Received: 3 October 2022 | Accepted: 7 November 2022

DOI: 10.1002/poi3.331

RESEARCH ARTICLE

P&I Policy & Internet PSO WILEY

Multisolving innovations: How digital equity, e-waste, and right-to-repair policies can increase the supply of affordable computers

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Abstract

Policy debates about the digital divide often focus on the availability and quality of Internet access, despite the fact that device inequities are persistent and widespread. To address this important but often overlooked policy concern, we present findings from a systematic literature review of policy research that informs the supply of low-cost, large-screen computers. Using the framework of *multisolving innovations*, we explore policies from across three disparate sectors—e-waste, right-to-repair, and digital inclusion—to determine whether any of these policies can serve as cross-sector solutions that work simultaneously to help reduce digital inequalities and e-waste, while strengthening secondhand device labor markets. As a result, we highlight a wide range of policies that would optimize both the supply and distribution of affordable devices to low-income consumers and, at the same time, broaden the base of stakeholders invested in digital equity.

KEYWORDS

digital divide, digital equity, e-waste, multisolving innovations, policy, right-to-repair

INTRODUCTION

Scholars of digital equity have long pointed out that meaningful digital access is composed of much more than simply getting online or just having in-home Internet access (DiMaggio & Hargittai, 2001; V. Katz, 2020; van Djik, 2020). At the same time, policy conversations

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related to digital equity often focus on Internet service. As an example, review of all digital divide-related legislation introduced in the United States Congress since the 1990s revealed an overrepresentation of policy related to Internet service compared to other forms of digital inequality (King, 2022). Yet, device access is also critical and can be difficult to sustain as digital devices are expensive to buy and maintain (Rideout & Katz, 2016). Even in a wealthy country, such as the United States, although 93% of the population is online, 23% still do not own a large-screen (i.e., desktop or laptop) computer (Pew Research Center, 2021a, 2021b). Vulnerable populations in particular (e.g., low-income groups, the unstably housed, the chronically ill) have much to gain from having reliable, individual access to a large-screen computing device, such as a laptop or desktop computer (Araque et al., 2013; Federal Communications Commission National Broadband Plan, 2021; Gonzales, 2016; Levine & Donitsa-Schmidt, 1996). In short, although policies to improve broadband access are important, policies that help ensure the availability of low-cost devices are also essential.

But advocates of digital equity are not the only constituent groups concerned with the supply and accessibility of computing devices. Environmental and labor rights activists advocate for policies that extend the lifecycle of existing devices, which can help to minimize e-waste and protect the viability of the repair and refurbishing labor markets, respectively. Making computer repair cheaper and bolstering secondhand and refurbishing markets better ensures that low-income consumers can afford to maintain the devices they already own and that they can purchase devices as needed (Fosdick, 2012; Islam et al., 2021). Extending the life of a device through repair is often a more affordable choice than purchasing a brand-new device (Svensson-Hoglund et al., 2021). Furthermore, optimizing the lifecycle of existing devices helps exert market pressures on manufacturer's pricing of new devices, helping to keep down the cost of brand new devices (Islam et al., 2021; Leclerc & Badami, 2020). Thus, policies championed to reduce e-waste and protect the right-to-repair (R2R) can also enhance digital equity.

Policies that have mutually beneficial outcomes for different sectors have been described as *multisolving innovations* (Dearing & Lapinski, 2020). Multisolving innovations can broaden the coalition of activists in support of a given policy issue and can be strategically framed to appeal to constituent bases that might otherwise be disinterested or even antagonistic (e.g., framing environmental policies around health outcomes to appeal to conservatives) to an issue. Previous scholarship on multisolving innovations has primarily explored policies at the intersection of health and the environment as a means of increasing cross-stakeholder support (e.g., Charles et al., 2021; Peters et al., 2022). Here we aim to identify policies that may serve as multisolving innovations for the digital equity, environmental, and labor rights communities. To do this, we provide a literature review, which "creates a solid starting point for all other members of the academic community that are interested in a particular topic" (Paré et al., 2015, p. 183). In this particular case, we employ a qualitative systematic literature review method to aggregate articles from across disparate disciplines that converge on aligned policy outcomes. Doing so will allow us to review a breadth of policies and also hone in on those that may be best-suited for targets as multisolving innovations.

