicated in usage, such individuals use digital resources for entertainment and leisure activities rather than work or capital-enhancing activities that might improve life chances. For the digitally disadvantaged, connectivity, device, software, skills, and usage gaps amplify one another. When layers in the digital inequality stack move in tandem with one another, all layers of the digital inequality stack reinforce disadvantage.

For example, we might consider the following digital inequality stack profile of "Alex," an individual for whom all stack layers are compromised. Alex lives in a rural area in a developed economy. Alex finished the minimal education required by the state but did not learn digital skills at school. As a customer associate in a large retail chain outlet, Alex does not engage any digital resources or skills acquisition training on the job. As an unskilled worker, Alex's low wages make consistent, quality home broadband, multiple personal devices, and subscription software unaffordable. Therefore, in parallel with others in Alex's family and social circles, Alex depends on an outdated smartphone with spotty reception for all digital activities, which are largely for social media or entertainment that is free-of-charge. For Alex, all layers of the digital inequality stack are reinforced by social networks and contacts that reinforce disadvantage. As this indicates, disruption to one layer of the digital inequality stack may damage the whole because when any layer in the stack is compromised, it may negatively affect the entirety of the stack.

Yet Alex's situation is largely rooted in socio-economic class disparities that are reinforced by education, rural residency, and social networks. As we have shown, equally salient forms of digital inequality include but are not limited to gender, sexuality, race and ethnicity, disability, aging, healthcare, and global disparities. All of these layers of the digital inequality stack magnify and amplify one another, particularly when combined with other forms of disadvantage. At the same time, the combination of these reinforcing forms of digital inequality serves to replicate social reproduction in multiple life realms. Digital inequalities, therefore, are reproduced through individuals' everyday experiences and embeddedness in different hierarchies. As we are increasingly aware of how digital inequalities are more interwoven with other disparities, we see that the main axes of social inequalities — *inter alia* those enumerated above — still influence and shape digital inequalities.

The multidimensionality and multi-layered nature of the digital inequality stack calls for a new interdisciplinary theoretical and empirical approach that takes into account not only these legacy inequalities but also emergent inequalities. Therefore, we take these arguments further in the second article in this two-part series, "Digital inequalities 3.0: Emergent inequalities in the information age." Across the two articles, we reject techno-determinism or market forces as solutions. Rather, as our work shows, social inequalities are strongly intertwined with digital inequalities; we cannot tackle digital inequalities in isolation from the social world that produces them. Concluding with our metaphor of the digital inequality stack, we reiterate how this multifaceted and multidimensional issue includes several layers that must be addressed together for our collective well-being.

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1. The order of authors reflects the sequence of contributions to the two-part article series as follows.

"Digital inequalities 2.0: Emergent inequalities in the information age" was co-authored by: Laura Robinson and Jeremy Schulz (Legacy inequalities in the information age: The digital inequality stack); Grant Blank (From digital divides to digital inclusion); Massimo Ragnedda (Economic class); Hiroshi Ono (Gender); Bernie Hogan (Sexuality); Gustavo Mesch (Race and ethnicity); Shelia R. Cotten (Aging); Susan B. Kretchmer (Disability); Timothy M. Hale (Healthcare); Tomasz Drabowicz (Education); Pu Yan (Rural and urban inequalities); Barry Wellman and Molly-Gloria Harper (Networked individualism); Anabel Quan-Haase (Global digital inequality); Aneka Khilnani (Digital inequalities and COVID-19); and Jeremy Schulz, Laura Robinson, and Massimo Ragnedda (2.0: Implications of legacy digital inequalities).

"Digital inequalities 3.0: Legacy inequalities in the information age" was co-authored by Laura Robinson and Jeremy Schulz (Emergent inequalities in the information age); Hopeton S. Dunn (Accessibility as a human right); Antonio A. Casilli and Paola Tubaro (The platform economy and digital labor); Rod Carveth (Automation); Wenhong Chen (Big data and algorithms); Julie B. Wiest (Digital intersections with criminal justice and security); Matías Dodel (Cybersafety); Michael J. Stern (Civic engagement and mobility); Christopher Ball (Gaming); Kuo-Ting Huang (Well-being and the life course);); Aneka Khilnani (Assistive technologies); Jeremy Schulz, Massimo Ragnedda, and Laura Robinson (3.0: Implications of emergent digital inequalities).

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