Because the structure of this paper is somewhat unconventional, we provide an overview of its structure here: we first contextualize results of the literature review within a brief discussion of other policy approaches historically used to address digital equity. We then explore research on policy recommendations to (1) reduce e-waste, (2) protect consumers' and small businesses' "right to repair," and (3) mitigate device inequalities. We first examine policies separately within each area that shapes the supply and affordability of large-screen computers, and then discuss how a number of these policies may be conceptualized as multisolving innovations, with outcomes that are cross-cutting the three sectors. We close by noting specific strategies that can be employed when leveraging multisolving innovations

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across constituent groups. Our hope is that, as a result of this analysis, researchers and policymakers might consider new ways to pursue policy change and advocacy across all three sectors and with a broadened base of stakeholders.

THE THREE PILLARS OF DIGITAL INCLUSION FROM A POLICY PERSPECTIVE

Digital equity practitioners refer to the three pillars of digital inclusion: (1) broadband Internet access, (2) a computing device, and (3) sufficient digital literacy (Siefer, 2015). We begin by providing a broad overview of long-standing policy approaches from around the globe to improving broadband Internet access and digital literacy, as two other key areas of digital equity policymaking, before presenting results from a literature review of those policies that have implications for device access more specifically. The focus of this review is not the regional differences in policy per se but, rather, the unaccounted-for breadth of options that may be available when conceptualizing solutions to device disparities. For this reason, we do not focus on the political factors that may shape policy options in any one region of the globe, even as we recognize that those factors vary dramatically.

A focus on broadband

At-home broadband is expensive but important (Read, 2022), thus it is not surprising that digital divide policy and policy research often primarily reflect efforts to promote broadband access. To illustrate this, an analysis of digital divide-relevant bills introduced in the US Congress since 1990s has revealed that about half of all bills are aimed at promoting broadband accessibility (King, 2022). In many cases, these policies have intended to reduce the price of broadband for qualifying households (e.g., Federal Communication Commission, 2022). Often, governmental funding has been allocated to help residents of rural areas, public housings, Tribal lands, and other low-income communities receive discounts for broadband purchases. In other cases, particularly in developing countries (e.g., Prysmian Group, 2018; United Nations, 2021), the goal has been to subsidize or incentivize development of the physical infrastructure needed to make stable telephone and broadband access available in places where it was not previously available. This is especially true in rural regions and indigenous communities (e.g., Compartel project in Colombia; the supply-side intervention in Canada) (Gómez-Torres & Beltrán, 2011; McMahon, 2020). As just one example of this, as part of Canada's broadband intervention, the First Mile Connectivity Consortium (FMCC) advanced proposals for reforms to existing funding mechanisms and new subsidies to further secure broadband access in indigenous areas that are often hard to reach and underdeveloped. This type of subsidy has been seen in other parts of the globe and reflects the technical infrastructure needed to provide broadband where fiber Internet is very expensive and market pressures are not always enough to incentivize development.

In addition to government subsidies for in-home service and development of infrastructure, policy aimed at privatization has been another approach to improving Internet access, especially in the early years of Internet adoption. For example, China's decentralization of the Internet market by introducing new telecommunication providers helped support telecommunications development in the interior regions of the country (Loo & Ngan, 2012). Similarly, Mexico increased telephone penetration and arguably strengthened the network quality in the 1990s as a result of paving the way for increased competition (Marscal, 2005). It is worth noting that in countries with highly centralized governments, ease of infrastructure development can speed Internet access, but this is

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sometimes counter-balanced by government controls based on concerns that access to uncensored information may increase dissent (Milner, 2006). However, a cross-national analysis of 30 member countries of the Organization for Economic Co-operation and Development (OECD) found that countries with competing broadband infrastructures had an average of 10 times greater access to digital subscriber line (DSL) compared to those without competition (Cava-Ferreruela & Alabau-Muñoz, 2006).

Despite the effectiveness of many of these interventions, challenges persist. First, even when high rates of Internet coverage and device penetration have been achieved, details about how to maintain telecommunications infrastructure are often lacking in digital equity legislation (Aziz, 2020; Liu & Wang, 2019; Mori & Assumpção, 2007). Scholars argue that low-income and other disadvantaged populations experience significant challenges in allocating monetary and human resources to maintain the connectivity of the network. And despite the effectiveness of increased market competition for expanding access, scholars argue that market prices are often not affordable, particularly in places where income disparities are dramatic (Aziz, 2020; Mariscal, 2005). As a result, growing scholarly attention has emphasized the importance of including the socioeconomically and demographically marginalized populations as a part of the policymaking conversations (Aziz, 2020; Moran & Bui, 2019).

Digital skills policy

After getting access to broadband and devices, having sufficient skills is often considered the third pillar to ensure digital inclusion. Internet users are expected to possess and constantly update a range of e-skills that have been grouped into: *operational skills* (to handle digital devices for Internet use), *information skills* (to explore, select, and apply necessary information resources on the Internet), *communication skills* (to encode, decode, and exchange messages on the Internet), *social skills* (to communicate and interact with others for increase in social contact and social capital on the Internet), *content creation skills* (to publish and share quality content with others on the Internet), and *strategic skills* (to use the Internet as a means for personal, professional, and societal goals) (van Deursen & van Dijk, 2019; van Deursen et al., 2016). Digital skills have become even more necessary in an era of the "Internet of Things" (IoT) (Ashton, 2009; van Deursen & Mossberger, 2018). But a skill divide, or differences in the ability to maintain and upgrade these skills, is a continued problem in many parts of the world. Even in developed countries, novice and low literacy users experience a range of barriers related to understanding and utilizing digital technology (Medhi et al., 2011).

Variability in digital skills can be found in countries around the globe. To illustrate the persistent disparities in skills and literacy in wealthy countries, recent assessments found that 43% of Europeans still do not have basic digital skills (T. C. Liu, 2022), and 30% of Americans are considered low in "tech readiness" (McClain et al., 2021). Even in countries that have moved steadily to build technical infrastructure and availability, skills training often lags. As one prime example, although early policy in Luxembourg designed to stimulate the information and communication technology (ICT) sector succeeded in establishing the underlying telecommunications infrastructure, it fell short of addressing the digital competence needed to take advantage of these new digital tools (Binsfeld et al., 2016). In this particular case, this stimulated the debate about the second-level digital divide among public, private, academic, and governmental stakeholders and, as a result, raised the importance of collaborative investments in training and education programs aimed at improving not only technical competences but also managerial and business competences necessary for sustainable ICT growth in the country (Danescu, 2019). Other European

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initiatives include the Belgian government's "Digital Champions," a national coalition to increase a digitally skilled workforce (Europe's Digital Progress Report [EDPR], 2017; see T. C. Liu, 2022 for more EU countries' policies) or the European Commission's (EC) new Digital Skills and Jobs Coalition program, aimed at digital transformation of European tech users by 2030 (EC, 2021). However, attention to digital skills is also reflected in public policies in developing countries as well—like the Kenyan government's Digital Literacy Programme, implemented in 2013, which involves the distribution of technological resources (e.g., computer labs, tablets) to schools across the country and innovative teaching of digital skills to all students (Kerkhoff & Makubuya, 2022; Makura, 2019).

Other initiatives reflect a more bottom-up approach to digital skills training, involving local/regional initiatives alongside national policy in designing digital inclusion efforts. Much of the research in this area has focused on senior-learners, which makes sense given the dominance of age as a factor predicting digital literacy and digital skills (Anderson & Perrin, 2017; Hecker et al., 2021). Evidence of this has been seen in a number of initiatives taking place in Europe that encourage e-Learning among elderly people, organized by nongovernmental organizations, nonprofits and local government agencies, such as Senior-Info-Mobil and the learning in later life (LILL) network in Germany, COMMA in the United Kingdom, and University of the Third Age in Finland (see details in Gilligan, 2003). Concerns about the digital inclusion of seniors have gained more attention during the COVID-19 pandemic (e.g., Ciesielska, Rizun & Baj-Rogowska, 2022; Ciesielska, Rizun & Chabik, 2022), especially given that seniors were often less digitally skilled to begin with and suddenly the most isolated (Bakshi & Bhattacharyya, 2021). Policies augmenting digital skills training for all segments of a nation's population will likely continue to be a concern, as many of the norms of digital communication established during the pandemic are likely to persist for the foreseeable future (e.g., remote work, telehealth).

The importance of devices

Ensuring Internet access has required policy negotiations among federal, state, and local government officials and Internet service providers as well as regional nonprofits to facilitate implementation. Policies to improve digital skills, on the other hand, are still evolving in many places (e.g., Digital Navigators in the United States) and often rely on an existing patchwork of interventions and experts (e.g., librarians, educators, nonprofit leaders, local and state governments) that have evolved from the ground up to meet local needs using the resources available. Despite the fact that stakeholders in both the Internet service and digital skills arena work across different policy scales, they are all predictable traditional actors within the digital divide policy sphere. In contrast, this review is intended to highlight policies that engage actors beyond the traditional digital equity policy sphere, specifically with the intention of improving affordable device access by broadening the stakeholder base. Before turning to a review of the research literature on policies that increase device access and the wider range of actors it could entail, we briefly revisit research on the importance of device access.

Across the globe, enormous disparities in device ownership persist (International Telecommunications Union, 2021), even in wealthy countries (Gonzales, 2014, 2016; Rideout & Katz, 2016; van Deursen & van Dijk, 2019; Vogels, 2021). Often smartphones are an internet service stopgap, but relying on smartphones for Internet access can limit the range of one's online activity (Napoli & Obar, 2014; Pearce & Rice, 2013) and may also limit one's ability to deepen digital skills (Correa et al., 2020). Ultimately, both Internet service and access to large-screen devices are considered key components of the physical access needed to bridge the "first-level" digital divide. But as van Dijk has noted (2020), "The problem [of internet access] only starts when everybody has a computer, smartphone, or

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Internet connection" (p. 47). After individuals achieve initial physical access, the ongoing work or *technology maintenance* required to reliably keep devices accessible to all members of a household is often difficult (Gonzales, 2014, 2016) and can lead to what Rideout and Katz (2016) refered to as "under-connectedness." Often, users come to expect periods of *dependable instability*, or fluctuations in access determined by when bills can be paid, or lost and broken devices can be replaced (Gonzales, 2014, 2016). These disruptions can be most consequential for vulnerable populations, such as youth, the chronically ill, or the unstably housed, as members of these groups are particularly reliant on computers for schooling, communicating with doctors, or staying in touch with the social and informational supports (e.g., Araque et al., 2013; Attewell & Battle, 1999; Beltran et al., 2008; Malone et al., 2014). These everyday users have the most to gain from creative policy approaches to inequities in computer device access.

LITERATURE SEARCH METHOD

The current literature review provides a systematic and critical assessment on research progress in the digital divide policy sphere. We adopted a qualitative systematic review approach (Paré et al., 2015) that aims to search for, synthesize, and appraise existing literature to examine the current state of knowledge in relation to digital divide policy and identify best practices as well as unaddressed areas of need. Some content analysis methods, such as grouping and classification schemes, were used to summarize and integrate the evidence of the selected articles (Paré et al., 2015).

Our literature review was designed to capture a broad range of research on policies from around the globe that shape the first-level digital divide, particularly large-screen device access. These policies come from disparate political arenas, but all play a role in shaping individual-level access to computing devices. We do not imagine that this review is comprehensive of every article at the intersection of policy and device access, but we hope that it provides a broad accounting of key approaches that have been undertaken and are currently in-progress.

We used the Google Scholar database to find the extant and relevant literature on digital divide policy. Google Scholar enables researchers to locate relevant articles on a specific topic, transcending disciplinary and geographic boundaries. This database has been employed as an established source of review articles in various fields (e.g., Hossain et al., 2016; Saputra & Mahaputra, 2022) and a useful tool for identifying interconnections between articles (i.e., a single article and subsequent articles that have cited it) and tracing the development of the given topic (Noruzi, 2005). After taking advantage of multidisciplinary coverage and citation indexing in this database, we also supplemented searches in the journals *Telecommunications Policy* and *Policy & Internet* that produce a high volume of articles that fit our review criteria to ensure that we did not miss any relevant literature. To encompass the breadth of relevant articles, our search terms included combinations of the following words and phrases: "digital policy," "digital literacy/skills policy," "digital policy analysis," "e-waste policy," "right to repair policy," "right to repair & digital divide," "circular economy policy," "computer reuse policy," "computer refurbishing policy," and "third-party resellers." These terms were developed and refined as the search process progressed to improve search result relevance and diversity. We also used advanced search techniques (e.g., "cited by" and "related articles" features in the databases) that enabled us to identify additional relevant articles that have referred to each retrieved article.

Through this search process, we collected academic papers and practical reports that were published from around the globe in the 2000s–2020s and directly or partly related to digital divide policy. We initially assessed the validity and relevance of the gathered articles based on the title and abstract of each. We then screened all qualifying articles in full length

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to include those published in established journals and reliable sources and exclude those with unavailable full text and without verifiable authorship. This selection process resulted in 147 initial relevant articles. These articles were reviewed multiple times to ensure general fit. Some of these articles were removed from the analysis because they primarily or exclusively centered on digital security policy or particular sectors, such as health or sustainability, that were testing novel technology-based interventions. After articles were further culled, the first author reviewed the remaining articles and grouped them into the following topic areas: e-waste policy, R2R policy, and digital divide policy. These were then read comprehensively to look for overlapping themes and frequently discussed or especially promising policies informing large-screen device access, which are presented below first sequentially then through the lens of target multisolving innovations (Dearing & Lapinski, 2020).

LITERATURE REVIEW RESULTS

E-waste policy

The first body of policy research considered here focuses on e-waste, or waste associated with electronic materials, as much of the policy to reduce e-waste has focused on extending the life of existing devices. As a result of extending device lifecycles, these policies can translate to a more robust second-hand device market, which lowers price points for consumers and should reduce the device divide.

E-waste is considered the fastest-growing form of waste, with 53.6 million metric tons of waste created in 2019 alone and 2.5 million metric tons of new electronic consumption added each year (Forti et al., 2020). Yet much of the e-waste that is discarded annually has the potential to be refurbished and reused. Such practices help promote a "circular economy," one that minimizes all waste through reuse and recycling (MacArthur, 2013). Because refurbished devices are often sold at a reduced cost, increased computer refurbishing would create more affordable computer options for low-income households. Although there are robust industries for second-hand cell phones (Kamigaki et al., 2017; Pinçe et al., 2016; Xu et al., 2016), the focus of this literature review is on the recirculation and life extension of large-screen devices.

There is a variety of policy approaches to encouraging the recirculation of large-screen computing devices. The centerpiece of these is the Basal Convention, a treaty put into place in 1992 to discourage the shipment of hazardous waste, including e-waste, from high-income to low-income countries. Although there are concerns about persistent loopholes within the treaty (Forti et al., 2020), its aim is to mitigate the toxic effects of e-waste on the people and environments in low-income countries where it historically has been disproportionately processed (Abalansa et al., 2021; Awasthi et al., 2019). By forcing wealthy countries to process their own e-waste, which can be expensive and complex (Halim & Suharyanti, 2019; Lepawsky, 2012), the Basal Convention was designed to reduce waste entirely and instead incentivize the three Rs: reduced use, recycling, and reuse, with the latter being the most relevant here.

Outside of the Basal Convention, researchers advocate for a variety of other waste reduction policies with target audiences across both public and private sectors (Halim & Suharyanti, 2019). To start, policies that target consumers could be used to increase awareness of the importance of reuse and could utilize financial incentives or centralized buy-back campaigns to increase donations of used devices (Islam et al., 2021). Certifications to signal that refurbished devices have met quality control standards might also help ease consumer concerns that secondhand devices are inferior, and would thus normalize second-hand purchases (Islam & Huda, 2020).

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Policies that target corporations could also be beneficial, including extended producer responsibility (EPR) policies, "requiring producers to take financial and/or physical responsibility for managing their used or end-of-life products" (Leclerc & Badami, 2020, p. 2). These might help incentivize safer, less wasteful design and engineering from original equipment manufacturers and include but are not limited to policies to limit the toxicity of computing parts at the point of manufacture; added producer fees at device end-of-life by tracking waste; and designing for increased recyclability of parts (Leclerc & Badami, 2020; Lepawsky, 2012; Tasaki et al., 2019). The refurbishing industry has much to gain from added EPR pressures, though there is tension between refurbishers, who advocate from added government intervention and retail refurbishers who want greater freedom in managing implementation of EPR (Kamigaki et al., 2017). In one such example, government intervention could eliminate the value-added tax on refurbished products (Whalen et al., 2018), which would ease refurbishing costs. This is just one of the possible policy approaches that can and, in some places, already is designed to reduce e-waste.

Despite the promise of these policies, it is also important to note that there are real barriers to reducing e-waste. Even with a healthy refurbishing industry, there is no guarantee that devices will be reused, and the condition of devices and the price of metals may often push devices toward recycling instead of refurbishers, which is not necessarily the goal of digital equity advocates or environmentalists (Leclerc & Badami, 2020). The cost of labor and the scarcity of skilled repair workers may also be a problem for the refurbishing market in some places (Matsumoto et al., 2016). Despite these barriers, there is ongoing interest from around the globe in supporting the refurbishing industry as a means of helping to streamline a circular economy. Better e-waste policies can play a powerful role in reducing digital inequalities (Fosdick, 2012) and may also create new jobs in the process (Kamigaki et al., 2017; Leclerc & Badami, 2020).

Right to Repair (R2R) policy

The R2R movement has gained momentum in recent years as *planned obsolescence*, the intentioned fragility of consumer goods, has also become a dominant approach to manufacturing within the electronics industry (Barros & Dimla, 2021). Like the policies described above, advocates of the R2R are driven, in large part, by the desire to extend the life of consumer goods as a means of reducing e-waste. However, with a policy focus on "repairability," it is also supported by small business owners and others who work in repair, such as do-it-yourself repairers (Svensson-Hoglund et al., 2021). Sabbaghi et al. (2017) report that, according to US Census Bureau data, "the number of annually established firms in the consumer electronics repair and maintenance industry has decreased from 4623 in 1998 to 2072 in 2015" (p. 137). This is due, in large part, to the fact that, as the cost of electronic goods has dropped, repairability is increasingly made difficult or impossible through manufacturers' nonrepairable product design, electronic password protection, or by withholding repair instructions or spare parts from the public (Sabbaghi et al., 2017). These tactics require consumers to return to the original equipment manufacturers for support when devices break or to purchase another product entirely.

Advocates of the R2R from around the globe have tried to tackle various policy solutions across different sectors to protect reparability. Intellectual property, consumer, contract, tax and chemical laws can inform the legal standing of repair around the globe (Svensson-Hoglund et al., 2021). The following are just a few examples of the policy approaches that could be considered that may also have short-term or downstream effects on computing costs: intellectual property laws could be redrawn to allow for modifications that would maximize the lifespan of a product; laws could expand the legality of tools to break digital

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locks that prevent electronic repair; consumer products could include a "repairability score" that signals ease of repair at the point of purchase; and Fair Repair bills, like those proposed in various US states (e.g., Washington, California, Vermont), would better ensure access to spare parts and manuals from producers for a minimum number of years after electronic appliances are purchased (Milios, 2018; Pihlajarinne, 2020; Svensson-Hoglund et al., 2021; Terryn, 2019; Whalen et al., 2018). These are just some of the promising policy approaches that could be taken to extend the life of home computers. Doing so provides for a robust second-hand computing market, which may have lower price points for consumers and also improves the chances that competitive, affordable repair is available.

Digital divide policy

Finally, we close by reviewing federal policies from around the globe that have been designed specifically to reduce digital inequalities by increasing access to affordable devices. Rather than shaping the supply chain or market pressures on new devices per se, these policies are centered directly on getting devices into the hands of consumers. Perhaps the most common are those that focus on large-scale distribution of devices to a population. In some cases, this is seniors or low-income households, but often it is students or youth (Gómez-Torres & Beltrán, 2011; Mori & Assumpção, 2007; Robinson et al., 2020). This was especially true over the last two years of the pandemic, but device distributions targeting school-aged children have long been a hallmark of digital divide policy. Best known is One Laptop per Child (OLPC), a nonprofit initiative created to distribute low-cost laptops to children around the globe, which was originated in MIT's Media Lab and was backed by the United Nations in 2006. From its inception, OLPC struggled with the target laptop price of $100 and was criticized for a top-down approach that did not appropriately consider regional needs (Robertson, 2018). Yet OLPC had successes before closing in 2014, including = exemplar results in Uruguay credited with measurably reducing device access (Dodel et al., 2018; Dodel, 2015), in large part by creating "an ecosystem of free educational software and contents, and distributed new pedagogical practices to complement them" (Robinson et al., 2020, p. 245). Indeed, the strength of holistic approaches to addressing digital inequalities is echoed throughout the literature. Multiple scholars emphasize the importance of buy-in from stakeholders across scale (i.e., federal governments, municipalities, community organizations) with an appreciation for both Internet, device and skills support (Assumpção, 2007; Aziz, 2020; Mori & Assumpção, 2007; Reggi & Gil-Garcia, 2021; Robinson et al., 2020).

More recently device distributions have increased in many places due to the 2020 global pandemic and the increased need for remote work and schooling. There are examples of this from around the world (e.g., Dimitrova, 2020; ECSTRA, 2020), but we elaborate briefly on policies in the United States, as one example. In 2021, the US Congress passed legislation that provided $3.2 billion for the Emergency Broadband Benefit (EBB). EBB not only provided up to $50 for in-home broadband but also $100 toward the purchase of a device for eligible households. Subsequent legislation provided another $14.2 billion to make these subsidies permanent through the Affordable Connectivity Program (Federal Communications Commission, 2022). The US federal government has subsidized mobile phones and hotspots (in addition to monthly cell phone service) for many years, but this is the first time it is widely subsidizing personal large-screen devices, such as desktop and laptop computers.

Finally, in addition to individual-level device distributions, another common government approach to improving digital access has been to fund devices and Internet access at public community centers. Scholarship from around the globe has found that such centers can provide critical resources, especially in areas of the world where household-level telecommunications infrastructure is lacking (Furuholt & Saebø, 2018; Rahman, 2016; Soriano et al., 2018; Uys & Pather, 2016). However, this approach also has its limitations. Staff are not always sufficiently

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trained, and there is often a lack of investment and device upkeep over time (Frans & Pather, 2021; Furuholt & Saebø, 2018; Rahman, 2016). That is, as is often the case with government spending, digital divide initiatives that may be funded in the short term do not necessarily have a continuous or reliable funding stream, sometimes compromising the quality of support such centers can provide over time.

DISCUSSION

Having a reliable device is a central component of digital inclusion, yet many around the globe lack computer access (International Telecommunications Union, 2021; Pew Research Center, 2021b), and even within wealthy countries inequalities persist, leaving many "underconnected" (e.g., Gonzales, 2014, 2016; Rideout & Katz, 2016). Much of the discussion about policy solutions to the digital divide has emphasized broadband access (Federal Communication Commission, 2022; King, 2022; United Nations, 2021), and to a lesser degree, efforts to improve digital literacy (e.g., EC, 2021; T. C. Liu, 2022). The purpose of this literature review was to explore policies that inform affordable device access specifically, many of which come from outside the digital divide sector.

Whereas digital divide policies have often focused on getting devices in the hands of consumers through device distribution campaigns or subsidies for device purchases (Federal Communication Commission, 2022), relevant policies from the environmental and R2R sectors have instead focused on increasing and maintaining the number of devices in circulation. Of the 3Rs typically promoted to help reduce waste (i.e., reduced use, reuse, and recycling), "reuse" may be especially helpful in narrowing the device divide in two key ways. First, policies that encourage refurbishing increase the supply of devices in the second-hand market, which is not only itself a source of low-cost devices but may also help to keep down the cost of new devices (Islam et al., 2021; Leclerc & Badami, 2020). Second, policies that make devices easier to repair better ensure that when devices break repair is a cost-efficient option relative to the purchase of a brand new device (Svensson-Hoglund et al., 2021). As a result, policies that encourage refurbishing and repair not only serve to help reduce e-waste, which has been the fastest-growing form of waste for many years (Forti et al., 2020) but also ease device access for low-income consumers who cannot easily afford expensive new devices for every family member every few years. In short, environmental and R2R policies increase the *number* of affordable devices available while digital divide policies help facilitate *distribution* of those devices to consumers. With this distinction in mind, we next discuss the idea of policies that can help ultimately achieve both of these ends.

The *Multisolving Innovation* approach to device access

A multisolving innovation refers to "a practice, program, policy, or technology new to a community that offers co-benefits of more than one type" (Dearing & Lapinski, 2020, p. 2177). It was originally proposed to describe interventions at the intersection of community health and environmental protection, such as closed street initiatives that both increase neighborhood social ties and reduce carbon emissions, or policies to implement anaerobic digesters that reduce harmful waste at factories and farms to the benefit of both humans and the environment (Dearing & Lapinski, 2020). Dearing and Lapinski draw on scholars before them (E. Katz, 2001; Kingdon & Stano, 1984; Lazarsfeld & Merton, 1948) to argue that multisolving innovations are especially useful insofar as they can be strategically framed to appeal to interest groups or political parties that may be supportive of one type of cause but not the other. In the case of environmental policy, this has often meant

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emphasizing health outcomes rather than environmental outcomes when appealing to conservatives, who are often disinclined to support environmental protections (Hart & Feldman, 2018; Petrovic et al., 2014).

Other scholars have also advocated for this calculated framing approach to soliciting support for environmental policy (e.g., Mason, 2021; Peters et al., 2022) but, to our knowledge, this is the first application of this concept at the intersection of digital and environmental policy. That is, most of the work in this area seems to foreground the need to build support for environmental policy by outreaching to those who are otherwise supportive of policies that improve health and well-being, since many environmental protections also have health benefits. We suggest instead that digital rights activists apply this same idea by outreaching to environmental activists, the larger of the two constituencies. Doing so would help broaden support in both arenas and may improve the chances of implementing policies that have improved environmental and digital justice outcomes.

Examples of possible multisolving innovations can be found in all three sectors. Policies that increase the number of devices that are refurbished rather than recycled or discarded and policies that lower barriers to device repair would both serve as multisolving innovations that can reduce e-waste and improve low-cost access to devices. A prime example of policies that would be relatively inexpensive to implement that are originating from within the e-waste sector includes requiring certifications for quality standards of refurbished devices and reductions in value-added taxes on refurbished products (e.g., Islam & Huda, 2020; Whalen et al., 2018). These policies would help increase the second-hand device consumption and elevate the visibility of the industry. Policies that put financial pressure on producers through extended producer responsibility costs (e.g., production costs on devices based on amount of waste generated) can also help bolster the refurbishing industry if producers are incentivized to extend device lifecycles. And policies originating from the R2R sector that might also reduce e-waste and increase affordable device circulation include preventing corporate locks on devices and ensuring widespread access to manuals and spare parts after the point of purchase (Milios, 2018; Pihlajarinne, 2020; Svensson-Hoglund et al., 2021; Terryn, 2019; Whalen et al., 2018). All of these policies would be relatively inexpensive to implement and would serve as multisolving innovations that address the needs of all three sectors.

But it is not only environmental policy and R2R policy that inadvertently reduce digital inequalities. There are also policy approaches advocated primarily by digital equity activists that serve the interests of environmental activists. A current example of this is H.R. 3544, the "Computers for Veterans and Students Act" which has been passed in the US House of Representatives and has been moved to the US Senate for review. This bill would increase the supply of devices available for refurbishing, which is one of the primary problems for refurbishers in the United States (Gonzales & Yan, 2020). The bill is primarily framed as a digital divide bill, but it is clear that it has environmental consequences as well by extending device lifecycles. And since digital equity policy has often enjoyed bipartisan support (King, 2022), environmental activists would be well served to embrace this partnership, especially in this moment in history in which digital inclusion policy is quite visible following the pandemic.

Finally, we note that all of these sectors—digital equity advocates, environmentalists, and R2R advocates—would be well served by joining forces to cocreate public campaigns that increase consumer awareness of these policies. Scholars from across sectors have noted the costs of poor public awareness, which compromises refurbishing donation streams as well as consumer willingness to purchase refurbished devices (Gonzales & Yan, 2020; Islam et al., 2021). Policies that not only directly act on device supply and distribution but also inform public awareness of these solutions would also be effective multisolving innovations.

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CONCLUSIONS

It is worth reinforcing the need for a holistic approach to addressing digital inequalities. Again and again, scholarship on the topic finds that any policy solution is only effective when it addresses multiple forms of digital need and does so over the long term. Because the complexity of digital technologies continues to evolve, and the capacity of any given device is quickly outdated, policies must try to appreciate the persistent and complex nature of digital inequalities and design solutions accordingly. This requires buy-in from stakeholders across scale (i.e., federal governments, municipalities, community organizations), with an appreciation for all aspects of digital access: internet, devices and skills support (Aziz, 2020; Mori & Assumpção, 2007; Reggi & Gil-Garcia, 2021; Robinson et al., 2020).

One way to accomplish this may be by considering a broader range of stakeholders. The policies highlighted in this qualitative systematic literature review point to opportunities for broadening the coalition of stakeholders engaged in digital equity work by leveraging *multisolving innovations* (Dearing & Lapinski, 2020). Reaching across sectors may be one way to engage a new body of advocates in digital equity outcomes, even if their primary focus is on environmental or labor issues. As Dearing and Lapinski (2020) noted, this also involves the risks of inviting new detractors of a policy. But one assumes the benefits outweigh costs of broadening a coalition. In this case, reimagining the boundaries of digital divide policy may help to reinforce and reinvigorate policy across all three of these sectors in a manner that will be mutually beneficial.

CONFLICT OF INTEREST

We have no conflicts of interest to disclose. Analysis of this literature was first presented as a private report by the first author as contracted for Digitunity, a nonprofit dedicated to closing the technology gap.

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How to cite this article: Gonzales, A. L., Kim, Y., & Wang, L. H. (2022). Multisolving innovations: How digital equity, e-waste, and right-to-repair policies can increase the supply of affordable computers. *Policy & Internet*, 1–16. https://doi.org/10.1002/poi3.331

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